Erasmus
School of
Economics

Master thesis

The effect of increasing information services offered by port authorities

MSc Urban, Port and Transport economics

Name: Jasper Kamer (443364)

Supervisor: L.M. van der Lugt

Second assessor: B. Kuipers

Date: 03/03/2022

Photo: Port of Rotterdam

Abstract

Sharing information is becoming more and more important in today's interconnected supply chains. Ports, and port authorities by extension, form an implicit link in many of these supply chains as a result of international sourcing and manufacturing becoming ever more prevalent. This thesis aims at providing port authorities with practical guidance on how to expand their information services in order to meet the ever-increasing demands of supply chain partners in an effective way. It is written using a case methodology on assignment from the Port of Rotterdam. As a result of the lack of previous literature on the specific field of information services offered by port authorities the theoretical review is expanded by a practical review using a methodology where important stakeholders in a port authority's information services are interviewed. From the theoretical and practical review, a research methodology is established aimed at investigating the effectiveness of increasing information services as a port authority dependent on the goal and the methodology of sharing this additional information as well as on the level of trust between the parties involved. A survey methodology involving simulations aimed at two stakeholders, captains and agents, is developed. It is found that the degree to which information is aimed at increasing safety in the port positively affects the effectiveness of that information while the degree to which it is aimed at reducing congestion does not display the same relationship. Information of moderate complexity and low novelty in the eyes of the information recipient is most effectively shared using a visual methodology while more complex and novel information is best shared using a more textual methodology, confirming theories established in previous literature. The level of trust between the port authority, captains and agents is found not to be inherently high, however the findings regarding this factor are limited in this thesis as more specific research on this factor requires a different research methodology. It is found that using the practical findings presented in this thesis increases the effectiveness of information sharing efforts by port authorities.

Acknowledgements

I could never have succeeded in writing this thesis without the help of some key people. I would first like to thank my thesis supervisor, Larissa van der Lugt, for her invaluable help as well as her flexibility throughout the difficult process of writing this thesis. I would also like to thank the Port of Rotterdam and Pieter Nordbeck in particular for the opportunity to write this thesis on a practical topic and for connecting me with the various stakeholders, participants and domain experts that were crucial in writing this thesis. I would also like to thank all participants in the interview and survey phases without whom there would be no results to present. Lastly, I would like to thank my family and girlfriend who have supported and encouraged me throughout the process of writing this thesis, writing this thesis would not have been possible without them.

Table of Contents

1. Introduction

1.1. Introduction and research questions

Sharing information is vital in today's ports where increased digitization rates facilitate easier sharing of information among members of transportation chains. Ports form an important link in most of today's global supply chains (Krieger-Boden, 2000) since around 80 percent of the global trade by volume is carried by sea and handled in ports worldwide (United Nations Conference on Trade and Development, 2018). The IT revolution and the level of information sharing that this has allowed has pushed the transportation industry to develop economies of scale (Montesinos, Connors and Gwartney, 2020). As a result of this development the world's producers are linked with the world's consumers in a cost-effective manner. Since ports form an important part in most global supply chains, they should also engage in information sharing to remain competitive and facilitate their users' processes. Port authorities are center staged in meeting the challenge of increasing information sharing rates in ports as they are party to most information streams within a port., and they are already responsible for providing certain pieces of information to all seafarers (Industry Partners et al., 2021).

The types of information that port authorities are required to provide to all seafarers includes general information on the port like its depth and location to allow for navigating to and in the port (International Maritime Organization, 1997A). This type of information also includes more detailed nautical information to allow ships to comply with SOLAS chapter V (International Maritime Organization, 1974), which should be used by a ship's crew when a "port passage plan" is developed during the first phase of the port call (International Maritime Organization 1999). From conducting interviews with stakeholders in a port authorities' information services it is found that most, if not all, ports provide at least a basic level of information services, allowing a vessel to dock in the port. Some port authorities however expand on their role by introducing additional information services to their offering.

In writing this thesis the viewpoint of a port authority that is trying to meet the ever-increasing informational demands from supply chain partners is taken as it is written on assignment from the Port of Rotterdam. Using this approach implies that this thesis is written using a case methodology which is a qualitative and exploratory methodology (Noor, 2008). This type of methodology was chosen as there is not much previous literature on the specific topic of the effectiveness of information sharing efforts of port authorities. Using the case methodology allows for expansions upon a basis of literature reviews using interviews conducted in the case port. Following this exploratory process of building a conceptual framework some theories are then tested using a survey methodology in which changes to the operations in the case port are simulated. The Port of Rotterdam authority aims to be best-in-class in the information services they provide to incoming vessels ("Port of Rotterdam's Advisory Services", n.d.), where they focus on providing dynamic information in addition to the static information that is required for vessels to navigate to a port at all. Dynamic information that relates to a port can be generalized to information relating to traffic, wind and weather and to depth, tides and currents. Providing dynamic information is likely to prove fruitful to efficiency in port operations as 93.6% of delayed schedules for ocean-going ships are attributable to restrictions in port access or congestion at terminals (Notteboom, 2006).

Interviews that are conducted in writing this thesis point out that not all dynamic information that stakeholders would like to have access to is currently offered by the Port of Rotterdam. Three different informational shortcomings arise from interviews with participants 1, 2, 7, 10, 11, 12, 13 and 14 and are therefore used as an input in the development of the research methodology involved with this thesis. These three shortcomings are: information regarding quay availability at terminals, information regarding actual depth in the port and information regarding the wind speeds as well as limitations on operations that are imposed by wind speeds. The fact that multiple pieces of information are labeled as missing or lacking in the eyes of the interviewees allows for the development of a research methodology testing the effects of adding additional information services by simulating the addition of these specific pieces of information.

As this thesis attempts to establish the effects of sharing additional pieces of information on the operations of captains and agents it is important to realize that the aim of information that is shared will likely influence the effectiveness of sharing that information. In shipping, sharing information is generally aimed at increasing the level of safety, reducing costs and, as a result, often aimed at reducing and/or avoiding (costly) delays (Industry Partners et al., 2021). The results of this thesis find that the effectiveness of sharing pieces of information differs based on the goal that sharing that information is aimed at.

The effectiveness of sharing information is also influenced by the method in which that information is shared (Wu et al., 2014). Information can be (digitally) shared using a verbal, written or visual methodology (Burgoon, Manusov and Guerrero, 2021). Where the effectiveness of any of these methods is dependent on certain characteristics of the information that is shared, such as the complexity and the level of novelty of that information in the eyes of the recipient (Wu et al., 2014 and Waern, 1981). In the case of information that a port authority shares a choice can be made in the methodology of sharing that information, where it could for example be shared using an email messaging system, through an application or even through an application programming interface (API) allowing other programs to display the information. This thesis finds that the method of sharing information in conjunction with characteristics of that information has a large effect on the effectiveness of sharing information.

In examining the effects of increasing informational services it is also important to realize that sharing information between any two parties can be lacking in effectiveness if certain preconditions are not met. A certain level of trust must exist between parties exchanging information for that information exchange to be effective (Özer & Zheng, 2017). If there is a lack of trust between the parties involved in an information exchange there might be fear of opportunistic behavior by one of the parties, reducing opportunities for shared improvements to operations and profitability (OECD, 2011 and Ryu, 2006).

This thesis is aimed at investigating the challenge posed to port authorities to increase their levels of information sharing as well as offer practical advice on how to meet this challenge most effectively. As a result of this aim, the effectiveness of sharing information must be defined and measured. As a port authority must balance the needs of many stakeholders in the field of information services (Jansson and Shneerson, 1982), this thesis focusses on the actions of two of the most important of these stakeholders: captains commanding a vessel that calls at a port as well as the agents representing those vessels in the port. The way in which sharing additional information affects the operations of these stakeholders can then be measured as the effectiveness of that information. As a result of this choice to focus on two stakeholders, the following main research question is posed:

"How does increasing the amount of information services offered by a port authority affect the operations of captains and agents in a port?"

Attempting to answer this main research question in combination with the observations that other factors mitigate the effectiveness of information sharing leads to the introduction of three hypotheses concerning the effect of the aim of the information that is shared, the method of sharing that information and the effect of the relationship between the parties involved in the information exchange:

1. **Hypothesis 1:** ***"Information aimed at reducing port congestion and/or increasing port safety is immediately reflected in captain's and agent's operations"***
2. **Hypothesis 2:** ***"Information of average complexity and low levels of novelty is most effective when shared through visual means"***
3. **Hypothesis 3:** ***"The level of trust that is attributed to a port authority positively affects the effectiveness of the shared information"***

1.2. Relevance

The main question is constructed considering the challenges currently faced by port authorities to adapt to meet the increased informational needs from stakeholders that are involved with operations in a port. As any other organization, a port authority is limited in their capacity to expand their operations by material and non-material constraints like finances and personnel availability. As a result of this fact, enacting prioritization in developing new information services for customers of a port is essential. In developing such a prioritization, an understanding of the information that could be shared, and the use of that information is needed. In order to offer advice on what fields of information port authorities should focus their investments, this thesis is designed to find the pieces of information with the highest priority in the eyes of stakeholders to the information services in the port of Rotterdam. In doing so the thesis will present a methodology that allows for reproduction of this process in other ports. When a certain prioritization is established port authorities are presented with the question of how that information should be shared. The port of Rotterdam port authority, like many other port authorities, currently shares different pieces of information using different methodologies while a thorough analysis of what methods are most effective is not employed. In order to aid in improving the effect of the information that is shared by port authorities, this thesis also considers the method in which information is shared with stakeholders through attempting to verify *hypothesis 2*.

This thesis aims to expand on academic knowledge in a few different fields of research. In the field regarding the impact of information sharing on behavior, this thesis aims to expand the existing knowledge by analyzing the differences in effectiveness of information that is shared with different aims (i.e., improving safety or avoiding delays) in a port environment. Existing knowledge regarding the effectiveness of sharing information in a visual or textual format is expanded by this thesis' research by exposing subjects to different levels of information complexity and analyzing the difference in effectiveness between the visual and textual formats presented to each subject. Lastly this thesis also aims to expand existing knowledge in the field of research on the preconditions to effective information sharing by including a measure of trust in the research which is established as the most important precondition to effectively sharing information in previous research (Özer & Zheng, 2017).

1.3. Thesis outline

In answering the research question of this thesis, a solid understanding of the concepts of information sharing between organizations and the specific issues related to information sharing in the context of ports is required. This thesis starts out by building that understanding through an analysis of previous literature establishing information as a concept, literature discussing information sharing between organizations within a supply chain, literature concerning the different aims of information sharing efforts in ports, literature concerning the effectiveness of the distribution method of information and literature concerning the preconditions to sharing information at all. As a result of the lack of previous literature in the specific field of information services by port authorities the theoretical basis that is developed from previous literature is expanded by conducting interviews with stakeholders in the information services of the case port. Using this theoretical framework, a research methodology

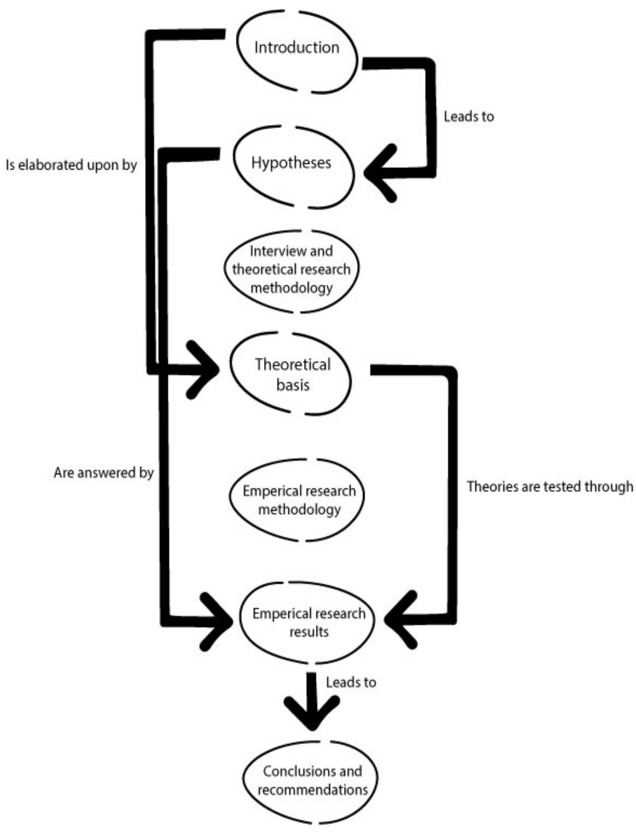


Figure 1.1: visual representation of survey structure

that is centered around a survey simulating specific information services is developed and distributed to captains and agents operating in the case port of Rotterdam. The results of this research are then analyzed to present practical implications for introducing new information services in ports. The thesis is concluded by establishing the limitations of its findings and suggestions on further research in this field. Figure 1.1 contains a schematic overview of the structure of this survey.

2. Theoretical and practical review

In order to develop a conceptual basis on the topic of information sharing in ports an extensive review of existing literature is conducted. It is found that the amount of previous research in the field of information sharing by port authorities is low. In order to supplement the more general theories on the effectiveness of information sharing efforts with more specific knowledge regarding information sharing by port authorities, interviews with stakeholders in these information sharing efforts are conducted.

2.1. Methodology

To supplement the gap in knowledge resulting from the previously discussed lack of previous literature an interview methodology is used. These interviews are also employed to find specific informational shortcomings in the case port of Rotterdam, which will later be used to develop a research methodology similar to methodologies employed by previous studies (Reams & Twale 2008, Holms, 1982 and Eide et al, 2018).

An interview methodology is the best fit in meeting the goal of these interviews of qualitatively exploration of the role of port authorities in the information services in a port (Cassell, 2015 and Jervis & Drake, 2014). A semi-structured interview style is the best fit (Kvale, 1996 and Podsakoff, MacKenzie & Lee, 2003) as this methodology allows for inductive open-ended as well as closed questions (DiCicco-Bloom & Crabtree, 2006) and is previously used in research attempting to discover diverse perceptions in complex relationships (Cridland, Jones, Caputi & Magee, 2014, Barriball & While, 1994). The semi-structured interview methodology requires that an interview guide is developed, in the context of this research the five-step process described by Kallio, Pietila, Johnson & Kangasniemi (2016) is used to develop this guide, which is included in appendix a.2.1. Pointers on the wording of questions from Turner (2018) and Cridland, Jones, Caputi & Magee (2014) are used to ensure the answers to the questions yield the most useful results. Such a methodology requires that attention be paid to the position an interviewee inhabits in a company (Becker et al., 2002), ensuring that the interviewee has direct knowledge on the way in which port-based information is used in the business process. The downside of the lack of generalizability resulting from the inherently small sample size involved with conducting interviews is mitigated by the depth on the topic which these interviews allow for (Crouch and McKenzie, 2006), where the generalizability of the findings is later improved through the research with more participants. To avoid interviewees from answering in a socially desirable manner (Richman, Kiesler, Weisband & Drasgow, 1999 and Leggett, Kleckner, Boyle, Dufield & Mitchell, 2003) it is stressed that the interviewer is not an employee of the port authority and that the contents of the interview will not be shared with the port authority without prior consent from the interviewee. The interviewer himself is also aware of previous research on the way in which interviewer behavior and his level of knowledge can impact the responses from interviewees (Hildum & Brown, 1956, Salazar, 1990 and Boyd & Westfall, 1965). Transcriptions are made of each of the interviews to ensure the academic rigor of the findings (Kvale, 1996) and a summary of the non-confidential interviews is included in appendix a.2.2.

In total 15 interviews were conducted, of which 4 were with captains, 3 with agents, 3 with ship operators, 3 with terminal operators, 1 with a representative from the association of pilots and 1 with a representative of the port of Rotterdam's harbor control center (HCC). An overview of the interviewees, their professional roles and the perspective they offer is included in appendix 2.3.

2.2. Information as a concept

In conducting the normal course of business every company creates and uses information. This takes many forms, and without a certain degree of information a business could not function at all. In order to discuss information sharing and the effects that it has on the operation of captains and agents in ports in particular, a discussion on the concept of information is required. This discussion allows for developing an understanding of the concept of information and knowledge within the context of this thesis' subject. This understanding forms the basis for analysis of the effects of sharing information in subsequent sections.

2.2.1. Defining information

Information can be defined in multiple ways, where in the context of this thesis the conceptualization of information by McCreadie & Rice (1999) viewing information as a resource/commodity seems to fit best. This conceptualization sees information as something that can be produced, purchased, replicated, distributed, sold, traded, manipulated, passed along and controlled. This conceptualization fits best when compared to the other conceptualizations as information that is shared within a business context, especially regarding operational data, will generally not be shared through less formal means or through books and documents. A full comparison between the different conceptualizations of information proposed by McCready & Rice (1999) can be found in appendix a.2.4. Utilizing this definition allows for defining information sharing in the context of this thesis to concern the sharing of messages and data points essential to operations in manners that were previously described.

All operational information starts out as raw data. An example of raw data in the maritime context could be sensor readings and values used in a weather forecast. Following this example, structuring this raw data could involve formatting the sensor data so that values are matched to certain areas that are monitored such as specific harbor basins, transforming the data into information (Stair & Reynolds, 2010), which can then be purchased, replicated, distributed, sold, traded, manipulated, passed along and controlled. However, the act of sending and receiving information on its own is not necessarily useful, as these structured data points do not directly trigger any action by the parties involved in the exchange.

According to Stair and Reynolds (2010), knowledge is "the awareness and understanding of a set of information and the ways that information can be made useful to support a specific task or reach a decision". This statement implies that for shared information to be useful to the other party in an exchange, that information first must be turned into knowledge. This transformation requires resources, which is why a person or company will only turn information into knowledge if it is expected that the knowledge gained from analyzing the information will be useful (Stair & Reynolds, 2010). This mechanism of filtering allows humans, and by extension corporations, to manage the near infinite amounts of information available (Maes, 1995). Knowledge is critical in the functioning of businesses, for example production quantities in a factory must be set based on knowledge distilled from information shared by customers (e.g., past demand figures, predictions). This example already shows that information sharing is critical in fulfilling business functions, and thus the mechanics of sharing information and the effect that this has on business operations presents itself as an interesting and impactful area of study.

2.3. Information sharing between supply chain partners

A port authority forms a part of many supply chains, and therefore it must cooperate with other companies by sharing information. Most information created and used in generic operational business processes is proprietary information, like product designs and strategies (Stefansson, 2002). On the other hand, every company must interact with other companies or individuals in order to produce a good or sell a service. This process inherently involves a stream of shared information (Stefansson, 2002, Lumsden & Mirzabeiki, 2008), includes order amounts (or providing suppliers with a prediction) or a product's features aimed at customers. In recent years, sharing this information has become ever more important in society as well as in business. The IT revolution has enabled an ever-increasing amount of information to be shared amongst individuals as well as between companies (Feldman, 2002). In order to analyze how the information exchange process between supply chain partners like a port authority and captains or agents works, the supply chain and management thereof must be defined, after establishing these definitions the relationship between information sharing and supply chain success can be analyzed from the perspective of a port authority.

2.3.1. Defining the supply chain and supply chain management

The field of Supply Chain Management has devoted entire pieces of literature to finding a definition of a supply chain (Beamon, 1998, Mentzer et al., 2001, Ayers, 2006). Establishing a definition of supply chains is important as this allows for the establishment of a full picture of all parties involved in information exchanges in a supply chain, and then allows for the placement of ports and port authorities within these supply chains. Reviewing previous literature on defining supply chains the definition by Ayers (2001) is deemed most applicable in the context of this thesis as it contains all the components that have the objective to satisfy end consumer needs, including the transportation chains containing ports. This definition defines supply chains as a "life cycle processes involving physical goods, information, and financial flows whose objective is to satisfy end consumer requisites with goods and services from diverse, connected suppliers". This definition allows for the mitigation of a common pitfall in supply chain analysis, where only the physical part in the eyes of consumers or companies is considered (Carter et al., 2015). Supply chains can generally be split into two parts, a physical and non-physical supply part. In the physical part products are physically handled where in the non-physical support part no movement of physical goods occurs in the eyes of the person analyzing the chain (Bardy and Langley, 2003 and Carter et al., 2015). Organizations that are usually considered part of the non-physical support part of a chain are financial institutions that handle the finances of a transaction or transporters that handle the movement of goods as a result of that transaction between parties in the supply chain (Carter et al., 2015), placing maritime transportation companies, and by extension ports, in this often unobserved part of the supply chain.

The management of supply chains through effective Supply Chain Management (SCM) is required. It is said that in today's day and age we live in a "supply chain society" where virtually every product comes to us through supply chains transcending national borders, and as a result managing those supply chains has become an increasingly important business function (Özer & Zheng, 2017). SCM is a business function entailing the coordination of product as well as information flows among suppliers, manufacturers, distributors, retailers and customers (Zhao et al., 2002). The coordination of supply chains, by coordinating actions of actors within it to achieve better performance, is driven by the exchange of information between those actors (Zuidwijk, 2018). These findings imply that in attempting to become a more effective supply chain partner port authorities must make sure they are considered by companies of which they are a secondary supply chain partner to allow their information services to be considered in the SCM process of the companies involved.

2.3.2. Placing ports within supply chains

Ports are an integral part of the global economy, they function as links between different economic areas, and are a natural phenomenon in a world where trading resources is essential (Polanyi, 1963). The first ports in today's form were developed during the classical Greek era as a result of increasing levels of trade between different geographical areas (Rhodes, 2011) and formed centers of trade that had facilities for ships to unload their cargo, warehouses, administrative buildings and lodging for mariners (Polanyi, 1963). These ports developed into many of the port cities we know today through processes of urbanization and development (Polanyi, 1963). Ever since the development of the modern port there has been competition between ports, where the competitive position of a port is mainly determined by its geographical location (Margariti, 2008 and Nijdam & Van der Horst, 2018). Ports can improve their competitive position by investing in factors involving connectivity and efficiency, which involves sharing information with supply chain partners (Tseng & Liao, 2012 and De Langen, 2007).

Notteboom and Rodrigue (2007) attempt to conceptualize the position that a port inhabits in the transportation part of a supply chain using a layered approach. The top layer, the logistical layer, includes the management of transporting goods from a to b. The second layer is the transport layer, concerning the actual operation of the transport as is demanded by the logistical layer. The transport layer in turn relies on the existence of the infrastructural layer underneath, which concerns the existence of capital investments in facilities that make transporting goods possible in the first place (this is the location ports inhabit). This infrastructural layer then also relies on the locational layer, which determines whether capital investment is profitable in that location as a result of that location's proximity to centers of economic activity (determining the location of ports). In figure 2.2 the relationship between layers in a transportation supply chain and the factors enabling their existence following Notteboom and Rodrigue's (2007) conceptualization is included.

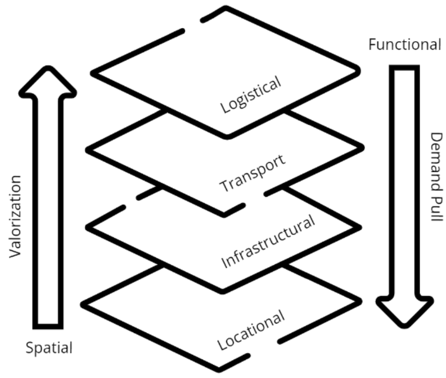


Figure 2.1: Adapted from Notteboom and Rodrigue's (2007) multi-layer approach to port dynamics

2.3.3. Sharing information within a supply chain

As described in the previous section, sharing information is an important part of SCM tasks which has been aided by the rapid advancement of information and communication technologies (Ha & Tang, 2017). These methods have sparked integrations along supply chains (e.g., make-to-order and just-in-time methodologies) making effective information sharing required to operate successfully (Ha & Tang, 2017). Supply chain cooperation through effective information sharing is generally aimed at avoiding the over-stocking (or 'bullwhip'/'whiplash') effect resulting from downstream demand variability being lower than upstream order variability which also leads to peaks and troughs in the demand for maritime transportation (Lee et al., 1997). Ryu (2006) examines the impact on total supply chain profits when a move from a system where orders from a downstream customer to an upstream supplier is the only information shared to a 'Collaborative Planning, Forecasting, and Replenishment' (CPFR) scheme, where downstream buyer and upstream supplier make joint decisions on production and ordering quantities, sharing knowledge on demand and predictions, is made. This impact is measured in different types of supply chains where it is found that on average total supply chain profits increase by 70%, with the downstream buyer's profit increasing by 58,9% and the upstream supplier's profit increasing by 61,4% (Ryu, 2006). These findings are consistent with other literature concerning the level of information sharing in a supply chain and the profitability of that supply chain (McCarthy & Golicic, 2002, Kurtuluş et al., 2012) resulting in the conclusion that not applying optimal information sharing strategies can be costly in a supply chain, and that all parties in a supply chain, including ports, should cooperate in information sharing efforts to optimize total supply chain performance.

2.4. Preconditions to sharing information

The act of sharing information is natural in human behavior (Wang and Chan, 2011) as it allows humans to connect, communicate and learn from one another (Schubert, 2001). As discussed in the previous section, it is essential for companies to share information along a supply chain. In information exchanges between persons as well as between companies, certain preconditions must be met for that information exchange to be effective. Understanding these preconditions and realizing the obstructions to sharing information can help in the implementation of any information sharing process and can help guide an organization to reach the desired outcomes of those processes. Companies sharing information might fear that that information will be used in an unintended manner by the other party. An example of shared information being used in such a manner is where online retailers like Amazon utilize sales data of sellers on their platform to decide in which product categories they should vertically integrate next (Zhu & Liu, 2018). In an informational relationship a certain level of trust must be established between the parties involved for the information sharing effort to be effective (Özer & Zheng, 2017).

A level of trust between parties can be established naturally, in the following situations:

- If the potential losses as a result of misuse of a particular piece of information is low (Özer & Zheng, 2017);
- If prior successful information sharing has occurred (Özer & Zheng, 2017 and Shamir and Shin, 2017);
- If the goal of sharing that piece of information is clear (Özer & Zheng, 2017);
- If there is limited asymmetric dependence between the parties involved (Brinkhoff et al., 2014);
- When a shared goal (like increasing profits) is achieved through sharing the information (Shamir and Shin, 2017);
- If information is more publicly shared making strategic information sharing more difficult (Shamir and Shin, 2017.

Even if, through the presence of the situations mentioned above, an inherent level of trust exists between parties involved in an informational exchange, the threat of opportunistic behavior still exists. In informational relationships the profitability of the whole supply chain increases if more information is shared. However, an individual link in the supply chain might have an incentive not to share information or manipulate the information that is shared in order to increase their own profits while decreasing the total supply chain profit (Shamir & Shin, 2017 and Oh & Özer, 2013). The existence of this dynamic might lead parties to doubt how genuine information shared with them is. These threats to the effective usage of shared information can be mitigated by showing a high level of commitment to the information that is shared by for example investing in advertising campaigns when high sales forecasts are shared, showing commitment to the validity of that information, and displaying that the sharing party is willing to take (financial) risks based on the information they share as well (Zhao, Xie and Zhang, 2002). In practice, participant 2 indicates that he would only act based on the information provided regarding tidal predictions if that information was the same information that is used by the port authority and pilots, indicating that this participant wants the port authority to commit themselves to the information by running their own operations on the information that is shared. The level of commitment to information that is shared is however also linked to the level of trust that exists between the parties involved in the information exchange (Brinkhoff et al., 2014). This means that in order to effectively share information between two companies, first a certain level of trust must be established, after which the party sharing information should show a high level of commitment to information that they share to signal the reliability of that information.

2.5. Goals of sharing information in a port

Now that it is established that information sharing is essential in the success of a supply chain and that, for information sharing efforts to prove effective, certain preconditions must be met, it is interesting to see how information is shared in the case of ports specifically as well as establish the role that port authorities play in information sharing efforts in ports. Increased rates of information sharing within ports, especially through digital means, could lead to improvements in processing and treatment of data by all players in the transportation part of a supply chain which in turn reduces costs (IMO NAV 55, 2009, Panayides & Song, 2009 and Murphy, 1998). Port authorities are stepping beyond their traditional role (Lugt, Langen & Hagdorn, 2015) by placing themselves center-stage in the development of integrated information systems called "port community systems" and "single windows" (UN, 2005, UNC TFBE, 2005 and van Baalen, Zuidwijk & van Nunen, 2008). Some port authorities, like those in Hamburg and Rotterdam, are already putting these concepts in practice by developing systems that integrate all the necessary information in a port call process in a single system (Heilig & Voß, 2016 and participant 3). In order to analyze the effectiveness of these steps taken by port authorities, first an analysis on what information is needed in port operations is made in this chapter, then the goals of sharing those pieces of information will be discussed as those have an impact on the way in which shared information is used.

2.5.1. Types of information shared in a port environment

As previously mentioned, ships entering ports require certain pieces of information in order to operate at all. As the focus of a port authority is to facilitate safe passage to ships (Geerlings, Kuipers & Zuidwijk, 2018 and participant 10) the information that they provide is mainly aimed at achieving that goal. Nautical information can however also be used to increase efficiency and reduce emissions, as will be laid out in this section.

Describing the general process involved with maritime transportation, Rodrigue and Browne (2008) find that a product first leaves the place where it originated from and is then most likely transported to a port using non-maritime or non-sea-going transportation methods. Once the cargo is in the port, a terminal lifts the freight onto a ship, which then transports that cargo to one or multiple other ports. At the destination another terminal then lifts the freight off the ship where it is then most likely transported to an inland destination using non-maritime or non-sea-going transportation methods.

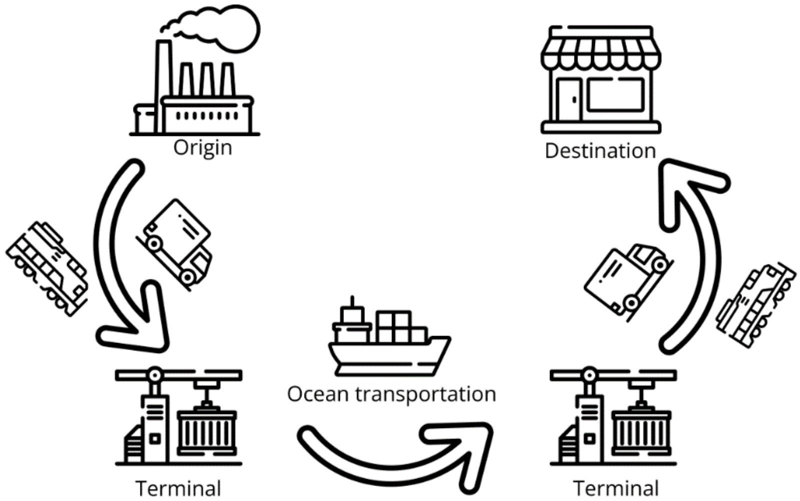


Figure 2.2: Representation of Rodrigue and Browne's (2008) generalized process description.

As this maritime transportation process is often omitted in supply chain analysis, being part of the "support supply chain", information sharing efforts between maritime supply chain partners and ultimate buyers or sellers could be lacking (Carter et al., 2015), requiring special attention on the part of supply chain managers. Proper information is vital, planning and operations are made practically impossible if it is not known in advance what type of cargo will be on board during the next trip. In ports, information sharing is equally necessary in order to operate at all. The information that is shared with supply chain partners within a port is inherently very diverse due to the nature of a port. A port is a location where water-based transport interacts with land-based transportation, and as a result of this both water- and land-based activities occur in a port (Alderton, 2017). This means that the information that must be shared throughout a port concerns different fields of business. For ports to operate and cargo to keep on flowing through, ships need to know if, when and how they can reach a dock at the harbor. Truck drivers, train drivers and barge shippers need to know what cargo they need to pick up, where that cargo is in the port, how they can get to that cargo and when that cargo will be at the port. Alderton (2017) expanded on the geographical definition of a port by stating that ports are "areas within which ships are loaded with and/or discharged of cargo and includes the usual places where ships wait for their turn or are ordered or obliged to wait for their turn no matter the distance from that area". Since the operations involved with loading and discharging vessels are generally not carried out by the port authority itself, a port inherently consists of many different information owners (Caschili & Meda, 2012). Examples of these information owners in ports include terminals, governmental agencies, and transportation companies (Geerlings, Kuipers & Zuidwijk, 2018) as well as nautical service providers like divers, pilotage firms, boatmen, etc. (Nijdam & van der Horst, 2018). The existence of many different information owners results in a domain issue regarding the responsibility of all these parties in sharing information with incoming vessels. Port authorities are uniquely positioned to take a central role in directing these information streams as they already interact with all the information owners in a port.

In order to help port authorities in fulfilling this role of directing the information provided to incoming vessels an overview of information required by ships to enter a port is required. In order to establish this information, the time-based definition of nautical information by the International Association of Ports and Harbors will be utilized. This definition states that nautical information regarding a certain port represents the information that is needed in a vessel's itinerary "from pilot boarding place up to the berth and vice-versa" (International Task Force Port Call Optimization, 2020).

The information that is required at each step of the process of docking in a port is analyzed using the operational description by Jansson and Shneerson (1982) as described in figure 2.3.

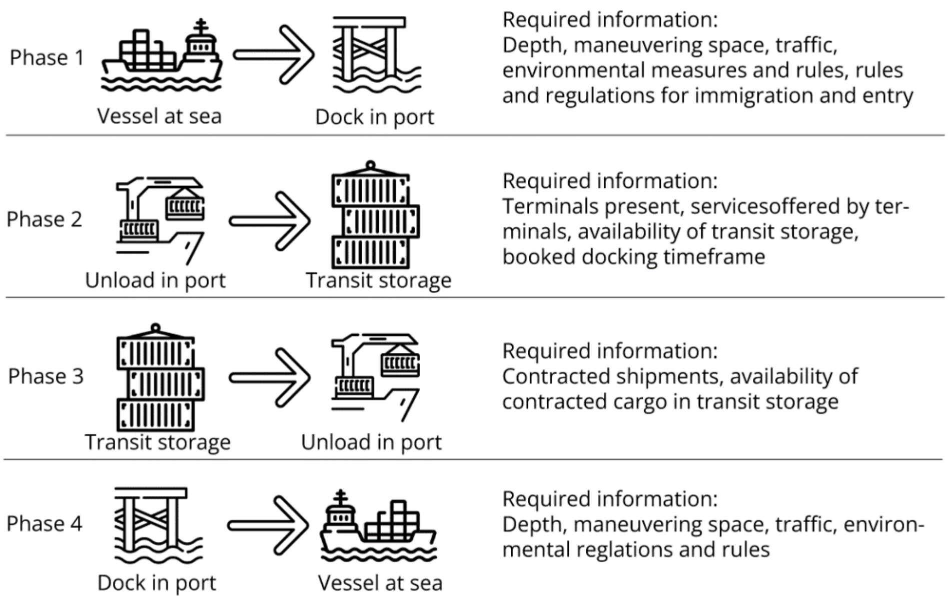


Figure 2.3: Jansson and Shneerson's (1982) description of operational processes involved in docking in a port.

In the first phase a shipping line will need to know whether a ship can enter a port based on factors such as its length, width, draught and maneuverability (Brennan, 2001), which should be provided by a port authority (Lugt, Langen & Hagdorn, 2015). In practice, this kind of information is also verified by the agent who represents the vessel, who in turn retrieves that information from a port authority (participant 2). In addition to physical factors, vessels need to know whether they will be allowed to dock in a certain country, and what restrictions, regulations and laws apply country-wide and locally (Baatz et al., 2018 and Helberg, 1994). In practice, most vessels again rely on their agents to retrieve this information and to verify whether they will be allowed to dock in a port (participant 3). In the second phase ship operators need to know whether transit storage is available at a terminal (Juhel, 1999). In order to allow for efficient operations ship operators need to book space ahead of time and exchange information with the terminal (Brennan, 2001).

This communication again often happens through the agent (participants 11 and 13), the timing of which greatly depends on the type of load that a vessel carries, where container and cruise ships are scheduled relatively long ahead of time contrasted by liquid and bulk carriers who are often scheduled at the last minute (participants 2, 3, 12 and 15). In the third phase vessels need to be re-loaded with cargo, for this to happen the shipping line must be contracted to transport certain goods to a certain destination while that cargo must have been stored into transit storage in the terminal ahead of being loaded on the ship. Without information streams in both directions, coordination of these cargoes would be impossible. In the last phase the vessel once again leaves the port and heads out to sea. For this to occur a ship needs similar information from a port authority to when the vessel enters port, like data on depth, tides, wind and traffic (participant 10). Appendix a.2.5 contains the pieces of information that a port authority should minimally publish according to the port information manual established by Industry Partners et al. (2021). From this overview, and the short analysis of general port operations above, it can be concluded that some of this information concerns relatively stationary data points whereas other information is more dynamic and can only be shared shortly before arrival of the vessel. These more dynamic pieces of information are the types of information that an agent is mainly concerned with, and in many instances is tasked with managing this information on behalf of the vessel (participant 3).

Dynamic information in ports is usually shared with bridge crews through the pilot assisting in bringing that vessel shoreside (Wild, 2010). This is because many agencies do not proactively share information, rather information is shared when it is requested by a vessel (participant 15). This dependency on the pilot leads to a "pilotage paradigm" where there is too much reliance on the knowledge of the pilot where a captain should always bear full responsibility for his or her ship (Drouin & Heath, 2009, Owen, Béguin and Wackers, 2009 and participant 10). In order to mitigate the risks that this "pilotage paradigm" poses, port authorities should share their dynamic information using other means as well, allowing bridge crews to be better prepared when entering a port.

2.5.2. Sharing dynamic information in a port

The dynamic information that a port could share is, as mentioned in the introduction, divided into three sections: traffic related dynamic information, wind and weather-related dynamic information and depth, tides and currents related dynamic information. The goals of sharing each of these types of information will be discussed in this section.

2.5.2.1. Traffic related dynamic information

Information concerning the levels of traffic and movements of traffic in a port should be shared to allow for the safe passage of vessels in a port and mitigate the risks of congestion. This type of information is often shared by the Vessel Traffic Service in a port (International Maritime Organization, 1998B), generally operated by a port authority (as in the case port of Rotterdam (participant 15)) as one of the most important information systems in a port area (Lee, Kim & Lee, 2015 and Heilig & Voß, 2016). Information regarding traffic is gathered by VTS operators using radar systems, radio communication, and traffic signals, all which vessels can also access. The VTS operators also have access to video surveillance and AIS information including speed, draft and destination (Lin & Huang, 2006), as well as predictions on future traffic based on the vessels that agents have signed on for the coming 24 to 72 hours (participant 2 & 15) in the case port of Rotterdam, allowing them to form a more complete picture of movements in the port. Sharing traffic related information such as a vessel's ETA can lead to mutual benefits where port authorities and terminal operators can plan for the arrival of vessels ahead of time to avoid wait time outside of the port (Parolas, 2016). Sharing ETA predictions is already common practice in most ports (participant 2) and these ETA predictions are dynamically updated in the case of the port of Rotterdam as the ETA draws closer (participants 3 & 5). The efficiency of port operations can be increased when all involved parties plan based on the levels of traffic expected in a port (Heilig & Voß, 2016 and Wang, 2014). This mutual benefit to vessels and ports in sharing traffic related information holds especially true for ports that must deal with tides, locks and bridges, such as the case port of Rotterdam (Thiers & Janssens, 1998, Smith et al., 2009 and participant 1). Sharing information that is focused at reducing port congestion can be worthwhile as congestion can be very costly and forms a major part of the costs incurred in a maritime logistics chain (De Borger, Proost & Van Dender, 2008 and participant 13). In order to avoid the delay effect of congestion, vessels could slow down, speed up or anchor (Jiménez, Gómez-Fuster & Pavón-Mariño, 2021), where avoiding anchoring leads to improvements in profitability and reduces emissions (Jiménez, Gómez-Fuster & Pavón-Mariño, 2021, Notteboom & Cariou, 2013 and participant 13).

2.5.2.2. Wind and weather-related dynamic information

Ports have a specific geographical footprint leading to difficulties in accurately predicting weather, where weather is one of the major factors hampering port operations (Athanasatos, Michaelides & Papadakis, 2014). Wind is an especially important factor in ports as they are generally large areas close to the sea that often show different local wind speeds compared to more general prediction models (participant 14). Ships harboring in a port can be put at risk of accidents from high wind velocities whether they are docked or not (Solari et al., 2012, Valet, Piskoty, Michel, Affolter & Beer, 2013 and participant 14). Long term wind predictions are generally not shared by port authorities as this information is often only shared through VTS operators in the hours before entering a port with the clear aim of avoiding dangerous situations from occurring in the port (participants 1 and 15). Sharing wind and weather information with a vessel allows that vessel to integrate the information in their arrival planning (Lang & Veenstra, 2009 and participant 7), speeding up or slowing down to avoid weather windows endangering the ship or hampering loading/unloading operations. Participant 3 indicates that agents generally do not share information regarding wind and weather with vessels and rely on pilots and VTS to do so.

2.5.2.3. Depth, tidal and currents related dynamic information

Vessels entering a port need to know whether the port is accessible for their specific vessel, where the accessibility hinges on whether the vessel's draft (the distance between the waterline and bottom of the hull (Le Carrer, Ferson & Green, 2020)) is shallow enough and whether the vessel is maneuverable enough to deal with currents (Industry Partners et al., 2021). Vessels in a port usually need to abide by the Under-Keel Clearance (UKC) policy that a port authority makes, stating how much water needs to be under the bottom of a vessel (Le Carrer, Ferson & Green, 2020). Many shipping lines and captains also have their own UKC policy that might deviate from the one of the ports (Patraiko, 2021 and participant 8). Currents can impact the maneuverability of a vessel and lead to delays (participant 15) and are especially impactful in ports dealing with large differences between high and low tide, like the case port of Rotterdam. Many factors impact the tide like gravitational attraction, geographical features, winds and discharge levels of rivers (Hicks & Szabados, 2006, Sannasiraj et al., 2004 and Godin, 1985). These factors make accurately predicting tides difficult, but predictions with an accuracy of a few centimeters can be produced up to 7 days ahead of time (Sannasiraj, Zhang, Babovic & Chan, 2004). Sharing depth, tidal and current predictions allow for increases in safety as vessels can avoid dangerous situations in which groundings and drifts resulting from tidal streams can occur (participants 1, 2, 10 and 11). Vessels might speed up or slow down to avoid having to wait for tidal levels restricting their port access (Notteboom, 2006 IMO, 2012) as well as increase or decrease their level of loading to operate at the highest possible level of efficiency within the boundaries set by the tide and current. In practice loading ships with more cargo if the tide is predicted to be high is difficult as the planning for loading is generally made by the charterer (participant 11) or ship owner (participant 1), far ahead of time. This factor negatively impacts the load of vessels when they are headed to port areas where a lower maximal draft is allowed (participant 4). Avoiding wait times for tidal windows as well as increasing a vessel's load could lead to significant reductions in the emission of harmful pollutants (Di Natale & Carotenuto, 2015 and Song, 2014). The impact that avoiding wait times can have on reducing the emissions of harmful pollutants is already acknowledged by crews (participant 13).

2.6. Effectiveness of information distribution methods

As was established in the analysis on sharing dynamic information in ports in the previous section, information can be shared by a port authority through a VTS, who distributes information using a verbal methodology and a VHF radio system. There are obvious other ways in which a port authority could disseminate information: through written and visual methodologies as well as through non-verbal communication. The non-verbal method is the only method that requires physical presence of all parties involved, and thus is not a feasible method of disseminating information in the context of a port authority. Captains generally only communicate in a non-verbal method with a provider of information when a pilot comes aboard (participant 10).

2.6.1. The effectiveness of distribution method depends on the information type

The effectiveness of sharing information using any of the other methods depends on the type of information that is shared. Previous research establishes that the following types of information are best shared using a verbal methodology (e.g., through a VTS operator or through telephone contact):

- Time sensitive information requiring immediate action, as this allows the sender to express the time sensitiveness of the information directly (Level, 1972).
- When a deep understanding of a complex topic, especially one that is new to the recipient, is needed, avoiding oversimplification of information when it is transformed into text (Wu et al., 2014).

Meanwhile previous literature finds that the following types of information are best shared using a written methodology (e.g., through an email, blogpost, pdf-file, etc.):

- Information involving fewer complex topics where in-depth understanding is not required, but memorization is more important (Waern, 1981).

Lastly, previous literature finds that presenting information in a visual form (e.g., using graphs, images, visualizations, etc.) is most effective when:

- The quick comprehension of information is required, as humans can establish the meaning of information shared in a visual manner more quickly than through textual means (Potter, Wyble, Hagmann and McCourt, 2013).

2.6.2. The effect of distribution method on recipient behavior

A large body of research has been established in the field of consumer choices that are based on different methods of information sharing. As a result of the wishes from the case port of Rotterdam to expand their information offering through digital means (rather than through services offered by phone or VTS operators) literature concerning experiments in the online retail space where experimentation is made easy through technical means is considered relevant. Including a visual representation of information on top of textual descriptions generally increases sales (Blanco, Sarasa and Sanclement, 2010). This research by Blanco, Sarasa and Sanclemente (2010) also shows that presenting information in a schematic form increases recallability and increases the speed at which the information can be analyzed.

These generic findings are moderated by the fact that the effect that a method of distribution has on the behavior of the recipient is moderated by the complexity of the shared information in the eyes of the recipient. Complex information inherently requires more analysis on the part of the recipient. Complex information is best remembered when it is shared using textual means (Blanco, Sarasa and Sanclemente, 2010). When the complexity of the subject of the information decreases, a more visual method of distribution increases the recallability (Govers and Go, 2005). This relationship is not linear however, as Govers and Go (2005) find that the effectiveness of a visual method decreases when complexity of information reduces below a moderate level. In many cases a more hybrid form, like schematically displaying textual information, improves the behavior of recipients by increasing the perceived quality of that information as well as increasing the level of recallability of the information (Blanco, Sarasa and Sanclemente, 2010). In attempting to explain the relationship between type of information and the most effective method of sharing that information, contradicting findings are found. Studies on reading comprehension of high school students have found that the inclusion of graphical representations of information increases their scoring on reading comprehension assessments (Paschall, 2014 and Cook, 2015). On the other hand, a study into the reading comprehension of elementary school students has found that the addition of visual information does not aid in comprehension (Norman, 2011). These contradictory findings might be explained by the finding of Hibbing & Rankin-Erickson (2003) establishing that middle school students who have issues forming mental pictures as a result of textual information extract more knowledge from visualizations than students who do not have these issues. These findings thus indicate that the extent to which visual representations of the information is useful depends not only on the type of information but also on the recipient of that information and their level of comprehension of that information. This finding indicates that the level of complexity of information might be partly subjective as recipients with a higher level of comprehension of a specific kind of information might also think the complexity of that information is lower than a recipient with a lower level of comprehension of the same information.

2.6.3. Effectiveness of distribution methodologies from a theoretical perspective

The contradictions that are found in the previous section can be explained further when they are analyzed from a theoretical perspective, established in previous literature on the theories of dual coding, schema and cognitive load. Understanding the ways in which information recipients handle information shared using different methodologies from a theoretical perspective aid in making better informed decisions on the methodology of sharing information on the part of a port authority.

The first theory analyzed concerns the dual coding theory, which holds that the formation of mental images aid in learning and understanding information. Verbal/textual and visual parts are processed along distinct channels in the human brain, meaning that both the verbal/textual and visual parts can be used to recall the information (Sternberg & Sternberg, 2012). In the context of previous research on the likelihood of making a purchase based on the information shared it is found that adding visual information increases this likelihood due to the increased recallability as a result of dual coding in the mind of the information recipient (Blaco, Sarasa and Sanclemente, 2010). In the context of this thesis' this theory implies that visual information should always be added on top of textual or verbal methods of information sharing.

The second of the theories analyzed is concerned with mental schemas that describe patterns of thought and/or behavior that organize information and the relationships between different pieces of information (DiMaggio, 1997). People are more likely to notice things that fit into their schema while contradictions to their schema are more quickly seen as exceptions or distorted to make them fit (Kite & Whitley Jr., 2016). As a result of this finding, combined with the fact that the human brain handles visual cues more quickly than textual ones (Potter, Wyble, Hagmann and McCourt, 2013), this theory implies that information on topics familiar to the information recipient should be shared using visual means, while information that more novel should not be shared using a visual methodology (Graziano & Webb, 2015).

The last theory on how different methodologies in information sharing are handled by recipients concerns the cognitive load theory which concerns the mental effort that a person must enact when he or she is absorbing information (Sweller, Ayres & Kalyuga, 2011). Humans can only process a limited amount of information at one time, meaning that parties sharing information must be careful to avoid overloading the recipient (Paas, Renkl & Sweller, 2003). When information consists of both visual and textual cues the cognitive load increases, meaning that redundancy between the two methodologies should be avoided (Sweller & Chandler, 1991).

Combining these theories, a framework as included in figure 2.4 can be made. The dual coding theory introduces the finding that adding visual cues to information can increase recallability of that information. The cognitive load theory moderates this finding by introducing the finding that sharing redundant information through multiple methodologies needlessly increases cognitive loads in recipients, implying that information should be shared using only a single methodology. These findings are then guided by the schema theory which describes the best methodology for sharing information based on the level of novelty in the eyes of the information recipient.

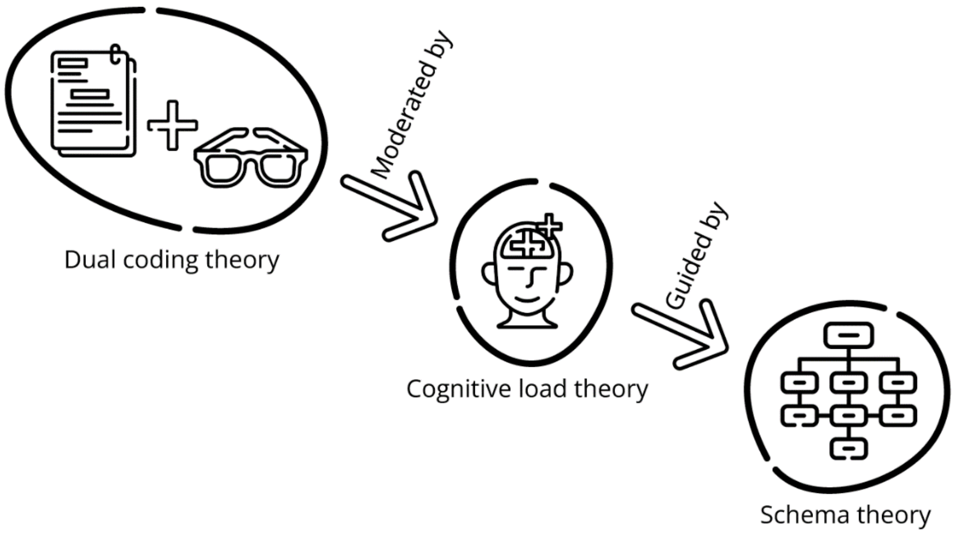


Figure 2.4: Representation of the interaction between the dual coding, cognitive load and schema theories.

3. Research methodology

From the theoretical and practical review a clear understanding of the role of information within a port is established, allowing for a full understanding of the important facets in answering the main research question: ***"How does increasing the amount of information services offered by a port authority affect the operations of captains and agents in a port?"***. As presented in the introduction, three different hypotheses should be tested to cover the variables that intervene in the effectiveness of the information services of a port. The variables and hypothesis involved are:

1. The goal of sharing certain pieces of information, leading to **hypothesis 1:** ***"Information aimed at reducing port congestion and/or increasing port safety is immediately reflected in captain's and agent's operations"***
2. The method of sharing information, leading to **hypothesis 2:** ***"Information of average complexity and low levels of novelty is most effective when shared through visual means"***
3. The relationship between the parties involved in information sharing, leading to **hypothesis 3:** ***"The level of trust that is attributed to a port authority positively affects the effectiveness of the shared information"***

To test these hypotheses a research methodology must be developed. This methodology must allow for testing how captains and agents, as the identified key stakeholders, respond to new pieces of information shared by a port authority. These responses must be measured based on variables that allow for proving or disproving the hypotheses. A survey methodology including simulations was chosen as the most appropriate methodology in testing these hypotheses.

3.1. Developing a survey with simulations

The main reason to use a survey as this thesis' research methodology is that it allows for setting up an environment in which the effect of providing certain pieces of information can be tested. A survey methodology allows for the simulation of the availability of certain pieces of information while testing the reactions of participants to that information by posing questions. The second reason for using a survey methodology, and an online survey methodology especially, is that it allows for the easier sampling of a larger part of the population compared to the interview methodology, leading to a higher level of generalization of the findings.

3.1.1. Mitigating the downsides of using an (online) survey methodology

Like any other research methodology, using an online survey also has downsides. To use the survey methodology effectively and accurately as a research method it is necessary to identify these downsides and try to mitigate any negative effects that these might have on the accuracy of the research.

The lack of physical contact between the respondent and the researcher is a downside as this means the respondent cannot be directly probed (Dalati, Gomez & Mouselli, 2018), which is mitigated by designing the survey in such a way that previous answers influence subsequent questions. This allows for attaining additional information that would otherwise be gathered through probing respondents in a physical interview setting. Another disadvantage of the distance between researcher and respondent in online surveys is that this generally leads to less elaborate responses (Donsbach & Traugott, 2008), which is mitigated by limiting the number of open questions in the survey by giving respondents the option to answer in a multiple-choice format using pre-phrased answers or phrasing the answer themselves using an "other" option. The physical distance between the researcher and participant also leads to an inability for the researcher to answer questions that the respondent might have (Dalati, Gomez & Mouselli, 2018). This downside is mitigated by phrasing questions as clearly as possible to avoid questions arising in the first place, as well as offering remote help to respondents.

Online surveys might lead to data-losses, where a respondent does not answer (all) of the questions posed to them (Dalati, Gomez & Mouselli, 2018). This downside of online surveys is mitigated by using software to store survey responses that are not fully completed as well. These partial responses are linked to identifying datapoints like the IP address of the respondent so that multiple partial responses from the same respondent are not recorded separately. The final disadvantage of online surveys compared to conducting offline surveys or interviews is that all respondents must have access to the internet and a computer to fill out the survey (Ritter & Sue, 2007). According to research by Nautilis, a large union of seafarers, most sea-going ships nowadays are connected to the internet (88%, (An investigation into connectivity at sea, 2016)), leading to the assumption that most captains would be able to participate. In order to further avoid the limited speed of internet on board to negatively impact survey response rates the survey is formatted to be as small as possible.

3.1.2. The survey design process

In designing the survey used in this thesis' research, the steps that are laid out in a guideline on how to develop effective self-administered surveys by Bourque & Fielder (2002) is used. Appendix a.9.1 includes a description of the most important characteristics of survey using Bourque & Fielder's (2002) specifications. Bourque & Fielder's (2002) guideline was followed in order to maximize the number of responses that the survey gathers as well as maximizing the reliability and validity of these responses.

Bourque & Fielder (2002) present their guidelines as a process involving multiple steps. Following these steps, the process of developing a self-administered survey becomes a structured endeavor. In the first of these steps the advantages and disadvantages of using the self-administered survey research methodology are defined and a decision is made on whether it is the right methodology for the research in question, as was done in the previous section. Then the content the survey should contain is determined in a structured manner by covering all five different informational areas that an effective survey should cover according to

Bourque & Fielder (2002). Appendix a.3.2 contains an overview of how these different informational areas of demographics, environmental, behavioral, experiences and thoughts/feelings are covered by this survey. The survey is then tested by the academic supervisor assigned to this thesis as well as by relevant personnel at the port of Rotterdam to ensure user-friendliness.

After these steps the distribution method is defined and the text of the invitation to participate in the research is drafted. Following Kramer, Schmalenberg & Keller-Unger's (2009) findings, the relevance of this research for the day-to-day operations of participants is expressed in this invitation to maximize response rates. Next, the required sample characteristics are drafted to determine the minimally acceptable sample size in order to know when data collection can be stopped. This size was set at 50 as a result off the time-intensive nature of the survey. In order to produce a sample that is as large as possible, the resources of the case port of Rotterdam, in the form of contacts and industry associations, are used to distribute the survey as wide as possible. Next the follow-up methodology aimed at non-respondents is defined, where it is chosen to only follow-up, by sending a second email, with the database of captains holding a Pilot Exemption Certificate (PEC) in the port of Rotterdam since the other distribution methods did not allow for this easy method of following up or already had a relatively high response rate after the first invitation. The final survey was distributed to 5 different groups:

- agents and captains who participated in the research
- captains who are a member of the "Nederlandse Vereniging van Kapiteins ter Koopvaardij" (the Dutch Merchant Shipping Association) through their newsletter
- a database of captains holding a PEC in the port of Rotterdam
- all agents that participate in the ongoing efforts of the port authority to improve information services called "werkgroep melding schip" (workgroup ship sign-on).

In addition, all respondents are asked to provide email addresses of colleagues who might also be interested in filling out the survey. These colleagues are then automatically sent an invite to participate as well. Lastly the issue of storing data and coding results is solved by using the advanced Qualtrics platform for data collection and the R suite of statistical software for analysis.

3.2. Outline of the survey

The survey design that results from following the steps laid out in the previous section can be divided into six different sections. The table in figure 3.1, below, contains a short description of each of these sections of the survey while a more extensive description and example questions are included in appendix a.3.3. Appendix a.3.4 includes a flowchart representing all possible survey flows.

Section 1: introduction and general information In the first section the survey and its goals are introduced to survey participants. Participants are asked to indicate whether they are a captain or an agent, how many years of experience they have in that role,

how many port calls they make or represent in the port of Rotterdam on a yearly basis and, in the case of captains, whether he or she holds a PEC in the port of Rotterdam.

Section 2: quay availability simulations
The first simulation asks respondents to imagine that they are sailing on, or representing, a vessel headed for the port of Rotterdam carrying either containers or liquids, scheduled to arrive in 24 hours. Respondents are asked to react to information predicting that the quay at which they intend to dock will not be free at their expected time of arrival. A prediction of a time (later than their initial expected time of arrival) is provided at which the dock will likely be free and a 95% confidence interval around that time frame is included. Responding captains are asked whether they would adjust their operations based on this information and whether they would verify this information. Responding agents are asked whether they would inform the vessel of this information and whether they would verify this information. Based on the initial answers to these questions captains are then asked to indicate, using a simulation, how they would alter their speed and reason the size of the alteration. Agents are asked whether they would share the information with the vessel as-is or whether they would advise a course of action. Captains and agents that indicate they would verify the information are also asked who they would verify the information with.

Section 3: tidal simulations
The second simulation asks respondents to again imagine that they are sailing on, or representing, a vessel headed towards the port of Rotterdam where the case (vessel, speed, distance, etc.) is different from the previous simulation but the ship is also scheduled to arrive in the port in 24 hours. Respondents are then asked to react to information informing them of a tidal prediction that would not leave enough Under Keel Clearance (UKC) at the expected time of arrival at their berth in port. The vessel can either speed up to arrive within the early tidal window or slow down to arrive in the later tidal window. Responding agents and captains are then asked to answer the same questions as in the first simulation.

Section 4: wind speed simulations
The last simulation asks respondents to again imagine that they are sailing on, or representing, a vessel sailing towards the port of Rotterdam with different case characteristics, while the vessel is again on track to arrive in the port in 24 hours. Respondents are this time asked to react to information informing them of high wind predictions at their estimated time of arrival. Along with these high wind predictions the wind limits for the operation of their vessel in port are shared, indicating that those limits will be exceeded at the time of their arrival. The vessel can then again either speed up to arrive prior to that window of high wind speeds or slow down to arrive after that window has passed. Responding agents and captains are then asked to answer the same questions based on this case as they answered in the previous two sections of the survey.

Section 5: the usability of information
In this section respondents are asked to rank the usability of the three simulated pieces of information in their day-to-day work. Respondents are also asked how long ahead of the arrival of the vessel to the Pilot Boarding Place they would like to receive these simulated pieces of information for these to be useful to their operations. Lastly this section also allows respondents to indicate if there are any other areas of nautical information services that they believe the port of Rotterdam is currently lacking in.

Section 6: peer referral
A peer referral mechanism is built into the survey, automatically sending an invitation email to any email addresses that are entered here as shown in appendix a.3.3.13.

Figure 3.1: final survey structure

4. Results

In this chapter the survey responses are analyzed. This chapter will start off by introducing descriptive statistics regarding the number of responses and the characteristics of the respondents. Then the different reactions to each of the three simulations will be analyzed and the opinions of respondents with regards to these simulations will be introduced. The questions that are specifically formulated to gain insight into the gaps in information services offered by the case Port of Rotterdam will not be discussed in this chapter as these questions are not useful in the context of this thesis. An analysis of these questions is included in a more practical report written for the Port of Rotterdam specifically.

4.1. Descriptive statistics

A total of 201 responses have been recorded in the period that the survey was opened to respondents, between July 26 and September 26, 2021. The survey targets two different groups of respondents, captains and agents, where captains account for most responses. 178 respondents are captains, compared to 23 respondents who are agents (88.6% and 11.4% respectively). The average completion time of the survey was higher than expected (75 minutes), this average is however driven up by a couple of outliers which are probably caused by surveys that were completed on a different date than at which it was started. Using a Rosner's test (Rosner, 1983) to detect multiple outliers, the 18 highest values (those above 76 minutes) are omitted, resulting in an average completion time of 15.2 minutes. A relatively large number of respondents did not fully complete the survey, which might result from the repetitive nature of the survey design or the relatively high level of effort that answering each question requires. As a result of the survey design and technical choices described in chapter 3 these incomplete responses can also be analyzed as will be elaborated upon in the introduction to section 4.2. An overview of the amount of survey responses by different respondents has been provided in figure 4.1.

Description	Statistic	Description	Statistic
Number of survey responses	201	Number of 100% completed survey responses	73
Number of survey responses by captains	178	Number of 100% complete survey responses by captains	61
Number of survey responses by agents	23	Number of 100% complete survey responses by agents	12

Figure 4.1: overview of the amount of survey responses by different respondents

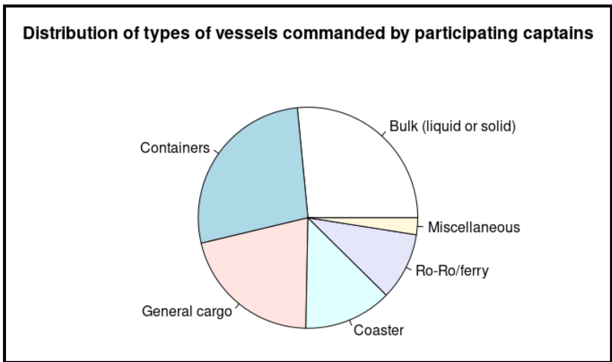
When the responses are split between those being filled out by captains and agents respectively the descriptive statistics of each of these groups can be analyzed, the results of which are presented in figure 4.2, below.

Description	Statistic	Description	Statistic
Captains			
Average yearly calls in Rotterdam	24.08	Average years being a captain	13.95 years
Percentage PEC holders	76.67%	Percentage "other" captains	52.87%
Percentage container captains	19.54%	100% completion rate	34.48%

Percentage bulk/liquid captains	20.69%		
Agents			
Average yearly calls in Rotterdam	64.33	**Average years being an agent**	17.09 years
Percentage mainly representing container vessels	26.08%	**Percentage mainly representing "other" vessels**	34.78%
Percentage mainly representing bulk/liquid captains	30.43%	**100% completion rate**	52.17%

Figure 4.2: descriptive statistics of the two different groups of respondents, captains, and agents

From figure 4.2 it can be deduced that the average respondent is experienced at their job, with the average number of years employed as a captain or as an agent being high (13.95 and 17.09 years respectively). It can also be seen that there is a high percentage of Pilot Exemption Certificate (PEC) holders in the sample consisting of captains. This can be attributed to the method of distribution of the survey as described in chapter 3, the largest database of email addresses used is the database of PEC holders in the Port of Rotterdam. This high percentage could skew the results of the survey towards the opinions of this group, and their prevalence in the sample should be considered when results are analyzed. In figure 4.2 the type of vessel that the respondent commands (as a captain) or represents (as an agent) is included. A high percentage of respondents did not identify themselves with either the container or the bulk/liquid categories. Looking at the responses in the "other" category it is found that this is the result of respondents believing the two categories to be too narrow as their responses include "General cargo", "Coaster" and "Ro-Ro ferry". Figure 4.3 presents the distribution of respondents between the different types of vessels they command or represent including the types that were entered in the "other" category.



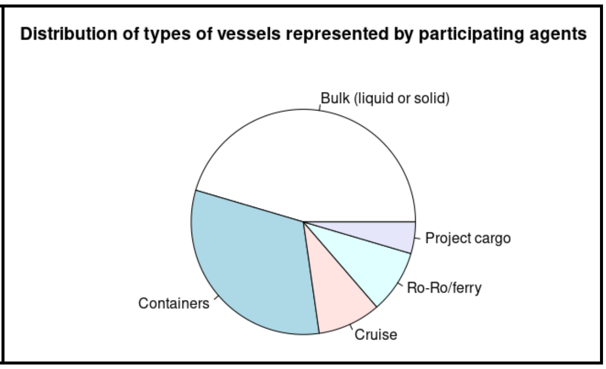


Figure 4.3: distribution of respondents between different types of vessels commanded or represented

4.2. Analysis of results

This section will introduce an analysis of the data generated by the responses to the survey. As mentioned in section 4.1, a relatively high percentage of surveys were not fully completed. As a result of the design choices made, the results from participants who partially completed the survey can also be used in the analysis of the full results. Before these partial responses are included in the analysis it is important to verify whether there are no significant differences between the samples of participants who did and did not complete the survey, as will be done in section 4.2.1. The responses are then analyzed according to the three different simulations in the survey introduced in chapter 1 (quay availability, tidal and wind speeds). Within these simulations, responses are analyzed according to the effectiveness of the information contingent on the delivery method, the effectiveness of the information based on the aim of sharing that information and on a metric representing the level of trust between the port authority and the information recipients.

4.2.1. Including incomplete survey responses

To include incomplete survey responses in further analysis, the samples of respondents who did and did not complete the survey should be compared. Figure 4.4 compares the descriptive statistics that were introduced in section 4.1 between respondents who have fully completed the survey and those who have not fully completed the survey.

Description	Statistic	Description	Statistic
Captains			
Fully completed (n=61)		**Not fully completed (n=117)**	
Average yearly calls in Rotterdam	24.08 calls	**Average yearly calls in Rotterdam**	22.55 calls
Average years being a captain	13.95 years	**Average years being a captain**	14.55 years
Percentage PEC holders	76.67%	**Percentage PEC holders**	78.44%
Percentage container captains	19.54%	**Percentage container captains**	9.40%
Percentage bulk/liquid captains	20.69%	**Percentage bulk/liquid captains**	23.07%
Percentage "other" captains	52.87%	**Percentage "other" captains**	67.53%
Agents			
Fully completed (n=12)		**Not fully completed (n=11)**	
Average yearly calls in Rotterdam	64.33 calls	**Average yearly calls in Rotterdam**	47.67 calls
Average years being an agent	17.09 years	**Average years being an agent**	13.44 years
Percentage mainly representing container vessels	26.08%	**Percentage mainly representing container vessels**	45.45%
Percentage mainly representing bulk/liquid captains	30.43%	**Percentage mainly representing bulk/liquid captains**	9.09%
Percentage mainly representing "other" vessels	34.78%	**Percentage mainly representing "other" vessels**	45.45%

Figure 4.4: Comparison of descriptive statistics between fully completed and not fully completed survey responses

From figure 4.4 no significant difference between captains who did not fully complete the survey and those that did is found, except for the slightly higher number of container captains who have completed the survey, this might be explained by the overrepresentation of PEC captains who mostly command small container vessels. There are however significant differences between the agents who did and those who did not completely fill out the survey. Agents who did complete the survey represent almost 17 port calls more on a yearly basis, as well as working 4 years longer than the average agent who did not complete the survey. The ratios of vessels these agents mainly represent also differs a large amount. These differences might be due to the relatively low sample sizes (12 and 11 of completed and not completed responses respectively). As a result of these differences the incomplete responses from agents will not be included in further analysis.

To incorporate the incomplete responses by captains in the analysis of the results these responses need to be categorized by what part of the survey a captain has completed. The structure of the survey is set up in such a way that it is possible to identify what part of the survey has been completed by categorizing incomplete responses by the last section completed. Using the survey structure, incomplete responses are categorized in one of six categories:

- Category 1: respondents who have not completed the first section of the survey, consisting of the introduction and general information sections,
- Category 2: respondents who have completed the first section but not the next section,
- Category 3: respondents who have completed the questions concerning the first (quay availability) simulation but not those concerning the second simulation,
- Category 4: respondents who have completed the questions that concern the second (tidal prediction) simulation but not those concerning the last simulation section,
- Category 5: respondents who have completed the questions concerning the last simulation (weather prediction) not the questions regarding usability of information,
- Category 6: respondents who have completed all the questions in the survey but have not passed the final section (concerning peer referrals).

The histogram in figure 4.5 summarizes the categorization of each of the 116 not fully completed surveys filled out by captains. It is found that most of the incomplete responses belong to category 3, meaning that most captains who did not complete the survey only filled out questions regarding the quay availability simulation, but did not fill out questions regarding the second or third simulations. Adding the incomplete responses to the complete responses adds an additional 68 respondents to the quay availability simulation, 22 respondents to the tidal prediction simulation and 5 respondents to the wind speed prediction simulation.

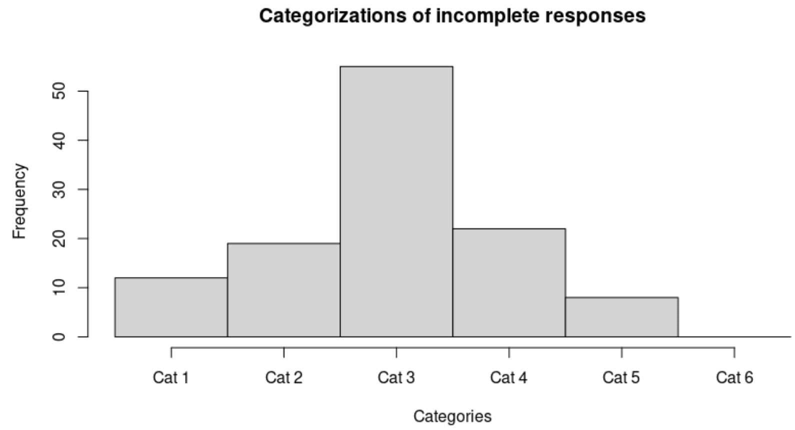


Figure 4.5: categorizations of not fully completed surveys filled out by captains

4.2.2. Simulation 1: quay availability simulations

The first simulation is the quay availability simulation where it is indicated that the quay the vessel is planning to dock at is predicted not to be free at the time of arrival. Captains and agents are then asked whether they would adjust their operations or inform the vessel respectively as well as whether they would verify this information. The effectiveness of this information based on the action a respondent intends to take is analyzed first. It will then be compared to these rates between the two delivery methods to analyze the impact of the delivery method on the effectiveness of the information. Next, the effectiveness of the information based on the actual actions that participants take when they are presented with this information will be analyzed. Finally, the level of trust between the port authority and the information recipient is analyzed based on the respondent's intention to verify the information and the party with which they intend to verify the information.

4.2.2.1. Effectiveness of sharing quay availability predictions contingent on the delivery method

Figure 4.6, below, contains a visualization of the responses to questions that presented participants with a simulated email containing a prediction regarding quay availability, indicating that the dock is predicted not to be free at their predicted ETA. It is found that most participants would verify the information as it is provided to them. It can also be seen that a slight majority (56%) of captains intend to adjust their operations based on this information. Most agents (66%) intend to inform the vessel. Figure 4.7, above, contains a comparison of the responses to these questions on the action a respondent intends to take and whether they would verify the information between the email distribution method (as presented in figure 4.6) and the web-app distribution method.

From figure 4.7 it is found that there is no large difference between the different distribution methods and the actions that captains intend to take. In the case of agents, there is a relatively large increase in the number of agents choosing not to verify the information, which is partly explained by the small number of observations in the "inform & no verification" category for agents in both distribution methods (1 to 3), as a result, no real conclusions can be drawn from this observation. In general, it is found that, in the case of the quay availability simulation, there is no discernible difference in the effectiveness of the information that is shared based on the indicated intent of participants when the distribution method is altered.

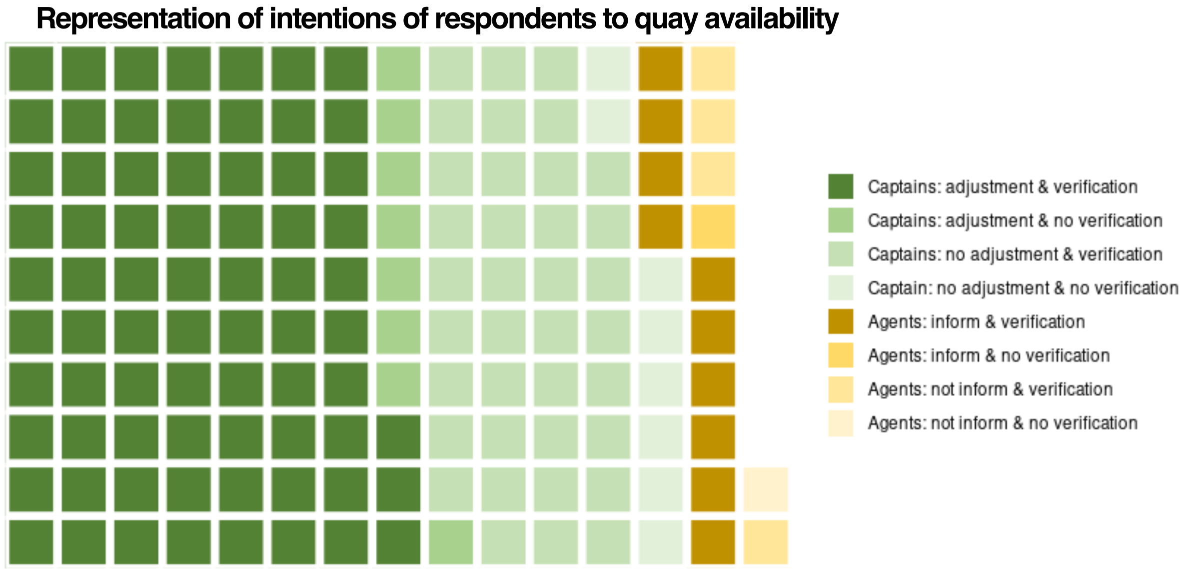


Figure 4.6: representation of responses to the first questions of the quay availability simulation involving the email distribution method

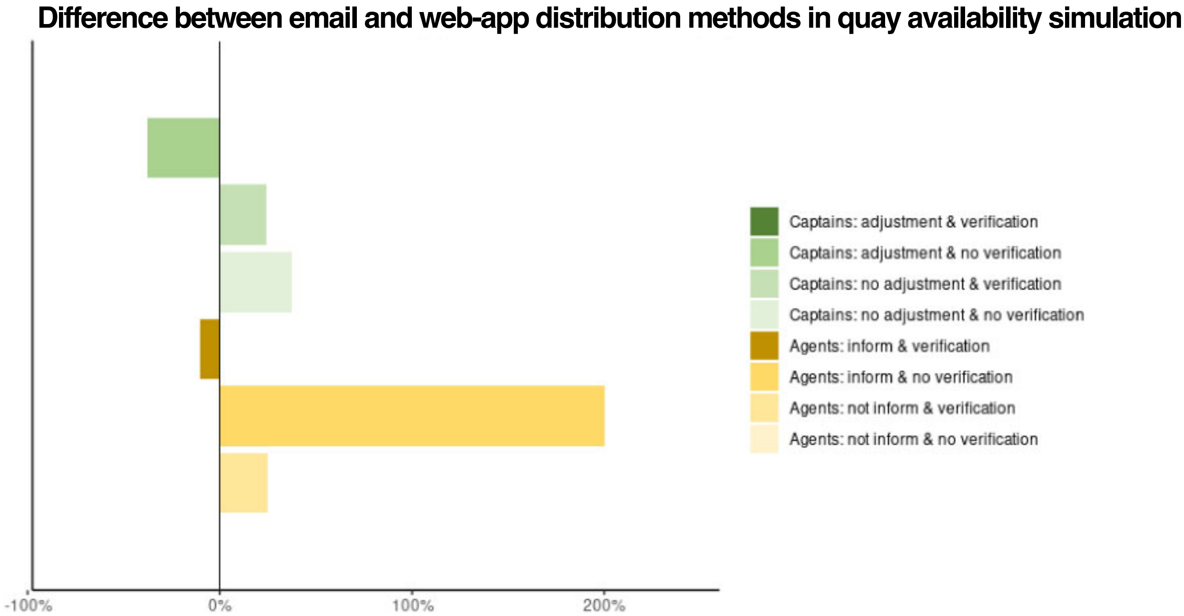


Figure 4.7: comparison of the responses to the quay availability simulation between the email and web-app distribution methods

4.2.2.2. Action based effectiveness of sharing quay availability predictions

In addition to asking for the intended action based on the information provided, the effect of the sharing of this information is also measured in a more quantitative method. Captains who indicate they would adjust their operations are asked to indicate how they would adjust their speed based on the information that is provided to them. In the case of the quay simulations two different scenarios are presented to two different groups of captains, where the first scenario involves a container vessel, and the second scenario involves an oil carrier. Figure 4.8 contains the data that was given to respondents in these different scenarios within the quay availability simulation.

Container vessel			
Trip	Oslo - Rotterdam	**ETA at Maascenter**	24 hours
Current speed	18kts	**ETA at quay**	16:45
Distance to Maascenter	432NM	**Predicted quay free**	19:15, 95% confidence interval between 18:25 - 20:05
Tanker vessel			
Trip	Suez - Rotterdam	**ETA at Maascenter**	24 hours
Current speed	14kts	**ETA at quay**	16:45
Distance to Maascenter	336NM	**Predicted quay free**	19:15, 95% confidence interval between 18:25 - 20:05

Figure 4.8: Scenario descriptions for the quay availability simulation

Using some simple calculations it can be found that container vessels must reduce their speed by 9.44% (-1.7kts) to arrive at the quay exactly at 19:15 or reduce their speed by 6.67% or (-1.2kts), to arrive at the quay at the boundary of the confidence interval (18:25). Tanker vessels need to reduce their speed by 10% (-1.4kts) to arrive at the quay exactly at 19:15 or reduce their speed by 6.43% (-0.9kts), to arrive at the quay at the boundary of the confidence interval (18:25).

	Email	Web-app
Container	-6.6% (n=67)	-9.2% (n=57)
Tankers	-10.0% n=16)	-9.4% (n=12)
Overall	-7.3% (n=83)	-9.2% (n=69)

Figure 4.9: Speed effects of quay availability simulations

From figure 4.9 there are differences in the speed alterations made by captains of container and tanker vessels as well as between the speed alterations triggered by the different distribution methods. Based on the email distribution method, an average container vessel that alters its operations reduces its speed by an amount that is just about high enough to arrive at the quay at the boundary of the confidence interval. The web-app triggers a larger speed alteration by container captains, sharing information using this method leads to an extra decrease in speed of 2.6% (0.47kts) making these container vessels arrive more closely to the center of the confidence interval. Looking at tanker vessels, on average, the speed reduction matches the center of the confidence interval more closely to container captains, meaning that these captains act more effectively on the information provided. This result might be due to possible differences in the consequences of leaving a dock unoccupied between the industries of container vessels and tankers.

4.2.2.3. Reasons for acting on the quay availability prediction

When analyzing the reasons given by captains on why they would act on the information (appendix a.4.1) it is found that most captains would act on the information to avoid wait times. This result is as expected; the most direct impact of changing speeds and adapting operations in accordance with predictions is the avoidance of wait times in port. It is interesting to note that the second most important reason, on average, is "cost related reasons", which indicates that captains generally realize that avoiding wait times in port might reduce costs as well. In fact, 78% of respondents who assigned a value to "avoiding wait times" also assigned a value to "cost related reasons". A significant portion of captains indicated ecological reasons weighing into their decision to act, which might be due to recent developments in the maritime industry ("Vermindering van de emissies van de scheepvaartsector", 2021).

A significant share of captains indicates that they have no intention to alter their operations based on the information provided. These captains were asked why they would not act. Appendix a.4.2 contains a complete overview of the reasons why captains would not act. The most important reason was found to be a lack of confidence in the effectiveness of adjusting their operations. Cost and contract reasons are also found to be important. Many respondents indicated "other" reasons as well, where most indicate that presenting these kinds of predictions 24 hours ahead of time is too long as they believe they can change their actions more effectively if the confidence in the information increases as the time of arrival draws closer.

4.2.2.4. Differences between categories of participants

The large sample of captain participants can be subdivided into whether a captain is a PEC holder or not, whether a captain is relatively experienced or not and the type of vessel that a captain generally commands. To analyze whether these categorizations make captains act differently the same analysis as in section 4.2.2.1 is performed on each of these categories (appendix a.4.3 through a.4.5). The differences in actions taken are not significant between the group of captains who are PEC holders and those who are not. The amount of experience of a captain has little effect on their intent to alter their operations. Captains who command container vessels act less effectively on the information compared to captains commanding bulk or other types of vessels. The captains of general cargo vessels act even less effectively on the information. The effectiveness of sharing this information through a web-app is higher for container vessels compared to bulk, general cargo, and other vessels. This finding might be due to the sample skew towards PEC holders as many vessels commanded by PEC holding captains are (relatively small) container vessels.

4.2.2.5. Verification of the quay availability predictions

As was found when the theoretical and practical basis was established in chapter 2, the most important precondition to sharing information between any two parties is that a level of trust must be established between those parties. To include this theory into this research, participants have been asked whether they would verify the information provided to them, and with whom they would verify that information. Appendix a.4.6 contains an overview of the percentages of participants who indicate that they would verify the information as it is provided to them. Most participants intend to verify the information they receive, indicating that the information provided might not be trusted. To analyze whether this drive to verify is motivated by the level of trust between the parties involved in the information exchange it is interesting to see with whom the participants intend to verify the information. Figure 4.10 includes a visual representation of the verification methods that captains intend to employ to verify the information they receive.

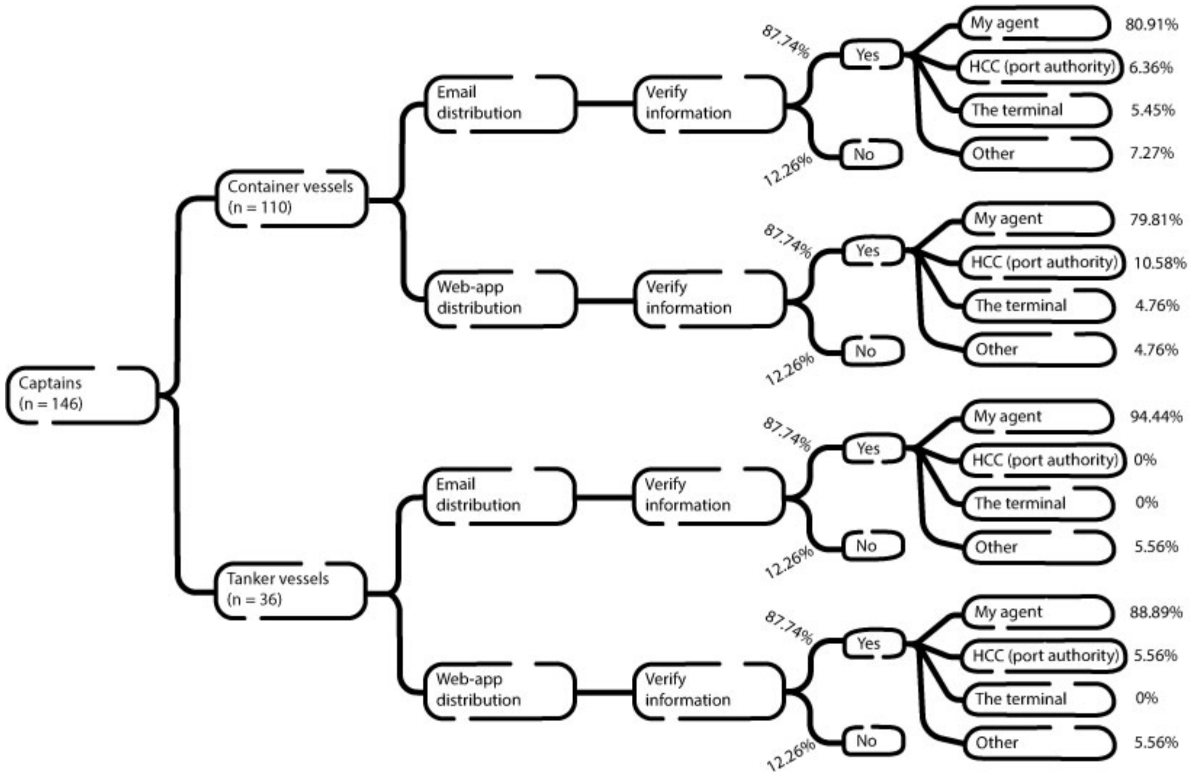


Figure 4.10: indication of who participants intend to verify their information with

From figure 4.10 it is found that most captains intending to verify will verify this information with their agent. This finding was expected because of the nature of the relationship between captain and agent (participants 1 and 2). Since this scenario involves a prediction that the arranged slot time can likely not be used it makes sense that most captains would contact the agent, as he or she is usually responsible for arranging this slot at the terminal. A significant part of container vessel captains would also contact the Port of Rotterdam (HCC) directly which has implications for the level of trust between the parties involved as this portion of captains indicate that they do inherently trust information coming from the port authority. The reason for verifying might be aimed at reducing the threat of errors in the distribution of the information or at verifying the information at a later point in time.

Since most captains intend to verify the information with their agent it is interesting to see what party agents would in turn verify their information with if they indicate their intent to do so. Since the sample of agents is much smaller than that of captains the choice was made not to split the responses between distribution methods and scenarios. Figure 4.11 contains a visual representation of the intention of agents to verify information and the parties that they would verify this information with.

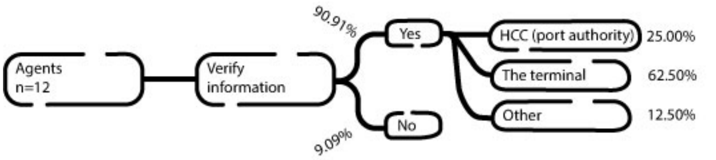


Figure 4.11: visual representation of the intention of agents to verify information and parties they would verify this information with

Agents mostly intend to verify the information with the terminal. This again makes sense considering the relationship between the vessel and the agent, where the agent is responsible for making a slot booking at the terminal. A significant part of the agents (25%) intends to verify the information with the Port of Rotterdam (HCC) instead of the terminal. This implies that a quarter of the agents would trust the information provided by the Port of Rotterdam over the information of the terminal regarding terminal availability. This links back to the interviews where it was indicated that terminals are not always transparent about the availability of the terminal and the waiting times for incoming vessels (participant 11). This finding might be a reason for an agent to verify the information with the port authority instead of the terminal.

4.2.3. Simulation 2: tidal window simulations

The second simulation is the tidal window simulation. In this simulation it is indicated that the harbor basin in which the vessel is aiming to dock is restricted by tidal levels around the time of the planned arrival of the vessel after which the same questions as in the first simulation are posed.

4.2.3.1. Effectiveness of sharing tidal restriction predictions contingent on the delivery method

Figure 4.12 contains a visualization of the actions participants intend to take after they receive a simulated email containing the predicted tidal restriction around the planned ETA.

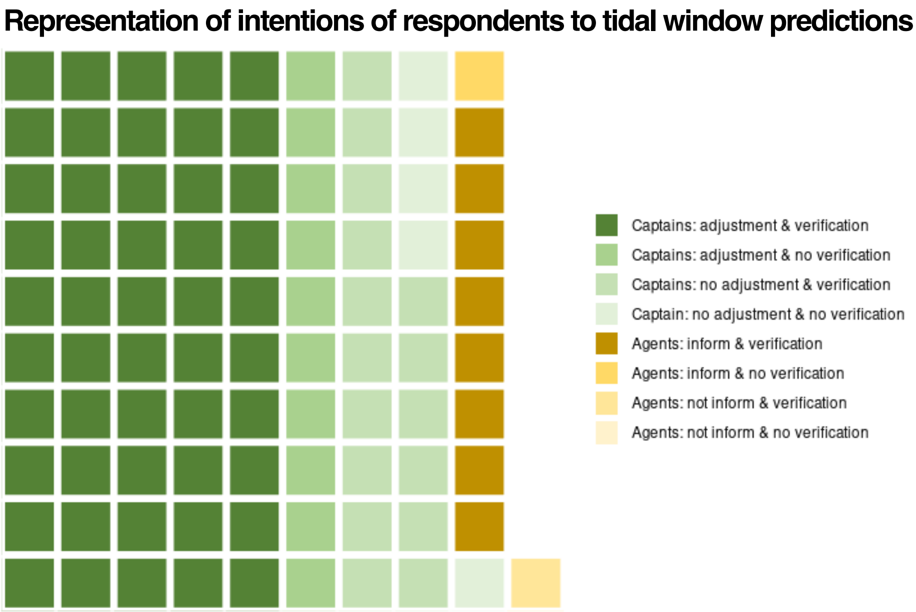


Figure 4.12: representation of participant responses to the first questions of the tidal window simulation involving the email distribution method

A majority (74%) of captains would adjust their operations based on the predicted tidal restriction. A vast majority of agents (90%) would inform the vessel of this information. Figure 4.13 contains a comparison of these responses between the email and web-app distribution methods.

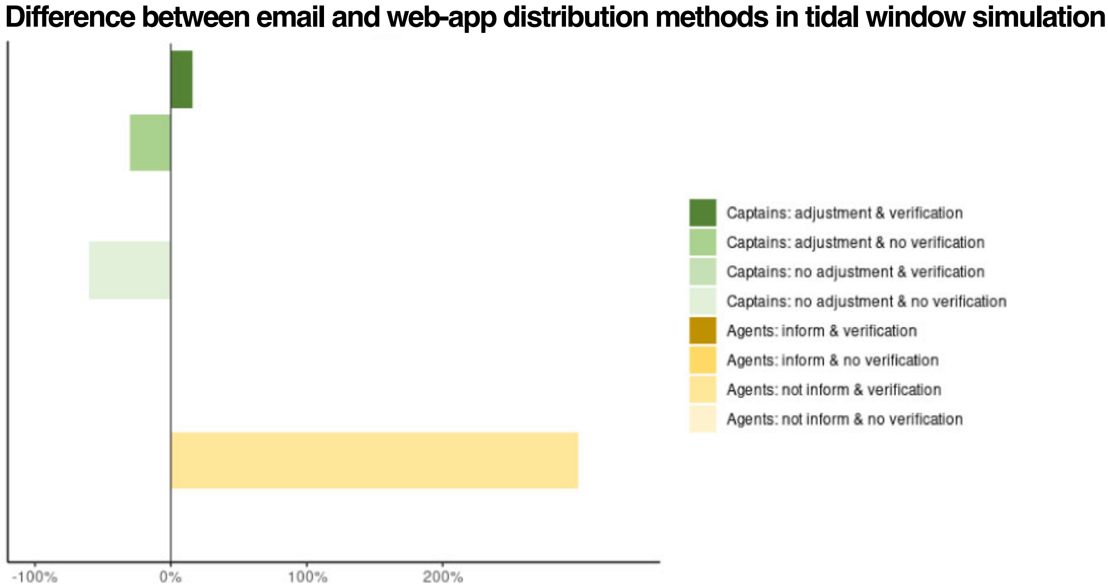


Figure 4.13: comparison of responses to the tidal window simulation between email and web-app distribution methods

There is a relatively large difference between the different distribution methods and the actions of captains. There is a relatively large increase in the number of captains who intend to adjust their operation when the distribution method is changed to a web-app instead of an email (6.17%, from 74 to 80% of captains). This is an indication that the web-app distribution method might be more effective in provoking actions by captains. In the case of agents, there is a very large increase in the number of agents that would not inform but would verify the information. This very large increase is however explained by the small number of observations in the not inform & verification category for agents in both distribution methods (1 to 4), as a result no real conclusions can be drawn from this observation.

4.2.3.2. Action based effectiveness of sharing tidal window predictions

Like in the case of the quay availability simulation, the effectiveness of the information is also tested based on a simulation, where the effects are analyzed using the same methodology as for the quay availability simulation. Figure 4.14 contains the data presented to participants in the case of this tidal window prediction simulation. Using some simple calculations it is found that container vessels need to either increase their speed by at least 2.35% (0.4kts) or decrease their speed by at least 9.41% (1.6kts) in order to arrive at the draft restriction within the predicted tidal windows. Tanker vessels need to increase their speed by at least 3.33% (0.4kts) or reduce their speed by at least 21.67% (2.6kts).

Container vessel			
Trip	Dublin - Rotterdam	**ETA at Maascenter**	24 hours
Current speed	17kts	**ETA at tidal restriction (Eemhaven)**	12:50
Distance to Maascenter	408NM	**Predicted tidal windows**	09:56 - 12:25 & 15:15 - 16:22
Tanker vessel			
Trip	Marseille - Rotterdam	**ETA at Maascenter**	24 hours
Current speed	12kts	**ETA at tidal restriction (7e PET)**	12:50
Distance to Maascenter	288NM	**Predicted tidal windows**	09:56 - 12:25 & 15:15 - 16:22

Figure 4.14: Scenario descriptions of tidal window simulations

Using figure 4.15 it is found that vessels that choose to increase their speed do so by much more, on average, than is needed to arrive within the boundaries of the tidal window. Captains who choose to decrease their speed do so more effectively when presented with the web-app compared to the email presentation, which might be the result of the usage of a visual communication method (a graph) for information that is relatively complex but is also dealt with by captains daily. The larger effect for captains who choose to decrease their speed compared to those who increased their speed is a result of the fact that less drastic increases to speed are necessary, in this case, to arrive at the beginning of the next tidal window. When a speed increase methodology is used, the whole tidal window can then be utilized. When the speed is reduced with only the minimal necessary amount instead, the vessel will arrive at the end of the tidal window, meaning that there is no time left for maneuvering or delays. In order to arrive at a similar point within the tidal window as is achieved by a relatively small increase in the speed the vessel needs to slow down by a lot more.

	Email (increase)	Email (decrease)	Web-app (increase)	Web-app (decrease)
Container	6.63% (n=22)	-11.56% (n=17)	6.12% (n=31)	-20.76% (n=14)
Tankers	4.40% (n=7)	-13.00% (n=5)	7.22% (n=9)	-21.67% (n=3)
Overall	6.09% (n=29)	-11.89% (n=22)	6.37% (n=40)	-20.92% (n=17)

Figure 4.15: Speed effects of tidal window simulations

4.2.3.3. Reasons for acting on the tidal window prediction

Appendix a.4.7 contains the reasons indicated by captains as to why they intend to act on the tidal window prediction simulation. Most captains, like for the quay availability simulation, intend to alter their operations in order to avoid wait times, which also again interacts with cost related reasons. Ecological reasons scored lower on average when compared to the results for the quay availability simulation, which might be due to the safety and operational implications of tidal restrictions (a physical obstruction) weighing more heavily on the minds of captains compared to the same implications for the quay availability information.

A quarter of the responding captains indicate that they do not intend to alter their operations based on the information provided. Appendix a.4.8 contains a complete overview of the reasons captains indicate as to why they do not intend to act on the information. The most important reason is generally indicated to be related to the charter contract which usually determines the speed a vessel sails at, and the crew might not be at liberty to alter this speed. Cost reasons also play a major role, implying that, in some situations, not acting and being denied entry into port upon arrival might be cheaper than delaying or moving up the arrival time. This is likely a consequence of the contract reasons mentioned before, where a vessel is paid while it is waiting outside of a port.

4.2.3.4. Differences between categories of participants

The large sample of participating captains is again subdivided based on the same descriptive statistics as in the case of the quay availability simulation. The figures resulting from this analysis can be found in appendix a.4.9 through a.4.11. Non-PEC captains are less likely to alter their operations based on the information than PEC captains overall. This difference is larger in the case of email simulations than for the web-app simulations, indicating that PEC captains trust emails more than non-PEC captains, which was not found in the quay availability simulation. This difference might be explained by previous interactions that PEC captains have had with the port authority mainly occurring by email. The amount of experience has little effect on the intent to alter operations to verify the information. More experienced captains are more likely to verify the information that is given to them, which is again not supported by the findings in the quay availability simulation. There is a general difference between the actions of captains who command container vessels and captains who command other types of vessels. This difference might be due to container vessels not encountering tidal limitations as often as liquid tankers for example. The response rate from container vessel captains to the information is lower than the overall response rate for all types of vessels in the case of the email distribution method while the opposite is true for the web-app distribution method. General cargo vessels and vessels that do not fit into any of the preset categories (e.g., cruise, ro-ro ferry, offshore support vessel, etc.) are less likely to react to the web-app distribution method than to the email simulation, opposing the findings for container vessels. This difference might be due to the special nature of some of these vessels implying that these captains are in more direct communication with port authorities or agents than more common container vessel operators. This, in turn, might lead to a lower likelihood for these captains to check information themselves rather than being fed that information by other parties.

4.2.3.5. Verification of the tidal window predictions

The stated intent to verify the information is again analyzed. Figure 4.16 contains an overview of the percentages of participants who indicate that they would verify the information as it is provided to them. Most participants intend to verify the information they receive and as was found in the previous section for the quay availability simulations, participants intend to verify the information more often when the distribution method is a web-app compared to an email. The verification methods that captains intend to employ are again analyzed as represented in appendix a.4.12. Appendix a.4.13 contains a visual representation of the verification methods agents intend to employ. Most captains intend to verify the information with their agent, just like in the case of the previous simulation on quay availability predictions. The rates of captains who intend to verify the information with the port authority has increased along all scenarios and distribution methods. Looking at the intention to verify on the part of the agent, similar results to the quay availability predictions simulation are found. The share of agents who intend to verify the information with the port authority has increased, implying a higher level of trust in the information provided by the port authority compared to the level of trust based on the quay availability prediction simulation.

Captains (n=93)		Agents (n=12)	
Email distribution method			
Container scenario	81.16%	Container scenario	100.00%
Tanker scenario	85.71%	Tanker scenario	83.33%
Web-app distribution method			
Container scenario	89.06%	Container scenario	100.00%
Tanker scenario	84.62%	Tanker scenario	66.67%

Figure 4.16: overview of percentages of survey participants intending to verify the information provided

4.2.4. Simulation 3: wind speed simulations

The third and final simulation indicates to respondents that high winds are expected around the time of the planned arrival of the vessel in the harbor basin the vessel intends to dock at. In addition to this information wind operating limits are shared, which are to be breached by the predicted wind speeds. Respondents are then asked the same questions as they were for the first and second simulations and their responses are again analyzed in a similar manner.

4.2.4.1. Effectiveness of sharing wind speed predictions contingent on the delivery method

Figure 4.17 contains a visualization, like the one presented in the previous two sections, describing the intentions of respondents based on the information provided to them. A majority (74%) of captains intend to adjust their operations based on the information, which is close to the same rate of captains intending to alter their operations as was found for the tidal window simulation, the rate is higher than it was for the quay availability simulation. A vast majority of agents (92%) intend to inform the vessel, which is close to the rate in the tidal window simulation and higher than the rate in the quay availability simulation. Figure 4.18

contains a comparison of the intentions of respondents between the email and web-app distribution methods.

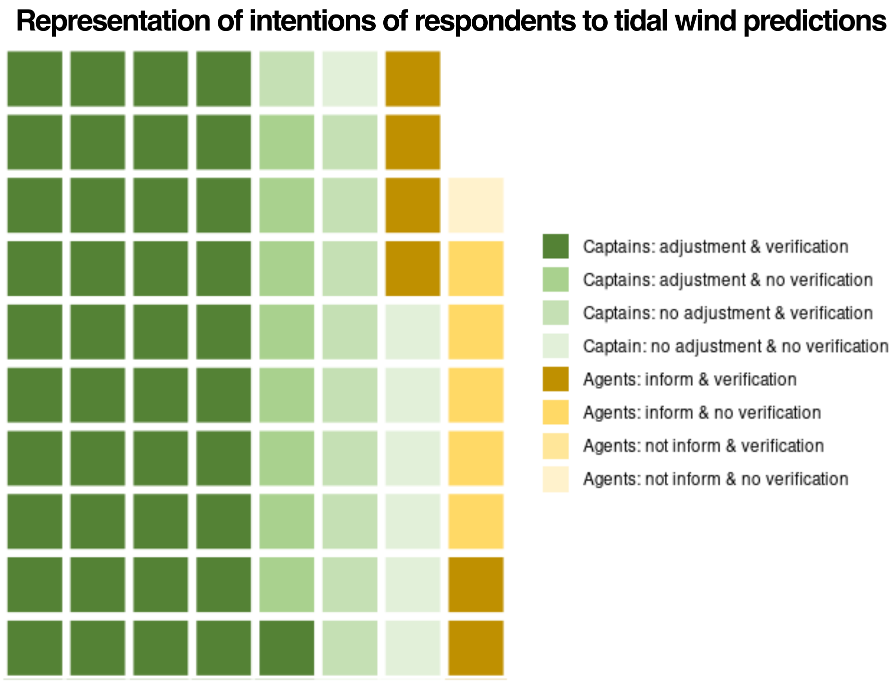


Figure 4.17: representation of responses to the first questions of the wind speed simulation involving the email distribution method

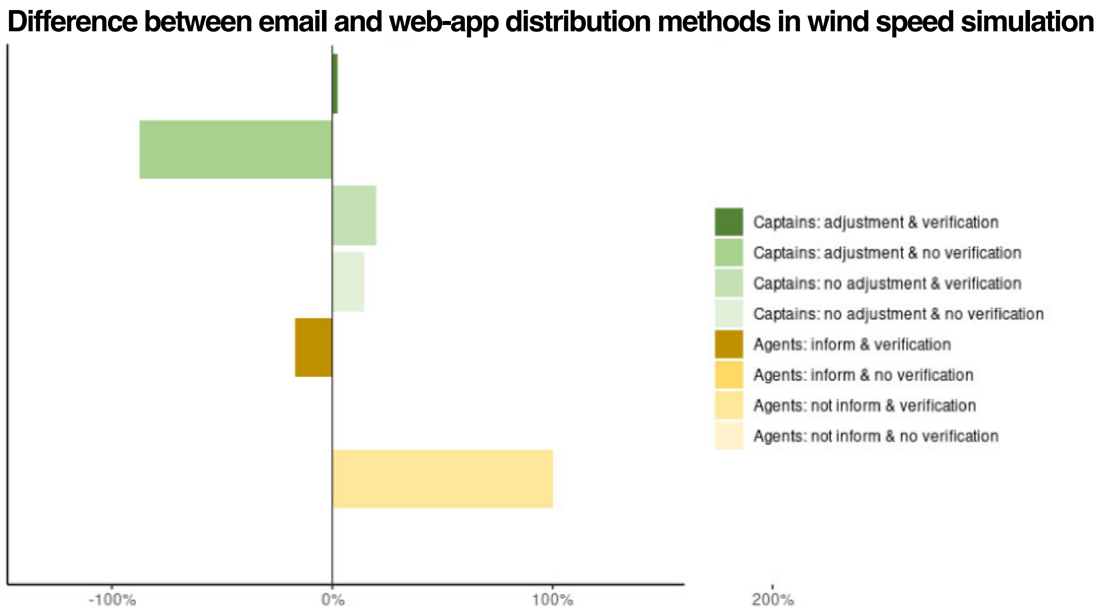


Figure 4.18: comparison of the responses of respondents for the wind speed simulation between the email and web-app distribution methods

Switching from an email to a web-app distribution method leads to an increase in the number of captains intending to adjust their operations while not verifying the information, indicating that captains might trust the information shared through the email distribution method more than the information shared through the web-app distribution method. This finding is supported by the increase in verification rates overall (+8.44%) when the distribution method is switched to a web-app. The email distribution method seems more effective in provoking actions by captains overall, as switching to a web-app distribution method leads to a decrease of 6% in the rate of captains intending to alter their operations. In the case of agents, there is again a large increase in the number of agents that would not inform but would verify the information. This very large increase is however explained by the small number of observations in the not inform & verification category for agents in both distribution methods (0 to 1), as a result, like in previous sections, no conclusions can be drawn from this observation. In the other categories of agents, it is found that there is also a reduction in the effectiveness of the information when the distribution method is switched to the web-app method (-8%). Due to the small sample size involved it is difficult to attach any conclusions to this finding.

4.2.4.2. Action based effectiveness of sharing wind speed predictions

The effectiveness of the information is again analyzed based on the simulation presented to captains intending to alter their operations. Figure 4.19 contains a summary of the case specifics in the context of the wind speed prediction simulation. Using some simple calculations it is found that container vessels need to increase their speed by at least 6.67% (1.4kts) or decrease their speed by at least 6.19% (-1.3kts) to arrive in the harbor basin outside of the period predicted to be wind restricted. Tanker vessels need to increase their speed by at least 12% (1.2kts) or decrease their speed by at least 7% (-0.7kts) to arrive in the basin outside of the wind restricted period.

Container vessel			
Trip	Suez - Rotterdam	**ETA at Maascenter**	24 hours
Current speed	21kts	**ETA at harbor basin**	14:25
Distance to Maascenter	504NM	**Predicted winds over wind restriction**	13:00-16:00
Tanker vessel			
Trip	Flotta - Rotterdam	**ETA at Maascenter**	24 hours
Current speed	10kts	**ETA at harbor basin**	14:25
Distance to Maascenter	240NM	**Predicted winds over wind restriction**	13:00-16:00

Figure 4.19: Case descriptions wind speed prediction simulation

Figure 4.20 again contains the aggregated speed effects resulting from the simulations filled out by captains. On average, captains who intend to alter their operations do so to at least schedule their arrival outside of the predicted "high wind window". It can also be seen that most respondents choose to lower their speed rather than increase their speed. This can be due to two different factors; the first of these factors is that it might be cheaper to reduce speed than to increase speed (as fuel burn increases with higher speeds). The second of these factors is that the speed adjustment in reducing the speed to arrive outside of the "high wind window" was less than the speed adjustment in increasing the speed to arrive outside of the window. However, this difference is rather small for container vessels (just 0.1kts).

	Email (increase)	Email (decrease)	Web-app (increase)	Web-app (decrease)
Container	11.43% (n=9)	-11.77% (n=32)	11.67% (n=8)	-10.90% (n=26)
Tankers	5.29% (n=4)	-15.60% (n=2)	13.00% (n=2)	-12.33% (n=3)
Overall	9.54% (n=13)	-12.00% (n=34)	11.94% (n=10)	-11.05% (n=29)

Figure 4.20: Speed effects of wind speed simulations

4.2.4.3. Motivations for using the information

Like during the analysis of the previous two simulations, captains are again asked why they intend to act on the information given. Appendix a.4.14 contains the reasons captains indicate as to why they intend to act. The most important reason indicated is again to avoid wait times. Compared to the previous two simulations, more captains indicated that they had "other" reasons to act. Among these "other" answers, ensuring safe berthing is mentioned often, implying that captains feel the need to adjust their operations based on the wind speed predictions stemming from their duty to ensure the safety of the vessel. Reasons like "following the predictions" and "following restrictions" are also mentioned, indicating that these captains intend to act on this information not out of their own or corporate interests but rather out of a feeling of following instructions by the port authority. In these cases, the indication of captains that they intend to act on the information based on the restrictions and/or following the forecasts an authoritative relationship seems to exist between the port authority and the captain.

More than 20% of captains indicate that they have no intention to alter their operations based on the wind prediction provided. These captains are, just like in the analysis of previous simulations, asked why they intend not to act on the information. Appendix a.4.15 contains a complete overview of the reasons that captains indicated for not intending to act on the information provided. Contract reasons are again found as the most important reason not to act, implying that many contracts do not allow the captain of a vessel to alter his or her speed, confirming the findings in the previous simulations. Just like in the analysis of the tidal window simulation, here it is also found that avoiding costs is a major reason not to act, likely concerning costs that would be incurred if the captain would abide by the contractual obligations he or she is under. A significant number of captains entered reasons falling under the "Other" category for why they intend not to act on the information. These reasons mostly mention the unpredictability of weather information up to 24 hours in advance and the contractual obligations discussed before.

4.2.4.4. Differences between categories of participants

The figures resulting from again splitting the sample among descriptive statistics and comparing the intentions to act based on these can be found in appendix a.4.16 through a.4.18. In these subcategories the general finding that in the context of the wind speed simulations the email distribution method is more effective is confirmed. PEC captains are more likely to adjust their operations based on the information regardless of the distribution method, which confirms the findings of the tidal restriction simulation while it differs from the quay availability simulation findings. Non-PEC captains are more likely to verify the information, which is a pattern not found in the previous simulations, indicating that PEC captains generally trust the wind-related information that they receive from the port authority more than captains who do not hold a PEC in the port. Less experienced captains have a higher intention to act on the information, which is the same pattern found in the tidal window simulation but not found in the quay availability simulation. Vessels falling in the "Other" category are most likely to act on the information overall, followed by captains in the "Container" and "General cargo" categories. This is different from the tidal restriction simulation, where "Bulk" vessels were most likely to act, which is likely due to the differences in operations of these types of vessels, where bulk vessels are more likely to be restricted by draft, and as a result of their relatively low vertical profile above the water, are less likely to be affected by wind. The vessels in the "Other" category contain cruise and ro-ro vessels, which do have a large vertical profile above the waterline, and, as a result, would be more affected by winds. An interesting finding is that vessels in the "Container" and "General cargo" categories are most likely to verify the information, while vessels in the "Other" category are, especially based on the email distribution method, less likely to verify the information. This finding can be attributed to the types of vessels that these categories concern where container and general cargo vessels likely have to plan more of their operations themselves and the operations for vessels in the "Other" category like cruise ships and project cargo will be more closely planned to use (shoreside) support.

4.2.4.5. Verification of wind speed predictions

Like for the previous two simulations, the intent to verify the information is analyzed. Figure 4.21 contains an overview of the percentages of participants who indicate that they would verify the information as it is provided to them. Most participants again intend to verify the information they receive and as was found in the previous two simulations, participants intend to verify the information more often when the distribution method is a web-app compared to an email. In order to understand whether this intent to verify is the result of a lack of trust between the port authority and the participant, a similar analysis to the one performed for previous simulations was conducted. Figure 4.22 includes a visual representation of the verification methods that captains intend to employ. Most captains, like in the previous simulations, intend to verify the information with their agent. The verification rate with the agent is however a lot lower than it was in the case of those other simulations. In the simulations concerning container vessels most of these captains who choose not to verify the information with their agent verify the information with the port authority instead, signaling a level of trust in the information provided by the port authority that is not present in the

Captains (n=66)		Agents (n=12)	
Email distribution method			
Container scenario	77.59%	Container scenario	50.00%
Tanker scenario	69.81%	Tanker scenario	50.00%
Web-app distribution method			
Container scenario	86.79%	Container scenario	50.00%
Tanker scenario	53.33%	Tanker scenario	50.00%

Figure 4.21: overview of the percentages of participants indicating they would verify the information

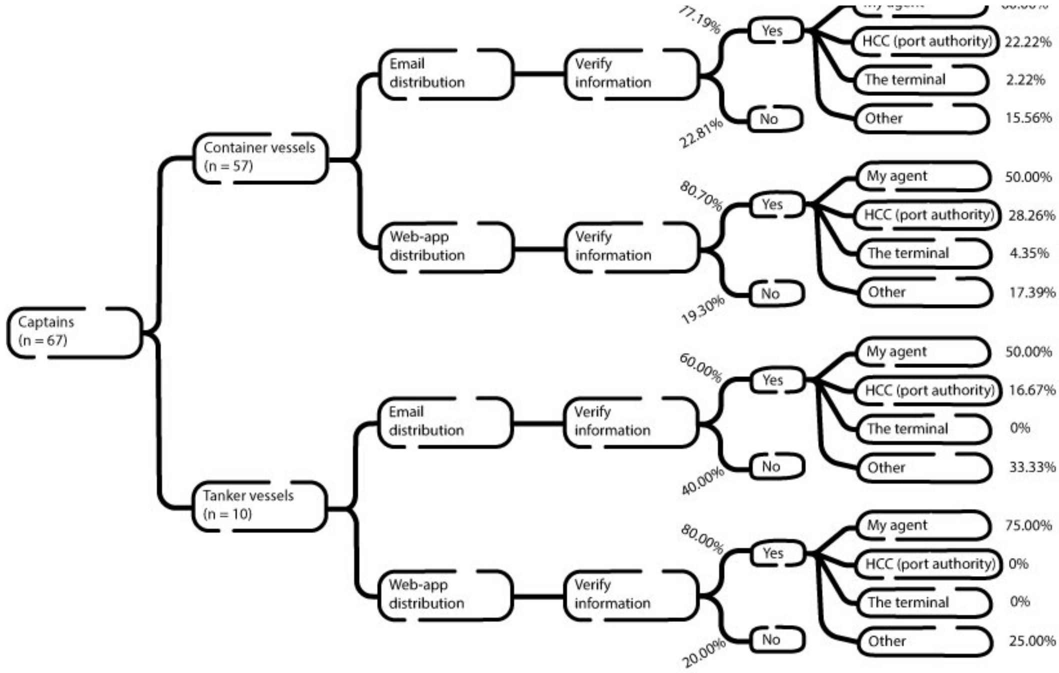


Figure 4.22: Visual representation of the intention of captains to verify information and the parties they intend to verify this information with

other two simulations. Since most captains again still intend to verify the information with their agent, the intentions of agents to verify information are included in appendix a.4.19.

Unlike in the analysis of the previous two simulations, most agents intend not to verify their information with the terminal. In fact, there is an equal split among the three options that agents have in responding to the survey. As the number of agents who intend to verify the information is relatively low no reliable results can be drawn from these observations.

5. Discussion

In order to answer the main research question of this thesis, "How does increasing the amount of information services offered by a port authority affect the operations of captains and agents in a port?", three hypotheses are proposed. These hypotheses are:

Hypothesis 1: ***"Information aimed at reducing port congestion and/or increasing port safety is immediately reflected in captain's and agent's operations"***

Hypothesis 2: ***"Information of average complexity and low levels of novelty is most effective when shared through visual means"***

Hypothesis 3: ***"The level of trust that is attributed to a port authority positively affects the effectiveness of the shared information"***

This chapter discusses the implications of the research results on each of these hypotheses and uses these results to answer the main research question.

5.1. Acting based on operational information

The first hypothesis, "information aimed at reducing port congestion and/or increasing port safety is immediately reflected in captain's and agent's operations", results from interviews where captains indicated that information shared by the port authority through the VTS is critical in safely operating in a port. Furthermore, these captains indicated that the type of information shared by a VTS, which relates to safety and/or avoiding delays, is always considered when operating in a port. Following these statements, information that pertains to safety or avoiding delays in a port is likely to be used by captains and agents to alter their operations. Confirming this hypothesis would imply that captains and agents use information that pertains to safety and/or avoiding delays even if that information is not delivered directly to them through a VTS operator. In order to analyze the actions taken by captains based on the information and relate that to whether that information pertains to the safety in a port or is mainly aimed at avoiding delays the simulated pieces of information need to be scored on the goals involved with sharing a certain piece of information.

5.1.1 Categorizing the simulations

Figure 5.1 contains an overview of the scores that each of the simulated pieces of information gets on the goals of improving safety in a port and avoiding delays in a port. Each of the researched simulations is placed on a different intersection of the goals of improving safety and avoiding delays. The wind speed simulations are placed in the top left corner, implying a relatively high level on the goal of improving safety and a relatively low level on the goal of avoiding delays. This placement is a result of the nature of sharing wind speed predictions, which is generally done to avoid dangerous situations. Sharing information stating that high wind speeds are expected should lead to vessels choosing not to enter the port while these dangerous

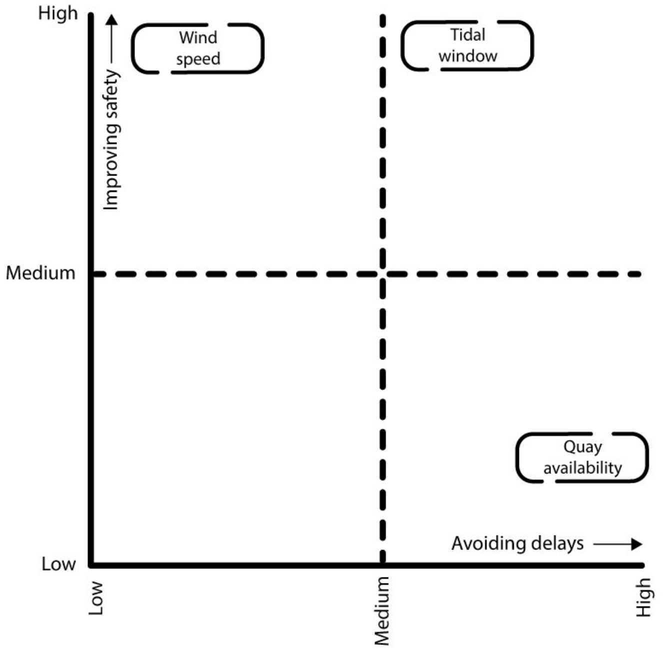


Figure 5.1: visual representation of the researched simulations and their scores on the goals of improving safety and avoiding delays

circumstances exist. On the other hand, the goal of avoiding delays is not really a factor in sharing wind speed information as while vessels might be able to avoid having to anchor by reducing their speed, the delay that these high winds cause to operations cannot be avoided.

The tidal window simulation is placed on the intersection of a high level on the goal of improving safety and an above medium level on the goal of avoiding delays. This placement is the result of the fact that informing vessels of tidal windows is inherently focused on the safety of those vessels, as an effort is made to reduce the risk of these vessels touching ground in the port, which is an inherent safety concern as this might damage the vessel, harm the vessel's occupants and/or lead to ecological damage. The placement of this tidal window simulation at an above medium level on the goal of avoiding delays is the result of the fact that, unlike for wind speed predictions, these windows show a predictable repetitive pattern every day, allowing for vessels to time their arrival to match a window in which they can enter the port. If this match is not made a vessel might be delayed because it is forced to wait for the next tidal window.

Finally, the quay availability simulation is placed on the intersection of a relatively low score on the goal of improving safety and a high score on the goal of avoiding delays. This placement is a result of quay availability predictions purely being aimed at avoiding or reducing a vessel's waiting time in port before that vessel can dock. There is a small safety aspect to sharing this information, which results from the fact that avoiding the early arrival of vessels in a port also avoids additional traffic that must wait before they are able to dock. These vessels take up anchorages or might even be drifting in harbor basins in the port. Having more vessels in and around the port inherently increases the risks involved with operating in a port and thus the small score on the goal of improving safety is the result of the aim of sharing this kind of information to reduce the number of vessels waiting in and around a port before they can dock at a terminal.

5.1.2. Actions based on information related to safety and congestion

To confirm or disprove the first hypothesis, *"Information aimed at reducing port congestion and/or increasing port safety is immediately reflected in captain's and agent's operations"*, the survey included two different approaches to analyze whether information aimed at increasing safety in the port and information aimed at reducing delays in the port leads to alterations in the operations of captains and agents. The first of these approaches consists of finding out what the participating captains and agents intend to do with the information they are presented with. The second of these approaches consists of presenting captains who indicate they intend to alter their operations with a simulation in which they are asked how they would alter their speed based on a certain scenario. Considering the first of these approaches, figure 5.2, below, compares the average intention to act on the information on the part of captains and the average intention to share information on the part of agents with these intentions based on the specifics of the simulations.

Captains		Agents	
Average intention to act on information	68.43%	Average intention to share information	75.00%
High on improving safety/low on avoiding delays (wind speed simulations)	+3.54%	High on improving safety/low on avoiding delays (wind speed simulations)	+12.5%
High on improving safety/above average on avoiding delays (tidal window simulations)	+7.76%	High on improving safety/above average on avoiding delays (tidal window simulations)	-4.17%
Low on improving safety/high on avoiding delays (quay availability simulations)	-7.19%	Low on improving safety/high on avoiding delays (quay availability simulations)	-8.33%

Figure 5.2: Intention to act or share information compared to the overall average

The intention to act on the information on the part of captains increases as the extent to which the information aims at improving safety increases as well. On the other hand, in the case of the simulation that does not aim as clearly on improving the safety, lower-than-average intentions to act are found. On the part of agents, a similar pattern is found, however, the tidal window simulations, which do mainly aim at improving safety, lead to less than average rates of agents intending to share the information. It is again important to note that the small sample of agents (n=12) might lead to distorted findings.

In order to confirm the findings from the intent that captains show these captains are then also asked to indicate how they would alter their speed in the simulated scenario. Figure 5.3 contains the percentages of speed alterations in relation to their current speed captains make in excess of the speed alteration necessary to meet the threshold at which the simulation predicts a vessel can dock, enter a harbor basin or maneuver safely for each of the three simulations respectively.

	Quay availability	Tidal window	Wind speed
Speed alterations in excess of the required alterations	1.54%	3.98%	5.99%

Figure 5.3: percentages of speed alterations in excess of the required alterations for each of the different simulations

The simulations that have high scores on the goal of increasing safety (tidal window and wind speed simulations) also score higher on how much additional time they add to arriving within the given tidal window or weather window. Since figure 5.3 includes the percentage of speed alterations in excess of the required alteration to arrive on the edge of the confidence interval, tidal window and weather window for each of the three simulations respectively, it can be concluded that captains act more decisively when the goal of the information is improving safety compared to when the goal of the information is avoiding delays in the port. This finding supports the previous finding that the extent to which the information is aimed at improving safety positively affects the action that is taken on that information. On the other hand, it also supports the finding that the extent to which information is aimed at reducing delays does not positively affect the action that is taken on that information.

5.2. Information complexity and distribution methods

The second hypothesis, *"information of average complexity and low levels of novelty is most effective when shared through visual means"*, results from the theoretical and practical review that was conducted in the context of this thesis. In order to analyze whether the research results confirm this hypothesis or not, the simulated pieces of information that were presented to survey participants first need to be categorized based on their respective levels of complexity and novelty. After this analysis the results from the research on each of these simulations can be used to test the hypothesis that the levels of complexity and novelty affect the effectiveness of the information contingent on the distribution method

5.2.1. Categorization of simulations

Figure 5.4 contains an overview of the scores that each of the simulated pieces of information get for their levels of complexity and novelty. All three simulations have been placed at a different intersection of the level of complexity and the level of novelty from the perspective of the respondent. The wind speed simulation is placed in the top left corner. This simulation has a high score on the complexity scale. This is because wind speed predictions, and especially predictions on a very localized level as is presented in the simulation, are inherently complex pieces of information. A visualized representation of wind speeds involves many lines representing pressure fields or wind directions and figures representing pressures or wind speeds. A textual

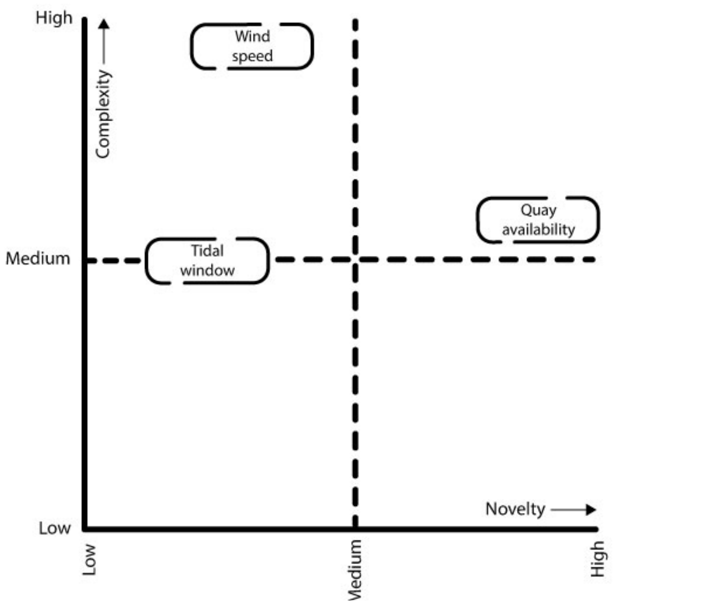


Figure 5.4: visual representation of the scores that each of the simulated pieces of information get on the levels of complexity and novelty

representation of wind speeds already forms an assumption on what information is needed as such a representation (in a tabular form for example) can only display wind predictions for certain places on the map of the visual representation. Apart from the inherent complexity of interpreting wind speed information the information itself is also very volatile and, as mentioned by multiple participating captains in this research, not always reliable. The combination of complexity of interpretation, volatility and lack of reliability makes the wind speed simulation the most complex piece of information in this research. The level of novelty of the wind speed simulation is relatively low, however. This is because, from the perspective of the users of the information (captains and agents) this simulation only involves an increase in the resolution and a change in the provider of information they already use in their daily operations. As a result of these factors, there still is a certain level of novelty to this information, it is however lower than for the new pieces of information involved with the other two simulations.

The tidal window simulation is placed on the intersection of a medium level of complexity and a relatively low level of novelty. This placement results from information involving tides to generally be considered relatively complex information as it involves non-linear changes in water levels over time that also shift from day to day and are dependent on many external factors like river flow, moon phase and wind speeds. Participants in this research are however very familiar with using this type of complex information as it is an important part in their day-to-day operations. The predictability of tides is higher than the predictability of wind speeds as the factors influencing tides can be more accurately measured and predicted. In addition, the level of interpretation required by the user is lower than for the wind speed simulation as tidal restrictions are inherently bound to a certain location (as they are dependent on the nominal depth in a certain location). As a result, the complexity of tidal window information is placed at a medium level. The level of novelty of this type of information could, in general, be considered low as participants already use this type of information every day. In the context of this research and its participants, the level of novelty of the information is considered a bit higher as currently, in the case of the Port of Rotterdam, this type of information is not provided by the port authority. Currently vessels entering the port that would be restricted by tide in a certain basin will be assigned a tidal window and will not be provided with information regarding actual water levels, predicted water levels and other tidal windows. The port authority currently only provides a tide prediction at certain fixed points in the port, receiving tidal predictions for a specific harbor basin thus involves new information for the participants.

The quay availability simulation is placed at an above medium level of complexity and a high level of novelty, which is due to this prediction involving concepts that are likely to be unfamiliar to the participants such as a confidence interval of a prediction. The level of novelty of this information is very high as a result of the fact that this type of information is currently not provided to captains and agents in any form in the case of the Port of Rotterdam.

5.2.2. Effectiveness of information contingent on distribution method, level of complexity and level of novelty

When the results considering the intentions of participants in the case of each of the simulations are combined with the distribution method and then compared to the overall average intention the figures as presented in figure 5.5 are found.

Captains			**Agents**		
	Email	Web-app		Email	Web-app
Average intention to act on information	69.78%	67.04%	Average intention to share information	75.00%	75.00%
High complexity/below medium novelty (wind speed simulations)	+4.46%	+2.66%	High complexity/below medium novelty (wind speed simulations)	+16.67%	+8.33%
Medium complexity/relatively low novelty (tidal window simulations)	+4.92%	+12.48%	Medium complexity/relatively low novelty (tidal window simulations)	-8.33%	0.00%
Above medium complexity/high novelty (quay availability simulations)	-5.44%	-9.06%	Above medium complexity/high novelty (quay availability simulations)	-8.33%	-8.33%

Figure 5.5: Intention to act or share information compared to the overall average

The patterns that were found in the overall analysis of the results in chapter 4 are confirmed. Captains overall are less likely to act on the novel type of information, the quay availability prediction, and agents are less likely to share this type of information as well. The tidal window simulation involves the highest intention to act on the part of participating captains while this simulation has a less than average intention to be shared on the part of the agents. The wind speed simulations are intended to be used by an above average number of captains, while a large majority of agents also intend to share this information.

It is also found that, as the theory suggests, the effectiveness of the information increases when a visual method of distribution is chosen for information that is of a medium level of complexity and a lower level of novelty. This can be seen by the clear increase in the intent to act by captains in the case of switching from an email to a web-app distribution when the tidal window simulations are concerned. A similar increase in the intent to share the information can be seen on the part of responding agents. On the other hand, the theory suggests that more complex or novel information should be shared in a solely textual manner. Looking at the results for captains, the simulation with the highest level of novelty (the quay availability simulation) has an increase in the intent to act on the part of captains when the distribution method is switched from web-app to email (from visual to textual form). On the other hand, this finding is not confirmed by the participating agents. It is however important to again realize the major difference in sample size between captains and agents, where the small sample size of agents might lead to less reliable results. When looking at the most complex information, the wind speed simulations, a similar pattern is found which is smaller in size when a switch is made from web-app to email distribution for participating captains. This pattern is consistent with the one found for agents in the case of this simulation. Overall, these findings seem to confirm the theory on complexity and novelty of information and distribution method, where a visual distribution method is best suited to present information that is medium in complexity and lower in level of novelty to the recipient.

In order to strengthen these findings, an analysis of the actual actions undertaken by captains based on the information in the case of information of medium complexity and medium novelty (tidal window simulations) is included in figure 5.6. This figure contains the percentages of speed alterations in excess of the required alterations to arrive within the presented tidal window. Switching to a web-app distribution method has a positive effect on the extent to which captains alter their operations. In the case of container captains this increase means that the visual web-app distribution method pushes container captains to arrive relatively earlier in the tidal window than predicted, allowing more time for maneuvering and delays. In the case of tanker vessels, the same is found, however here the change in actions of the captains is much larger. In the email simulation captains of tanker vessels are found to, on average, not alter their speed by enough to arrive within the predicted tidal window. When the switch is made to a visual web-app distribution method these captains do arrive within the window, leaving time to spare for maneuvering and delays. These findings support the general finding that this type of information, of medium complexity and novelty to the recipient, is most effectively shared in a visual rather than textual manner.

	Email	Web-app
Container (n=42)	+3.35%	+4.13%
Tanker (n=12)	-2.99%	+2.92%

Figure 5.6: percentages of speed alterations in excess of the required alteration to arrive at the edge of the tidal window

5.3. Trust between captains, agents and a port authority

The third hypothesis, *"The level of trust that is attributed to a port authority positively affects the effectiveness of the shared information"*, is based on the findings in previous literature that a level of trust must exist between parties involved in sharing information for that information to be effective. To establish the level of trust between the port authority and the recipient, a trust-based mechanism was included in the survey, based on the participant's intention to verify the information. Using this mechanism, it is assumed that when a captain acts, or an agent shares the information without verifying it with another source, the level of trust that this participant attributes to the port authority must be high.

Information regarding the quay availability simulation leads to the least number of actions by captains and agents without verifying the information first, with only 6.35% and 6.25% of captains and agents respectively acting on the information without verifying. On the other hand, the tidal window and wind speed simulations lead to a larger propensity to act on the part of captains and agents. These results make sense when analyzed from the perspective of the agent or captain receiving that information. This is because captains are used to dealing with information regarding tidal windows and wind speed predictions, and agents are also more used to working with those types of information when compared to the newly introduced quay availability prediction simulation. In addition to this simulation being newly introduced, it also involves a third party, the terminal, that does not publish this information themselves. Even with these larger percentages of trusting participants, 12.35% and 10% in the tidal window simulation as well as 12.12% and 41.67% in the wind speed simulation for captains and agents respectively, most participants intend to verify the information with another source.

In addition to asking respondents to state their intention to verify the information or not, respondents are also asked to indicate who they would verify the information with. Some respondents indicate that they intend to verify the information with the port authority itself. Verifying the information with the port authority instead of a third party still implies a level of trust attributed to the port authority by the respondent. In some of these cases, respondents indicate they are unsure of their own ability in interpreting the data or retrieving it using the web-app simulations. When the participants who intend to verify their information with the port authority directly are included, the pattern between the different simulations found previously persists, and most participants do not attribute a high enough level of trust to the port authority to act on information provided by the port authority alone. This conclusion might be a result of the fact that shipping is a very safety-oriented industry, likely leading to people in this industry inherently doubting information they receive and verifying that information with other parties. When the effectiveness of the information between respondents who trust the information from the port authority (respondents who either act/inform without verification or with verification by the port authority) and the responses of all respondents are compared it is found that there is no large difference, showing no indication that more trusting respondents act more effectively on the information, as presented in figure 5.7.

	Quay availability		Tidal window		Wind speed	
	High trust	Overall	High trust	Overall	High trust	Overall
Captains	60.87%	57%	73.91%	74%	65.38%	74%
Agents	80.00%	66%	60.00%	90%	87,50%	92%

Figure 5.7: percentages of participants intending to act on the information between high trust subcategory and overall

These findings seem to contradict the hypothesis *"The level of trust that is attributed to a port authority positively affects the effectiveness of the shared information".* However, it is important to note that the results can also be explained in a different way. Since the survey is not specifically aimed at testing different levels of trust and comparing them (by for example including different sources) it is difficult to claim that different levels of trust would have resulted in different outcomes. In addition to this lack of availability of different sources to survey participants, a case can also be made that it cannot be known for certain that respondents would have wanted to verify the information if they were not asked whether they would. Especially in the safety-focused maritime industry it is likely that if respondents are given the option to verify their information they would do so (participants 2 and 12). As a result of this methodological choice to focus on the goal of the information and the method of delivery resulting in a less clear split between high and low trusting participants this hypothesis cannot be confirmed or rejected.

5.4. Effect of additional information services in a port

Combining the conclusions for each of the three hypotheses discussed in the previous sections the following conclusions can be drawn:

- the extent to which information is aimed at improving safety positively affects the intent to act on that information as well as the effectiveness of the action taken.
- the extent to which information is aimed at reducing delays does not positively affect the intent to act on that information or the effectiveness of the action taken.
- information of high complexity and/or novelty from the perspective of the recipient should be shared through textual means.
- information of medium complexity and a relatively low level of novelty from the perspective of the recipient can best be shared through visual means.
- the reduction in effectiveness of information sharing that this lack of trust should cause is partly mitigated by the nature of the maritime industry and the fact that repeated interaction has not occurred yet, which is not covered by this thesis' research methodology.

When these conclusions are analyzed in the context of this thesis' main research question, "How does increasing the amount of information services offered by a port authority affect the operations of captains and agents in a port?", the following findings are reached:

- increasing the amount of information services aimed at improving the safety in a port generally leads to consideration and action by captains and agents.
- information that is shared should be analyzed based on the levels of complexity and novelty from the viewpoint of the recipient to match the right distribution method with the right kind of information.
- in order to find out whether the level of trust between the port authority and information recipient has a large impact on the effectiveness more specific research should be conducted.

From these findings it can be concluded that the way in which increasing the amount of information services offered by a port authority affects the operations of captains and agents in a port depends on the goal of the information that is shared and whether that information is shared using the right distribution method. If information shared by a port authority is used by captains, their operations will be affected in order to avoid the possible negative consequences of not using the information, like delays and dangerous situations. In the context of this thesis' research, it is shown that captains who are presented with information that implies that if their vessel would alter their speed, they could potentially avoid delay in the port would generally act on this information and alter their speed by enough to avoid this potential delay. Agents' operations are affected by the information shared by a port authority through an alteration in the information that these agents would share with the vessel as well as an alteration in the information sources an agent uses to assess the port entry of a vessel he or she represents. The practical consequences of these findings will be discussed in the final chapter, chapter 6.

6. Recommendations, limitations and future research

As a result of the increases in global shipping traffic and the increased digitization rates throughout the industry which leads to massive increases in the amount of available data, port authorities are looking towards developing additional information services to aid in fulfilling their role of ensuring port safety and efficiency. As was found during the establishment of the conceptual and practical base for this thesis through the analysis of previous literature and the interviews conducted with relevant stakeholders, many ports attempt to increase the amount of information that is available digitally, while reducing the amount of person-to-person contact as much as possible. Employing digital means to disseminate information is generally done to allow for the wide distribution of that information while reducing the amount of manpower needed to reach that wide distribution. As an example of such approaches the Port of Rotterdam has developed a dashboard that contains real-time weather, tidal and wave conditions (Port of Rotterdam, Weather & Tide). The goal of this dashboard is to allow vessels to make their own decisions based on this information, and, as a result, reduce the workload for VTS operators. The results of this thesis form practical recommendations that can be used when developing new (digital) information services is considered by a port authority. Following these recommendations should maximize the effectiveness of the information that is shared and, as a result, maximize the impact the information could have on port safety and efficiency.

6.1. Practical recommendations for developing new information services in a port

When the development of new information services is considered by a port authority, the results of this thesis show that certain characteristics of the information that is intended to be shared should be analyzed to maximize the effectiveness of sharing that information. The first practical finding involves the aim of the information that is shared. This thesis' research has established that, for information to be most effectively acted on, it should be aimed at improving the safety in the port. Information aimed at the second general task of a Port Authority, avoiding congestion, is generally less acted on when shared through the (digital) methods employed in this research. As a result, Port Authorities should highlight the implications on safety of new information services to the users of those information services in order to maximize the effectiveness of sharing the new information.

The second practical implication of this thesis' research is that port authorities should assess the complexity and the novelty of the information that they intend on sharing from the viewpoint of the intended user. In establishing these levels, it is important to this viewpoint, as it was found that the level of perceived complexity of information is related to the experience of the recipient in dealing with that type of information. When the level of novelty of a certain piece of information is established from the viewpoint of the intended user it is important to consider what information they previously used. As was found in this research, it cannot be assumed that previous information services that a Port Authority offers will always be used by potential users of a new information service. Once the levels of complexity and novelty from the viewpoint of the intended users are established it is important to adapt the presentation method of that information accordingly to maximize the effectiveness of the information that is shared. Information of a relatively medium level of complexity and a relatively low level of novelty should be shared using visual means while information of higher complexity or novelty should be shared using more textual means.

The last practical finding of this thesis' results involves the apparent lack of trust between a port authority, captains and agents. Trust is identified as a major factor in the effectiveness of information sharing processes by previous literature. Even though this relationship between trust and effectiveness of information sharing is weakened by specific factors of the maritime industry (e.g., the existence of a safety-first mentality) the relationship likely does still exist. As a result, it is important for port authorities to focus on increasing the level of trust between them, captains and agents. As described in the second chapter, such a process takes time as repeated interaction is one of the major ways of improving the level of trust between two parties. A major factor identified in previous literature that affects the development of a trusting relationship between two parties is the level of dedication of the sending party to the information that is sent. As a result of this finding port authorities who develop new information services should show a high level of dedication to the information that is shared (e.g., share the information that they use themselves) in order to maximize the trust between the parties involved.

As is found in this thesis, employing the practical recommendations presented in this section will significantly affect the effectiveness of sharing new information with port users. In the aim of port authorities to maximize the safety and efficiency of port operations these recommendations should be used to maximize the effect that sharing new information has on these factors.

6.2 Limitations and future research

In conducting this research certain choices that have been made limit the generalizability of the findings. In general, the choice was made to focus the research on two groups of stakeholders, captains and agents, as they are major information users in a port. There are many other stakeholders in the information services offered by a port authority like terminals, vessel operators and nautical service providers among others. Future research could focus on including other groups of information users and find out if this thesis' findings also hold for these other groups. In addition, future research could also focus on the input, or creation side of the information and find out how to incentivize stakeholders that own or generate information to share this information with the port authority, allowing them, in turn, to also improve their services.

Another consequential choice that was made involves the method of simulation that was employed. In all simulations a digital distribution method was used, resulting from the general trend of port authorities developing new information services in a digital, computerized, manner. The choice was then also made to focus on two different methods of distribution, an email as a textual method of distribution and a web-app as a visual method of distribution. Future research could also include non-computerized distribution methods like sharing new information through VHF channels. Furthermore, the distribution methods of an email and a web-app could also be expanded upon by researching other textual and visual manners of sharing the information where, for example, textual documents can also be shared through a webpage and visualizations of information can also be sent as an image through email.

In making the methodological choice to focus on the aspects of information goals and delivery method the dynamic involving the level of trust and its effect on information effectiveness is not captured fully. In order to fully capture this dynamic, future research could include multiple different sources of data in a survey (e.g., from a port authority and a weather service) and ask respondents to attribute metrics of trust to these different sources. Such an approach would allow for a direct comparison between actions that a participant bases on information from sources that they trust to a different degree.

The last limitation of the research in this thesis is based on the choices that were made in distributing the survey to potential research participants. As can be seen from the descriptive statistics there is an overrepresentation of captains holding a PEC in the case port. It can also be seen that the sample of agents that responded is relatively small, leading to less generalizable results. Future research could focus on investigating whether the findings of this thesis hold in a larger sample of agents or different sample of captains.

Bibliography

2016. An investigation into connectivity at sea. *1st ed. [ebook] Nautilus International.* Available at: <https://www.nautilusint.org/globalassets/public-resources/pdfs/connectivity_at_sea_nautilus_whitepaper.pdf> [Accessed 15 October 2021].

Alderton, P. (2017). *Port management and operations (3rd ed.).* London: Informa Law.

Applying Advanced Information Systems to Ports and Waterways Management. (1999). https://doi.org/10.17226/6451

Athanasatos, S., Michaelides, S., & Papadakis, M. (2014). Identification of weather trends for use as a component of risk management for port operations. *Natural Hazards, 72,* 41-61.

Ayers, J. (2006). *Handbook of supply chain management.* Boca Raton, Fla.: Auerbach.

Baatz, Y., Velasco, A., Debattista, C., Gurses, O., Hjalmarsson, J., Lista, A., Lorenzon, F., Serdy, A. and Tsimplis, M., 2018. *Maritime Law. 4th ed.* New York: Informa Law.

Beamon, B. (1998). Supply chain design and analysis:. *International Journal Of Production Economics, 55(3),* 281-294. doi: 10.1016/s0925-5273(98)00079-6

Becker, H., Berger, P., Luckmann, T., Burawoy, M., Gans, H. and Mills, C., 2002. Observation and Interviewing: Options and Choices in Qualitative Research. In: T. May, ed., Qualitative Research in Action. Thousand Oaks: Sage Publications, pp.200-224.

Blanco, C., Sarasa, R., & Sanclemente, C. (2010). Effects of visual and textual information in online product presentations: looking for the best combination in website design. *European Journal Of Information Systems, 19(6),* 668-686. doi: 10.1057/ejis.2010.42

Bourque, L., & Fielder, E. (2002). *How to Conduct Self-Administered and Mail Surveys (2nd ed.).* SAGE Publications, Inc.

Boyd, H., & Westfall, R. (1965). Interviewer Bias Revisited. Journal Of Marketing Research, 2(1), 58. doi: 10.2307/3149339

Brennan, J. (2001). *Measurement Approaches: Port Capacity Methodology. In Marine Board Seminar on Waterway and Harbor Capacity* (pp. 8-11). Norbridge. Retrieved 10 May 2021, from.

Brinkhoff, A., Özer, Ö., & Sargut, G. (2014). All You Need Is Trust? An Examination of Inter-organizational Supply Chain Projects. *Production And Operations Management, 24(2),* 181-200. https://doi.org/10.1111/poms.12234

Burgess, T. (2001). *A General Introduction to the Design of Questionnaires for Survey Research* (1st ed.). Leeds: University of Leeds.

Burgoon, J., Manusov, V., & Guerrero, L. (2021). *Nonverbal communication* (2nd ed., pp. 5-46). New York: Routledge.

Carter, C., Rogers, D., & Choi, T. (2015). Toward the Theory of the Supply Chain. *Journal Of Supply Chain Management, 51(2),* 89-97. doi: 10.1111/jscm.12073

Caschili, S., & Meda, F. (2012). A Review of the Maritime Container Shipping Industry as a Complex Adaptive System. *Interdisciplinary Description Of Complex Systems, 10(1),* 1-15. doi: 10.7906/indecs.10.1.1

Cassell, C., & Symon, G. (2015). Qualitative Research in Organizations and Management: ten years on. *Qualitative Research In Organizations And Management: An International Journal, 10(4).* doi: 10.1108/qrom-10-2015-1329

Commission Of The European Communities. (2009). *Strategic goals and recommendations for the EU's maritime transport policy until 2018.* Brussels.

Cook, M. (2015). *Reading Graphically: Examining the Effects of Graphic Novels on the Reading Comprehension of High School Students (Ph.D).* Clemson University.

Crainic, T., Gendreau, M., & Potvin, J. (2009). Intelligent freight-transportation systems: Assessment and the contribution of operations research. *Transportation Research Part C: Emerging Technologies, 17(6),* 541-557.

Cridland, E., Jones, S., Caputi, P., & Magee, C. (2014). Qualitative research with families living with autism spectrum disorder: Recommendations for conducting semistructured interviews. Journal Of Intellectual And Developmental Disability, 40(1), 78-91. doi: 10.3109/13668250.2014.964191

Crouch, M., & McKenzie, H. (2006). The logic of small samples in interview-based qualitative research. Social Science Information, 45(4), 483-499. doi: 10.1177/0539018406069584

Dalati, S., Gomez, J. & Mouselli, S. (2018). Surveys and Questionnaires. In J.Gomez (Ed.), *Modernizing the academic teaching and research environment* (Vol. 1, pp. 175-186). essay, Springer.

De Borger, B., Proost, S. and Van Dender, K., 2008. Private Port Pricing and Public Investment in Port and Hinterland Capacity. *Journal of Transport Economics and Policy, 42(3),* pp.527-561.

De Langen, P., 2007. Port Competition and Selection in Contestable Hinterlands: the Case of Austria. European *Journal of Transport and Infrastructure Research, 7(1),* pp.1-14.

DiCicco-Bloom, B., & Crabtree, B. (2006). The qualitative research interview. Medical Education, 40(4), 314-321.

Di Natale, F., & Carotenuto, C. (2015). Particulate matter in marine diesel engines exhausts: Emissions and control strategies. *Transportation Research Part D: Transport And Environment, 40,* 166-191. doi: 10.1016/j.trd.2015.08.011

DiMaggio, P. (1997). Culture and Cognition. *Annual Review Of Sociology, 23(1),* 263-287. doi: 10.1146/annurev.soc.23.1.263
Donsbach, W., & Traugott, M. W. (2008). Self-Administered Paper Questionnaires. In *The sage handbook of public opinion research* (Vol. 1, pp. 262–269). essay, SAGE Pub.
Drouin, P. and Heath, R., 2009. The Pilotage Paradigm: the need for a paradigm shift. *Seaways Magazine*, [online] Available at: <http://safeship.ca/uploads/3/4/4/9/34499158/pilotage_paradigm_drouin_heath.pdf> [Accessed 17 May 2021].
Eide, A., Dyrstad, K., Munthali, A., Van Rooy, G., Braathen, S., & Halvorsen, T. et al. (2018). Combining survey data, GIS and qualitative interviews in the analysis of health service access for persons with disabilities. *BMC International Health And Human Rights, 18(1).* doi: 10.1186/s12914-018-0166-2
Feldman, M. (2002). `The Internet revolution and the geography of innovation. *International Social Science Journal, 54(171),* 47-56. doi: 10.1111/1468-2451.00358
Geerlings, H., Kuipers, B., & Zuidwijk, R. (2018). *Ports and networks* (1st ed.). New York: Routledge.
Godin, G., 1985. Modification of Riber Tides by the Discharge. *Journal of Waterway, Port, Coastal and Ocean Engineering,* pp.257-274.
Govers, R., & Go, F. (2005). PROJECTED DESTINATION IMAGE ONLINE: WEBSITE CONTENT ANALYSIS OF PICTURES AND TEXT. *Information Technology & Tourism, 7(2),* 73-89. doi: 10.3727/1098305054517327
Graziano, M., & Webb, T. (2015). The attention schema theory: a mechanistic account of subjective awareness. *Frontiers In Psychology, 06.* doi: 10.3389/fpsyg.2015.00500
Ha, A., & Tang, C. (2017). *Handbook of Information Exchange in Supply Chain Management.* Springer International Publishing.
Hafizi Said, M., & Saharuddin, A. (2009). The Marine Electronic Highway Project in Straits of Malacca and Singapore: Observation on the Present Development. *Transnav, International Journal On Marine Navigation And Safety Of Sea Transportation, 3(3).* Retrieved 23 April 2021, from https://www.researchgate.net/publication/314286085_The_Marine_Electronic_Highway_Project_in_Straits_of_Malacca_and_Singapore_Observation_on_the_Present_Development.
Heilig, L., & Voß, S. (2016). Information systems in seaports: a categorization and overview. *Information Technology And Management, 18(3)*, 179-201. doi: 10.1007/s10799-016-0269-1
Helberg, D. (1994). Operating Environment for Today's Ports. *In National Conference on the Intermodal Freight Terminal of the Future.* Washington, DC: Transportation Research Board.
Hibbing, A., & Rankin-Erickson, J. (2003). A Picture Is Worth a Thousand Words: Using Visual Images to Improve Comprehension for Middle School Struggling Readers. *The Reading Teacher, 56(8).*
Hicks, S., & Szabados, M. (2006). *Understanding tides* (pp. 5-10). Silver Spring: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Center for Operational Oceanographic Products and Services.
Hildum, D., & Brown, R. (1956). Verbal reinforcement and interviewer bias. The Journal Of Abnormal And Social Psychology, 53(1), 108-111. doi: 10.1037/h0040518
In: IMO NAV 55. 2009. The 55th session of IMO Sub-Committee on Safety of Navigation. London: Lloyd's Register.
Industry Partners, Standards Partners and Endorsers of the ITPCO, IHMA, IAPH and UKHO, 2021. Port Information Manual For Ship-Port Interface Data. [online] International Taskforce Port Call Optimization. Available at: <https://portcalloptimization.org/images/Port%20Information%20Manual%203.02.pdf> [Accessed 12 May 2021].
International Maritime Organization, 2012 Guidelines For The Development Of A Ship Energy Efficient Management Plan (SEEMP), MEPC.213(63) (2 March 2012). Retrieved from https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/MEPCDocuments/MEPC.213(63).pdf
International Maritime Organization, Assembly, Code of Practice for the Safe Loading and Unloading of Bulk Carriers, A.862(20) (27 November 1997A). Retrieved from https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/AssemblyDocuments/A.862(20).pdf
International Maritime Organization, Assembly, Guidelines for Vessel Traffic Services, A.857(20) (27 November 1997B). Retrieved from https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/AssemblyDocuments/A.857(20).pdf
International Maritime Organization, Assembly, Guidelines for Voyage Planning, A.863(21) (25 November 1999). Retrieved from https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/AssemblyDocuments/A.893(21).pdf

International Maritime Organization, International Convention for the Safety of Life At Sea (1 November 1974), 1184 UNTS 3. Retrieved from https://www.refworld.org/docid/46920bf32.html
International Taskforce Port Call Optimization. (2020). Appendix to Port Call Process. International Association of Ports and Harbours. Retrieved from https://portcalloptimization.org/images/Business%20process%20appendix%20200406.pdf
Jervis, M., & Drake, M. (2014). The Use of Qualitative Research Methods in Quantitative Science: A Review. Journal Of Sensory Studies, 29(4), 234-247. doi: 10.1111/joss.12101
Jiménez, P., Gómez-Fuster, J., & Pavón-Mariño, P. (2021). HADES: A Multi-Agent Platform to Reduce Congestion Anchoring Based on Temporal Coordination of Vessel Arrivals—Application to the Multi-Client Liquid Bulk Terminal in the Port of Cartagena (Spain). *Applied Sciences, 11(7),* 3109. doi: 10.3390/app11073109
Juhel, M., 1999. Global Challenges for Ports and Terminals in the New Era. *Ports and Harbors, 44(2).*
Kallio, H., Pietilä, A., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review: developing a framework for a qualitative semi-structured interview guide. *Journal Of Advanced Nursing, 72(12),* 2954-2965. doi: 10.1111/jan.13031
Kalyvas, C., Kokkos, A., & Tzouramanis, T. (2017). A survey of official online sources of high-quality free-of-charge geospatial data for maritime geographic information systems applications. *Information Systems, 65,* 36-51. https://doi.org/10.1016/j.is.2016.11.002
Keceli, Y. (2011). A proposed innovation strategy for Turkish port administration policy via information technology. *Maritime Policy & Management, 38(2),* 151-167. https://doi.org/10.1080/03088839.2011.556676
Kite, M., & Whitley, Jr., B. (2016). *Psychology of Prejudice and Discrimination* (3rd ed.). New York: Routledge.
Kramer, M., Schmalenberg, C., & Keller-Unger, J. (2009). Incentives and Procedures Effective in Increasing Survey Participation of Professional Nurses in Hospitals. *Nursing Administration Quarterly, 33(2),* 174-187. doi: 10.1097/naq.0b013e3181a10db6
Krieger-Boden, C., 2000. Globalization, integration and regional specialization. *Kiel Working Papers,* 1009.
Kumar, R., & Pugazhendhi, S. (2012). Information Sharing in Supply Chains: An Overview. *Procedia Engineering, 38,* 2147-2154. doi: 10.1016/j.proeng.2012.06.258
Kurtuluş, M., Ülkü, S., & Toktay, B. (2012). The Value of Collaborative Forecasting in Supply Chains. *Manufacturing & Service Operations Management, 14(1),* 82-98. https://doi.org/10.1287/msom.1110.0351
Lambrou, M., Rødseth, Ø., Foster, H., & Fjørtoft, K. (2012). Service-oriented computing and model-driven development as enablers of port information systems: an integrated view. *WMU Journal Of Maritime Affairs, 12(1),* 41-61. https://doi.org/10.1007/s13437-012-0035-0
Lang, N., & Veenstra, A. (2009). A quantitative analysis of container vessel arrival planning strategies. *OR Spectrum, 32(3),* 477-499. doi: 10.1007/s00291-009-0186-3
Le Carrer, N., Ferson, S., & Green, P. (2020). Optimising cargo loading and ship scheduling in tidal areas. *European Journal Of Operational Research, 280(3),* 1082-1094. doi: 10.1016/j.ejor.2019.08.002
Lee, G., Kim, S., & Lee, M. (2015). Economic evaluation of vessel traffic service (VTS): A contingent valuation study. *Marine Policy, 61*, 149-154. doi: 10.1016/j.marpol.2015.08.011
Lee, H., Padmanabhan, V., & Whang, S. (1997). Information Distortion in a Supply Chain: The Bullwhip Effect. *Management Science, 43(4).* https://www.jstor.org/stable/2634565?seq=1.
Level, D. (1972). Communication Effectiveness. *The ABCA Journal Of Business Communication, 10(1),* 19-25. doi: 10.1177/002194367201000102
Lin, B. and Huang, C., 2006. Comparison Between ARPA Radar and AIS Characteristics for Vessel Traffic Services. *Journal of Marine Science and Technology, 14(3),* pp.182-189.
Lugt, L., Langen, P., & Hagdorn, L. (2015). Beyond the landlord: worldwide empirical analysis of port authority strategies. *International Journal Of Shipping And Transport Logistics, 7(5),* 570. doi: 10.1504/ijstl.2015.072021
Lumsden, K., & Mirzabeiki, V. (2008). Determining the value of information for different partners in the supply chain. *International Journal Of Physical Distribution & Logistics Management, 38(9)*, 659-673. https://doi.org/10.1108/09600030810925953
Maes, P. (1995). Agents that Reduce work and information Overload. *Readings In Human–Computer Interaction*, 811-821. doi: 10.1016/b978-0-08-051574-8.50084-4
Margariti, R. (2008). Mercantile Networks, Port Cities, and "Pirate" States: Conflict and Competition in the Indian Ocean World of Trade before the Sixteenth Century. *Journal Of The Economic And Social History Of The Orient, 51(4),* 543-577.
Martin, D. (1999). Edifact and the book trade. *Publishing Research Quarterly, 15(2),* 14-17.
McCarthy, T., & Golicic, S. (2002). Implementing collaborative forecasting to improve supply chain performance. *International Journal Of Physical Distribution And Logistics Management, 32(6).* Retrieved 30 April 2021, from https://www-emerald-com.eur.idm.oclc.org/insight/content/doi/10.1108/09600030210437960/full/pdf.
McCreadie, M. and Rice, R., 1999. Trends in analyzing access to information. Part I: cross-disciplinary conceptualizations of access. *Information Processing & Management, 35(1),* pp.45-76.

Mentzer, J., DeWitt, W., Keebler, J., Min, S., Nix, N., Smith, C., & Zacharia, Z. (2001). DEFINING SUPPLY CHAIN MANAGEMENT. *Journal Of Business Logistics, 22(2),* 1-25. doi: 10.1002/j.2158-1592.2001.tb00001.x
Montesinos, H., Connors, J. and Gwartney, J., 2020. The Transportation-Communication Revolution: 50 Years of Dramatic Change in Economic Development. *The Cato Journal, 40(1),* pp.153-198.
Murphy, E. (1998). Information Technology Could Transform Logistics. *Purchasing, 125(7),* 115-118.
Nanes, M., & Haim, D. (2020). Self-Administered Field Surveys on Sensitive Topics. *Journal Of Experimental Political Science,* 1-8. doi: 10.1017/xps.2020.12
Nijdam, M., & van der Horst, M. (2018). Port Definition, Concepts and the Role of Ports in Supply Chains. In H. Geerlings, B. Kuipers & R. Zuidwijk, *Ports and Networks* (1st ed.). Routledge. Retrieved 10 May 2021, from.
Norman, R. (2011). Reading the graphics: what is the relationship between graphical reading processes and student comprehension*? Reading And Writing, 25(3),* 739-774. doi: 10.1007/s11145-011-9298-7
Notteboom, T. (2006). The Time Factor in Liner Shipping Services. *Maritime Economics & Logistics, 8*, 19-39.
Notteboom, T., & Cariou, P. (2013). Slow steaming in container liner shipping: is there any impact on fuel surcharge practices?. *The International Journal Of Logistics Management, 24(1),* 73-86. doi: 10.1108/ijlm-05-2013-0055
Oh, S., & Özer, Ö. (2013). Mechanism Design for Capacity Planning Under Dynamic Evolutions of Asymmetric Demand Forecasts. *Management Science, 59(4),* 987-1007. doi: 10.1287/mnsc.1120.1581
Organization for Economic Co-operation and Development, 2011. Information Exchanges Between Competitors under Competition Law. *Policy Roundtables.* Organization for Economic Co-operation and Development.
Owen, C., Béguin, P. and Wackers, G., 2009. *Risky work environments: Reappraising Human Work Within Fallible Systems.* 1st ed. Boca Raton: CRC Press.
Özer, Ö., & Zheng, Y. (2017). Establishing Trust and Trustworthiness for Supply Chain Information Sharing. In A. Ha & C. Tang, *Handbook of Information Exchange in Supply Chain Management* (pp. 287-309). Springer Nature. Retrieved 30 April 2021, from.
Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive Load Theory and Instructional Design: Recent Developments. *Educational Psychologist, 38(1),* 1-4. doi: 10.1207/s15326985ep3801_1
Paixão, A., & Marlow, P. (2002). Strengths and weaknesses of short sea shipping. *Marine Policy, 26(3),* 167-178. https://doi.org/10.1016/s0308-597x(01)00047-1
Panayides, P., & Song, D. (2009). Port integration in global supply chains: measures and implications for maritime logistics. *International Journal Of Logistics Research And Applications, 12(2),* 133-145. doi: 10.1080/13675560902749407
Parolas, I., 2016. *ETA prediction for containerships at the Port of Rotterdam using Machine Learning Techniques.* MSc. Delft University of Technology.
Paschall, K. (2014). *A comparison of a traditional text and its graphic adaptation on reading comprehension in a secondary classroom (Ph.D).* Union University, Jackson TN.
Patraiko, D. (2007). Introducing the e-navigation revolution. *Seaways, The International Journal Of The Nautical Institute,* (March). Retrieved 23 April 2021, from https://www.nautinst.org/uploads/assets/uploaded/0e0ad118-f084-4e56-942c6c148a4fa6ff.pdf.
Patraiko, D. (2021). Under Keel Clearance. *The Navigator - Inspiring Professionalism In Marine Navigators, (26), 2.*
Patraiko, D., Wake, P., & Weintrit, A. (2010). e-Navigation and the Human Element. Transnav*, International Journal On Marine Navigation And Safety Of Sea Transportation, 4(1).*
Podsakoff, P., MacKenzie, S., Lee, J., & Podsakoff, N. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal Of Applied Psychology, 88(5), 879-903.
Polanyi, K. (1963). Ports of Trade in Early Societies. *The Journal Of Economic History, 23(1),* 30-45. doi: 10.1017/s002205070010333x
Port of Rotterdam. (n.d.). Weather & Tide. Weather & Tide Dashboard. Retrieved January 27, 2022, from https://weather-tide.portofrotterdam.com/desktop/
Potter, M., Wyble, B., Hagmann, C., & McCourt, E. (2013). Detecting meaning in RSVP at 13 ms per picture. *Attention, Perception, & Psychophysics, 76(2),* 270-279. doi: 10.3758/s13414-013-0605-z
Reams, P., & Twale, D. (2008). The promise of mixed methods: discovering conflicting realities in the data. *International Journal Of Research & Method In Education, 31(2),* 133-142. doi: 10.1080/17437270802124509
Rhodes, P. (2011). *A History of the Classical Greek World* (1st ed.). Hoboken: Wiley.
Richman, W., Kiesler, S., Weisband, S., & Drasgow, F. (1999). A meta-analytic study of social desirability distortion in computer-administered questionnaires, traditional questionnaires, and interviews. Journal Of Applied Psychology, 84(5), 754-775. doi: 10.1037/0021-9010.84.5.754
Ritter, L., & Sue, V. (2007). Introduction to using online surveys. *New Directions For Evaluation, 2007(115)*, 5-14. doi: 10.1002/ev.230
Rodrigue, J., & Browne, M. (2008). International Maritime Freight Transport and Logistics. In *R. Knowles, J. Shaw & I. Docherty, Transport Geographies: Mobilities, Flows and Spaces* (1st ed.). New Jersey: Wiley-Blackwell.

Rosner, B. (1983). Percentage Points for a Generalized ESD Many-Outlier Procedure. *Technometrics, 25(2),* 165-172. doi: 10.1080/00401706.1983.10487848

Ryu, C. (2006). *An Investigation of Impacts of Advanced Coordination Mechanisms on Supply Chain Performance: Consignment, VMI I, VMI II, and CPFR (Ph.D.).* State University of New York at Buffalo.

Salazar, M. (1990). Interviewer Bias. AAOHN Journal, 38(12), 567-572. doi: 10.1177/216507999003801203

Sannasiraj, S., Zhang, H., Babovic, V., & Chan, E. (2004). Enhancing tidal prediction accuracy in a deterministic model using chaos theory. *Advances In Water Resources, 27(7),* 761-772. doi: 10.1016/j.advwatres.2004.03.006

Schubert, A., 2001. *Shared knowledge, body language, and time: A collaborative model of communication. Ph.D.* Syracuse University.

Shamir, N., & Shin, H. (2017). In *A. Ha & C. Tang, Handbook of Information Exchange in Supply Chain Management* (pp. 263-287). London: Springer Nature.

Smith, L., Sweeney, D. and Campbell, J., 2009. Simulation of alternative approaches to relieving congestion at locks in a river transportation system. *Journal of the Operational Research Society, 60*, pp.519-533.

Solari, G., Repetto, M., Burlando, M., De Gaetano, P., Pizzo, M., Tizzi, M., & Parodi, M. (2012). The wind forecast for safety management of port areas. *Journal Of Wind Engineering And Industrial Aerodynamics*, 104-106, 266-277. doi: 10.1016/j.jweia.2012.03.029

Song, S. (2014). Ship emissions inventory, social cost and eco-efficiency in Shanghai Yangshan port. *Atmospheric Environment*, 82, 288-297. doi: 10.1016/j.atmosenv.2013.10.006

Stair, R., & Reynolds, G. (2010). *Principles of Information Systems, A Managerial Approach* (9th ed., p. 6). Cengage Learning.

Stefansson, G. (2002). Business-to-business data sharing: A source for integration of supply chains. *International Journal Of Production Economics, 75(1-2),* 135-146. https://doi.org/10.1016/s0925-5273(01)00187-6

Sternberg, R., & Sternberg, K. (2012). *Cognitive psychology* (6th ed.). Belmont: Wadsworth.

Sub-Committee on Safety of Navigation. (2007). NAV 53/22 (pp. 38-45). International Maritime Organization. Retrieved from https://www.mpa.gov.sg/web/wcm/connect/www/94967ff3-ddd6-434c-99c4-01f5c50026de/nav53-22.pdf?MOD=AJPERES

Sweller, J., & Chandler, P. (1991). Evidence for Cognitive Load Theory. *Cognition And Instruction, 8(4),* 351-362. doi: 10.1207/s1532690xci0804_5

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive Load Theory* (1st ed.). New York: Springer Science.

Talley, W. (2009). *Port economics.* Abingdon: Routledge.

Thiers, G., & janssens, G. (1998). A Port Simulation Model as a Permanent Decision Instrument. *Simulation, 72(2),* 117-125.

Tseng, P., & Liao, C. (2012). Supply Chain Intgration, Information Technology, Market Orientation and Firm Performance in Container Shipping Firms. *The International Journal Of Logistics Management, 26(1),* 82-106.

Turner, D. (2018). Qualitative Interview Design: A Practical Guide for Novice Investigators. The Qualitative Report, 15(3). doi: 10.46743/2160-3715/2010.1178

United Nations Centre for Trade Facilitation and Electronic Business, 2005. Recommendation No.33. Geneva: United Nations.

United Nations Conference on Trade and Development. (2018). *Review of Maritime Transport.* New York: United Nations Publications.

Valet, S., Piskoty, G., Michel, S., Affolter, C., & Beer, M. (2013). Accident caused by dynamic overloading of a ship mooring rope. *Engineering Failure Analysis, 35,* 439-453. doi: 10.1016/j.engfailanal.2013.03.027

van Baalen, P., Zuidwijk, R., & van Nunen, J. (2008). Port Inter-Organizational Information Systems: Capabilities to Service Global Supply Chains. *Foundations And Trends In Technology, Information And Operations Management, 2(2–;3),* 81-241. doi: 10.1561/0200000008

Vermindering van de emissies van de scheepvaartsector. (2021). Retrieved 15 October 2021, from https://ec.europa.eu/clima/eu-action/transport-emissions/reducing-emissions-shipping-sector_nl

Verstichel, J., De Causmaecker, P., Spieksma, F. and Vanden Berghe, G., 2014. *The generalized lock scheduling problem: An exact approach. Transportation Research, 65,* pp.16-34.

Waern, Y. (1981). On the Relation between Comprehension and Memory of a Complex Text. *Scandinavian Journal Of Educational Research, 25(1),* 21-37. doi: 10.1080/0031383810250103

Wang, D. and Chan, H., 2011. A Theory Of Instinctive Information Sharing. In: *PACIS 2011.* Brisbane: Queensland University of Technology.

Wang, X., 2014. *Operational Transportation Planning of Modern Freight Forwarding companies: Vehicle Routing under Consderation of Subcontracting and Request Exchange. Ph.D.* University of Bremen.

Wild, R. (2010). The Paradigm and the Paradox of Perfect Pilotage. *Journal Of Navigation, 64(1),* 183-191. doi: 10.1017/s0373463310000366

Wu, R., Appel, L., Morra, D., Lo, V., Kitto, S., & Quan, S. (2014). Short message service or disService: Issues with text messaging in a complex medical environment. *International Journal Of Medical Informatics, 83(4),* 278-284. doi: 10.1016/j.ijmedinf.2014.01.003

Zhao, X., Xie, J. and Zhang, W., 2002. The Impact of Information Sharing and Ordering Coordination on Supply Chain Performance. *Supply Chain Management,* [online] 7(1), pp.24-40. Available at: <https://www.emerald.com/insight/content/doi/10.1108/13598540210414364/full/html> [Accessed 4 May 2021].

Zhao, X., Xie, J., & Zhang, W. (2002). The impact of information sharing and ordering co-ordination on supply chain performance. *Supply Chain Management: An International Journal, 7(1),* 24-40. https://doi.org/10.1108/13598540210414364

Zhu, F., & Liu, Q. (2018). Competing with complementors: An empirical look at Amazon.com. *Strategic Management Journal, 39(10),* 2618-2642. doi: 10.1002/smj.2932

Zuidwijk, R. (2018). *Ports and Global Supply Chains.* In H. Geerlings, B. Kuipers & R. Zuidwijk, Ports and Networks (1st ed., pp. 26-38). Routledge. Retrieved 10 May 2021, from.

Zuidwijk, R., & Veenstra, A. (2010). *The Value of Information in Container Transport: Leveraging the Triple Bottom Line.* Rotterdam: Erasmus Research Institute of Management. Retrieved from https://repub.eur.nl/pub/20994