THE INTERNET OF THINGS IN THE PORT OF ROTTERDAM

LITERATURE REVIEW ABOUT INTERNET OF THINGS

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Abstract

A literature review has been done to investigate the influence of the Internet of Things development on the efficiency of container transport. Further on these changes will be applied to the Port of Rotterdam, giving their influences on the changed competitive position.

By conducting a literature review applications of the Internet of Things will be identified. This will contribute to increased efficiency. Main focus will be on changes influenced by the opportunities for improvement in Port Community system and Intelligent containers. These efficiency changes will be applied to the current competitive position of the Port of Rotterdam. Part of this analysis will come from a conducted interview.

The first application is the real-time tracking of containers. Secondly, container information can be used for optimal stacking. Thirdly, the Internet of Things eases the transition to automated terminals. Fourthly, the handling time customs need can be shortened. Finally, the increased data exchange gives the possibility to optimize and change the supply chain. However, there are three major threats that can endanger the implementation of the Internet of Things in the port of Rotterdam. These are security risks, support for changes and shifts in the economic spectrum.

Summarizing, the potential influence of the five aforementioned IT developments has profound consequences for the efficiency of container shipping in the port of Rotterdam if the three threats can be tackled. Leading parties in the development should be The Port of Rotterdam Authority and Portbase. By stimulating other parties to keep up with the evolution of the Internet of Things they can help make Rotterdam the most attractive port compared to its two main rivals, Hamburg and Antwerp. Rotterdam's exquisite geographical location contributes here as well.

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Introduction

Introduction

The Netherlands is the home of the largest port of Europe: the port of Rotterdam. This is also the largest container port in Europe, with an annual throughput of 12.304.876 TEU's in 2014 (Port Of Rotterdam, 2015). However, it's global position is becoming less important. From once being the largest port Rotterdam now has become the twelfth largest port worldwide, with rivals coming close to overtake this position (Vossers, 2015). One can conclude that Rotterdam is not able to compete anymore with ports worldwide. Its position as largest port of Europe is at risk also. Hamburg and Antwerp are firm competitors in the race for market share. Losing a lot of market share is not an option; the port is accountable for 3.5 percent of the Dutch economy (Vossers, 2015). It is one of the most important economic hubs in the Netherlands, so losing its strong position would mean a decrease in the whole Dutch economy. Keeping ahead of the rivals is an important matter.
Another trend in the last 15 years is the upcoming use of the internet. Since the implementation during the 90's it became an essential source, influencing almost everything around us. It became an indispensable factor in the logistics-sector, ports included. According to some scientists we are upon a new revolution, called the Internet of Things. An Internet of Things society is a place where every physical object is connected and exchanging information with other objects in a network. Less than one percent of its potential is as yet implemented. The total potential is estimated to be 1.5 trillion objects (DHL & Cisco, 2015). It can also be applied to the logistics and supply chains. It is estimated that the Internet of Things can create a value of 1.9 trillion dollars in this sector (DHL & Cisco, 2015). One can conclude that the potential of this future trend is enormous. This paper aims to give insight in the influence of implementation of the Internet of Things to container transportation, and more specifically the efficiency of container transportation. The effects on efficiency on ports itself will be examined, and in addition two major changes in the supply chain will be covered in this research. Chosen is to apply the changes to the port of Rotterdam.

This research paper will focus on container transport for numerous reasons. Since it has been the fastest growing commodity in the port of Rotterdam, it is socially and economically relevant to study developments in this field (De Langen & Nijdam, 2012). Furthermore it has some practical reasons. Containers are the commodity where implantation of new information technology can be applied most easily due to its nature. Its standardized size and fixed walls make it easy to attach sensors. In this way containers will probably become the precursor when implementing these new technologies.

Research Question

This paper will be answering the following question

What is the influence of the Internet of Things-development on the efficiency of container transportation?

Structure of this research

Due to the lack of data available this paper will consist of a literature review.
The research will cover three major parts. The first part will be the literature review. Container transport will be introduced and the role of ports in container chains will be discussed. The main players in container ports as well as main port determinants for container carriers will complement the container stage. It continues with the Internet of Things development. This topic will be introduced, when two key elements will be discussed: the Intelligent container and the Port community system.
The second part will be the empirical analysis, in which the benefits of the IoT developments will follow, giving the applications of the development. When the benefits are discussed they will be applied to the current situation of Rotterdam. Also the risks will be examined, giving a veracious view.
The conclusion will consist of the most important risks and benefits of implementation. Furthermore an attempt will be made to predict if Rotterdam is able to hold its competitive position, with a recommendation for the development of IoT in Rotterdam.

Literature Review

Container transport:

During the 1950's an American truck-company owner named Malcom McLean started using containers as a method of shipping. By using a specially customized ship he was able to transport 35 containers around the east coast of the United States, hereby avoiding the jammed roads (Curry, 2013). In 1966 a company called Sea-Land was the first to use containers for transatlantic shipment. By sailing from Port Elizabeth, U.S.A., to Rotterdam in the Netherlands the first international container journey became reality. Due to the extreme costs of investments involved with adjusting material to container usage a lot of carriers did not change immediately to container shipment. However, later on, it turned out the investments costs were worth their while. The shipping costs of a container compared to traditional break-bulk shipment were lower, making it possible for companies like Sea-land to make extraordinary profits (World Shipping Coucil, 2015). However, container transportation was still far from ideal. Due to differently sized containers used by different companies the transportation cycle was not optimized. During the 1960's a standardized size was introduced in container shipment. The twenty foot equivalent unit, TEU for short, became the standard unit for a container. One TEU equals 20 x 8 x 8 feet. Nowadays most containers used are equal to 2 TEU (Levinson, 2006). The standardized dimensions have since caused a boost in the use of containers. This was accountable for making intermodal transportation more easy. Also, it replaced the need of handling all cargo piece by piece. This resulted in a more efficient way of transportation (Baalen, Zuidwijk, & Nunen, 2009).

Seaports as hubs

Seaports are an important hub in multiple global transportation networks. According to Veenstra (2006) ports serve three main purposes. Firstly, ports are transhipment points. Secondly, ports are logistic centres in supply chains. These logistic centres are specialized in value adding activities such as transforming and re-packaging cargo. Distribution centres near ports are a good example of such activities. Thirdly, ports serve as industrial areas.

Due to the nature of container transport the first two purposes are most relevant. The port of Rotterdam is mainly used as transhipment hub (Notteboom & Rodrigue, 2005).

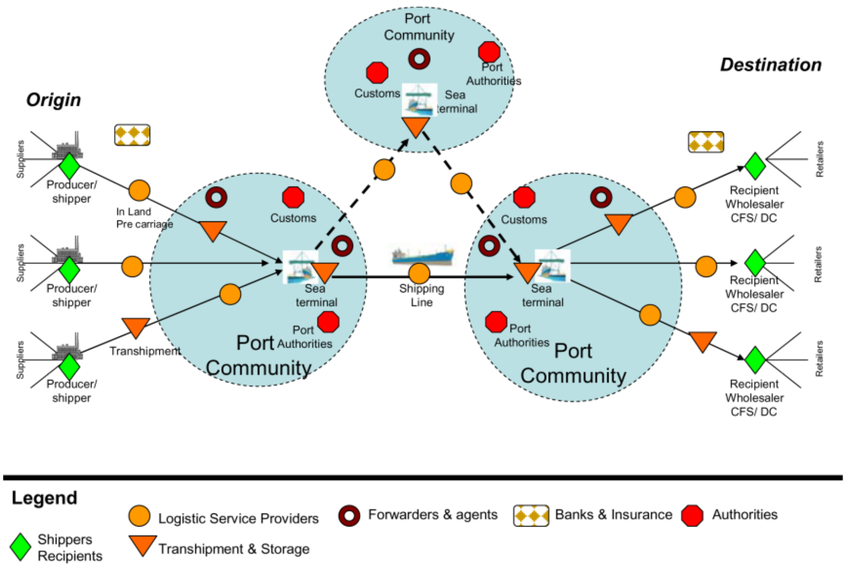

Figure 1: (Baalen, Zuidwijk, & Nunen, 2009)

Players in container transportation

There are five types of organizations involved in the shipping of containers in the global transportation networks. These are customer groups, organizing groups, physical groups, authorization groups and financial groups (Wagenaar, 1992).
The customer groups are the senders and the receivers of the final container. The organizing group consists of the companies which arrange the transportation of the container. Nowadays companies outsource the transportation to specialized companies whose core business is transportation. Examples are freight forwarders and logistic service providers. The physical group is the group which actually handles the container and takes physical care of the container. This group is responsible for the actual transport. Terminal operators and carriers are examples of physical group actors. The fourth group is the authorization group, which consists in an extended way of the government. This group sets and maintains rules in the port, like customs and port authorities. The final group is the financial group, with banks and insurance companies as most important actors. The financial group is responsible for the financial actions between different groups. This research will focus on the organizing, physical and authorization group since it focusses on the actual handling and transferring of containers in the supply chain.

The main investors in terminal facilities for the transhipment of containers can be found in the physical group. There are two different types of investors. The first type consists of shipping companies with pre-destined routes. These companies are vertically integrated in multiple chains. The shipping companies want to have their own terminals to load and unload their own ships. Their terminals are determined for own or partner use only. The second type of investors are the independent terminal operators. Independent terminal operators are specialized in the loading and unloading of vessels. They have multiple

customers who make use of their facilities.
The authorization group can also be seen as a main investor in port-related activities. Contrary to the physical group investors their investments are more of a facilitating nature. Their function is to make the port environment as interesting and safe as possible for all actors in the port, creating a competitive playing field for private port actors.

Port competition

While the tonnage of containers that is transported is growing over time, the number of container transfer points is also increasing (Veldman & Bückmann, 2003). This results in a more fierce competition in the container market than other commodities. This level of competition is caused by the nature of containers, which can be easily shifted between ports. Port shifting will be more easy for independent carriers due to their lack of investment in terminal facilities (De Langen & Nijdam, 2012). The shipping companies with own terminal facilities are more conservative decision makers who will not change ports often. This is displayed by the fact that more than 80 percent of shipping companies will not shift to other ports if the current port is performing satisfactorily, even if other ports show a better performance (Tongzon, 2002). Part of this nature of non-active changing between ports consists of long-term contracts between port-authorities and shipping companies. These contracts are making it impossible for shipping companies to change ports on a short-term base.

The port selection process of carriers and shipping companies is influenced by multiple factors. However, the influencing factors do not coincide in all research. Of these factors three will be looked at more closely as main determinants for port choice: geographical location, monetary costs and port quality.
Malchow (2004) considers geographical location as the most important factor of influence. Port accessibility, hinterland accessibility and distance to location are parts this factor is based on. Port accessibility will be mainly determined by the draft of a port. Due to economies of scale that occur the size of container vessels is growing over time (Cullinane & Khanna, 1999). In 2006 the largest vessels had a capacity of 15500 TEU, but the first 20000 TEU vessels have already been ordered (Shen, 2015). Not all ports are able to receive the largest vessels anymore due to draft problems, so the accessibility of ports can be an advantage. The second important determinant is monetary costs (Ng, 2006). Port charges and terminal fees are components of this determinant. The last main factor for port choice will be port quality (Ng, 2006). Port quality consist of multiple components. Important factors are shipping frequency, port efficiency, port infrastructure, service quality and a good reputation related to cargo handling (Tongzon, 2002).

Port Efficiency

This research will focus on the efficiency of ports. According to PWC & Panteia (2013) port efficiency can be described as the correct mix and standard of port services provided with the minimum use of resources. Time can be considered as one of these resources. The efficiency can be determined for every distinct chain, like terminal handling or custom handling, but also for ports altogether.

As stated above, port efficiency is one of the determinants of port quality according to Tongzon (2012). Although he argues that there is no ranking in importance of aspects of port quality, other research debunks this. According to Clark, Dollar and Micco (2004) the most important quality determinant is port efficiency. They found that an increase in efficiency from 25th to 75th percentiles can lower the shipping costs with over 12%, which will result in declining costs. This relationship is confirmed by Sanchez et al. (2003), who show a significant relationship between port efficiency and transportation costs. So one can say that increased efficiency leads to fewer costs.
Efficiency will also influence the environmental impact of container transportation. Environmental issues are becoming more important in ports the last decades. This can be displayed by the fact that in 85% of port award contracts an environmental clause is included (PWC & Panteia, 2013). Companies are more aware of their environmental responsibilities. Efficiency-increase can help companies in this field by making their operations less harmful to environment and more sustainable.

IT-development

Information Technology (IT) has been of vital importance for the supply chains all over the world. Since the increased possibilities of information exchange IT has changed supply chains radically. It starts with the exchange of data electronically, the so-called EDI, and hereby replaces paper forms. This can be developed into whole platforms made from data exchange between different organizations, an inter-organizational system (IOS).

Internet of Things

A major development in the IT-sector is the Internet of Things (IoT). The Internet of Things is an environment in which all kinds of objects will communicate with each other. The IoT is a global development which is not just applicable for port use. The potential of the IoT in general is enormous, as it can generate a value equal to 4.6 trillion dollars for the public sector and 14.4 trillion dollars for the private sector over the next 10 years (Bradley, Reberger, Dixit, & Gupta, 2013). Part of this added value can be generated in ports, and more specifically in the container transport.

The IoT environment which will be relevant for the container handling will connect all the different parts of the supply chain via the internet. This will be the machinery, the terminals, the containers themselves, but also human beings or inland freight transporters (Xia, Yang, Wang, & Vinel, 2012). All these parts will provide information about their current status, which will be retrieved by its owner. However, the extra value will be created when the information of multiple parties is exchanged. This information exchange will happen via a Port Community System (PCS), which is already facilitating the exchange of data in ports. If all the data from the whole supply chain will be exchanged via a PCS, the port will become an information hub where an enormous amount of information will be exchanged. This can result in increased port- or terminal efficiency and an increased level of security.

Port Community System

A Port Community system (PCS) is a central platform which connects different actors in a port community with each other. It is a standardized platform for communication in a port. Exchanging data via a PCS will increase the efficiency of the port actors' systems (IPCSA, 2015).

The centralized approach of using a PCS instead of different actors who operate by themselves to exchange data has three major advantages. Firstly, the PCS will be a central place where information exchange will occur. Multiple companies will be connected to the PCS, hereby creating a multilateral web of connections. This avoids problems with bilateral contact between two actors in the port community since all companies are connected via the PCS.

The second advantage is that there is no need to retype data for specified systems. All PCS-applications are using the same language for all actors. This means that all data that is available in the central storage of a PCS can be used immediately, without the need to be rewritten. It also replaces the physical documentation since only digital information is allowed on a PCS. The electronical exchange of documentation without the need for rewriting results in a reduction of errors and processing costs.

The last advantage of a PCS is the transparency of the data. The data available will automatically be synchronized with the latest information companies have. This will result in the availability of up-to-date data. This data can be used perfectly for testing the efficiency of systems and the tracking and tracing of goods. Furthermore, there will be no misunderstandings with the usage of older data (Baalen, Zuidwijk, & Nunen, 2009).

System Architecture

A PCS generally focusses on three key factors: data capturing, data organization and data processing.

Data Capturing

The first step of a communication system is the retrieving of relevant data. This information can be provided by the container itself, such as location information, or facilities used for the transportation, like terminals. The data can be obtained in two ways. Firstly, the data can be received from other organizations and be used for further implementation. It can occur that this information needs to be rewritten to be of any value, which can lead to processing costs. The second option is that the organization itself retrieves the data from the container. The data can be retrieved by barcodes or radio frequency identification (RFID), complied of small chips with antennae for sending signals. RFID is hereby the most favourable option. In contrast to barcodes it does not need to be positioned precisely beneath a scanner to be read (Technovelgy, 2013). Furthermore it does not need human intervention, which is an unpredictable factor and thus a risk in the container flow (McFarlane & Sheffi, 2003). Another advantage of RFID is the option to write extra information on the tag. While a barcode contains a certain amount of information an RFID tag is capable of containing even more relevant information, which can be retrieved at a next stop.

An evolution going hand-in-hand with the development of the Internet of Things is the evolution of a container into an intelligent object. Intelligent objects are able to communicate and participate in systems. There are five main factors which need to be present for an object to be considered intelligent. These requirements are that (1) it has its own unique identity, (2) it can communicate with its environment in an effective way, (3) it is able to contain and exchange information about itself, (4) it is capable of deploying a language to show its current status and (5) it has the capacity to influence decisions about its destination (Zaharudin, et al., 2002). Containers are able to contain all five of these requirements.

The most attainable improvement in intelligent containers lies in the tracking abilities of containers. Real-time updates of the current positioning of containers can have huge value for the transportation of containers. These give the possibility to increase the port efficiency, while at the same time a change in the supply chain in general of container transport may be caused (Baalen, Zuidwijk, & Nunen, 2009) (UPS Supply Chain Solutions, 2005). Furthermore, the real-time tracking can also be beneficial for the container security (Tsai, 2006).Intelligent containers can also be equipped with e-seals. E-seals are electronic seals which will register whether the seal is broken or not. In combination with real-time location data this is useful information for customs (Tenacent, 2014).

Data Organization

Next from the data capturing is the exchange of data between different organizations. There is a need to establish connections between the different actors. This can be done in various ways. The most straightforward way is via a network with a lot of bilateral connections. However, in a bilateral system there are a lot of connections that need to be made if one wants to create a well-connected port community. Therefore, the solution is to create a hub. A hub is a central platform to which all different actors are connected . In this way there are less connections needed since an actor is able to connect to the network with just one connection to the hub. There are multiple forms of hubs, such as private hubs or central hubs. The characteristics of the hub are of great importance for the communication system that is created. A private hub means the network is controlled by one strong party, while an independent operator is the stronghold of a central hub. The central hub is thought to be the most efficient in communities without a dominant party (Baalen, Zuidwijk, & Nunen, 2009).

Data Processing

The last part of the Port Community system is the processing of the retrieved and communicated data. The processed data can be used for the planning of container transport. There are four manners of planning by data from IOS. This can be done in a range varying from intra-organization to inter-organization. It might seem that the further the cooperation reach the more successful the planning would be, but this is not true; due to the changing organizations in the supply chain and the fact that various organizations participate in multiple supply chains, which involves taking a lot into account, the intra-port planning turns out to be the most effective (Baalen, Zuidwijk, & Nunen, 2009).

Rotterdam

At the start of the 20th century the port of Rotterdam began implementing the first universal communication system within the port. Before this date one can hardly speak of a successful information exchange within the port. In 2002 Port Infolink was established with as main focus the replacement of paper forms by electronic messages, resulting in both time and monetary benefits. In 2009 Portbase was introduced, a central hub system originated from Port Info link and the Amsterdam' system Port Net. Both systems where used to create a new universal system for both ports with the goal to get nationwide coverage. Up until today Portbase is being used as communication platform for various actors in the port. There are two shareholders, Port of Rotterdam and Havenbedrijf van Amsterdam, who made Portbase a neutral actor without the need to generate profit. Its Advisory Board is formed by representatives of many sectors in the port, hereby creating an independent company with support of the port actors. This created a structure which let Portbase grow into one of the most successful PCS in the world.

Portbase consists of three different layers; an application layer with a variety of specific services being provided (Appendix 1), a general level which provides general facilities and a database where all collected data comes together and are stored. In 2014 there were 72 million messages sent electronically via Portbase (Wolf, 2015).

Changes due to the Internet of Things

The Internet of Things has the potential to influence the level of information-exchange via the PCS. The main fields where the Internet of Things will lead to improvement are the data capturing and the processing of the available data. This will lead to changes in the efficiency level of ports, the security level and the possibilities of monitoring the transportation.

Port Efficiency

The efficiency-increase by the IoT can be gained at different stages during the supply chain. Firstly, the real-time status of actors increases the planning possibilities and reliability. This will be beneficial for all actors in the supply chain, and will cause an increase in time efficiency and efficient use of facilities available during the transportation of containers.

The real-time positioning of container vessels which are planning to call in at the port gives more information about the vessels' estimated time of arrival. The physical group, like terminal operators, can prepare the upcoming arrival and make sure everything is set to unload a ship when necessary. When something goes wrong en route, this information will be transferred directly to the terminal operator. This insight in delays more early on in the supply chain gives terminal operators the option to free up handling capacity, which will result in an up-to-date list to align supply and demand for their facilities. The extra space which became available by the delay can be used by other barges, which will lead to a more efficient use of terminal resources, and hereby reduce costly downtime (Kim & Lee, 2015). The hinterland transporters will also benefit from the status updates provide. In the same way they can adjust their schedules to changes earlier on and hereby reduce unexpected waiting time.
The real-time information exchange will also effect the level of congestion. Congestion is a side-effect which can occur when an increased number of TEU is being processed at the port of Rotterdam. Increased efficiency makes it possible for more ships to call in at the port, causing more congestion. However, the expanded possibilities to make a reliable planning provide possibilities to prevent congestion as well.
Congestion can happen at both terminal level and at port level. Congestion at port level occurs when there are too many vessels or vehicles in the port, which are taking up space needed by others. When implementing factors as traffic jams and weather forecasts into the PCS one can predict whether an inland freight transporter is able to pick up its containers as agreed and hereby shorten their stay in the port. By only giving access to the actors that need to be in or around the port it should be less congested. Providing real-time updates about processing status gives inland freight transporters the ability to adjust schedules in time, reducing unnecessary waiting time in the port (SAP, 2014). The harbour master can give access to those only who need to unload within a certain timespan, making it less busy.
Congestion at terminal level is caused by the rising number of TEU that needs to be processed due to the increased number of ships that will be calling in at a port. What's more, the trend of increased vessel capacity causes a higher peak demand for terminal operators to process. By making terminal facilities more efficient, their capability to handle a certain number of TEU in one hour increases without expansion of physical capacity, hereby

preventing congestion. To cope with the higher peak demand without creating more congestion a better terminal planning is needed. Part of this terminal planning deals with the stacking of containers by terminal operators, which is the second field which suits improvement by the Internet of Things.

The stacking planning can be optimized with information about expected pick-up time and the modality being used for further transhipment. With containers giving signals about destination and the modality of further transport, terminal operation systems could implement these factors in their stacking planning. This implementation will lead to fewer unnecessary moves by terminal cranes, making stacking facilities more efficient (Henriksson, 2015). It also makes the handling faster, resulting in a time advantage (Nextlogic, 2015). This handling efficiency will also improve? when implementing automation in port terminals. The Internet of Things can contribute to the development of automated terminals, which is the third application. The increased level of data being exchanged gives unmanned terminals more information to use with their execution. It gives feed back to the system, so it can adjust when something may go wrong (Chui, Löffler, & Roberts, 2010). Terminals become even faster and more predictable when they are automated (TBA, 2009). Automation in terminal facilities can happen at three levels; ship-to-shore (STS), automated guided vehicles (AGV) and automated stacking cranes (ASC). Automation at these level will cause more predictability, less pollution and in the long run significantly more efficiency compared to humanly operated terminals (City of Los Angeles Harbor Department, 2014). This will all result in lower costs per move, giving a monetary advantage.

Security benefits

The fourth efficiency increase lays in the handling by the authorization. This increase will most likely be obtained by the handling of customs, who can save a lot of time by better provision of information. Nowadays almost all information forms of companies based in the port of Rotterdam are exchanged via Portbase. This saves both time and paper and increases reliability of the documentation. The PCS creates an opportunity to send the loading and unloading lists before entering the port to Rotterdam based customs without the need to hand them in by person. In this way time is saved, but also the reliability of the forms is increased since they are written in a language which is understood by the PCS. There is no need to retype the forms and information will be stored on a central database for further use.

Not only will the IoT increase the time efficiency of the handling by customs, it will increase the reliability of security. Information about whether a container has been opened can be provided by the implementation of E-seals. Data from an E-seal is, in combination with its location path, important information for custom services. When this information is provided the authorization group can make better estimations about risks and the possible need of further inspection. For example, customs are able to identify risky events during the path of a container. The main risky events are the loading and unloading of containers, complemented with a container which is on hold during its path (Baalen, Zuidwijk, & Nunen, 2009). E-seals and GPS trackers are able to provide information to identify these risks, hereby creating a more secure container environment which is also time effective (Kim, Deng, Gupta, & Murphy-Hoye, 2008).

Monitoring benefits

The third key feature of a PCS is the database. This database consists of all data that has been implemented in the PCS. Real time updates will also keep the data relevant. There are two ways of benefitting from this situation. Governments have the possibility to gain all information exchanged on the PCS by just joining the PCS-system themselves. Previously it was necessary to collect data from all companies individually, making it a long process to get a good view on port performance. It took up to six months for the CBS to give good insight in performances of the Port of Rotterdam. By accessing the PCS database they are able to shorten this interval to 1 month (Rook, 2015), while this information is again more reliable due to less errors.

The shorter interval allows governments to intervene at a shorter notice if necessary, and thus intervene in a more reliable way.

Not only governments benefit from the database storage of information. Companies themselves have access which enables them to gain insight in processes in progress. They can look for more efficient ways of transporting, with is the fifth efficiency benefit of the Internet of Things. However, not all companies are willing to give that much transparency in their confident business information.

Methodology

This research will identify the influence of the efficiency results on the competitive position of the port of Rotterdam. Chosen is to obtain results by a literature review. There is a lack of available data that is useful to conduct a quantitative research. This is caused by the lack of data which is publicly available. Furthermore, the data which is available faces multiple limitations. A lot of productivity and efficiency research focusses on single factors in the supply chain. They ignore the efficiency and productivity between the chains, which is something the Internet of Things could provide with improvement. Research focussing on port efficiency in general also faces limitations. Academic research is scarce, due to the difficulty of obtaining enough data to make statistically relevant influencing factors in efficiency results. In addition, port efficiency research compares ports in different life-time stages. Ports approaching their maximum capacity will be considered more efficient due to their maximisation of output with given facilities. However, these ports may also face congestion problems. New ports will not be considered efficient, due to their surplus in facilities and their limited outcome (PWC & Panteia, 2013)

The empirical analysis will start with outlining the current competitive position of the Port of Rotterdam. The quality of services will be covered, as well as the current involvement in Internet of Things-related activities. This will be based on literature found. Thereafter, the application of the efficiency changes due to the IoT will be adjusted to the port of Rotterdam. This will also be based on findings from qualitative research. The empirical analysis will be strengthened with an interview with Hans Rook, Senior Business Development Consultant at Portbase and Chairman Standards and Technologies at the IPCSA.

Empirical Analysis:

Competitive position

Rotterdam is the largest European port for container transportation. Twenty eight percent of total European container shipments go via Rotterdam. Its largest rivals are Antwerp and Hamburg, which are respectively responsible for a market share of 24.2 and 22.5 percent (Port Of Rotterdam, 2015). These three ports have at least 10 percent more market share than their next rival, Bremerhaven, so one can speak of the three largest container ports in Europe. Rotterdam can be characterized with the presence of all transport modalities. Most used transport modality is by barge shipping. Because of its location barge shippers can use both the Rhine and the Maas for inland shipping. This results in 40 percent of containers being processed further by barge (Wu, 2011).

Rotterdam is one of the 5 ports in Western-Europe that is attainable by the largest containerships due to the new Maasvlakte II, together with Bremen, Felixstowe, JadeWeser Port and Gdansk (Rook, 2015). With the economies of scale which appear in container transport these ports will be its largest rivals . Antwerp and Hamburg are ports that are more likely to lose market share if the trend of growing vessels will continue. The port of Hamburg has relatively old cranes, limited space and has a need to deepen the Elbe every now and then, which will result in a less efficient handling of the containerships (JOC Port Productivity, 2014). The port of Antwerp has problems with its attainability for the largest ships due to the Schelde river that connects the port with open water and is facing congestion problems (Rook, 2015). However, this change in the spectrum will be a long term process, since shipping companies are under contract or do not see the instant need to change. In the short-term, competition can be fierce which can be seen by the growth in container handling of the port of Antwerp compared to Rotterdam. This growth is 2.5 times larger than the growth in the port of Rotterdam(Barnard, 2015).

Like every big port in Europe both Antwerp and Hamburg have developed their own PCS. The system in Antwerp is called APCS, while the Hamburg version is called Dakosy. APCS is an older system, which will not be ready for the full implementation of an Internet of Things environment. This lack of capability has resulted in the Port of Antwerp having chosen to continue with its system a decade ago and not renewing the system (Rook, 2015). Dakosy on the other hand is more comparable to PCS. It's PCS is advanced and renewed, so it will be able to implement all changes necessary. Furthermore, the company does not only provide a system for ports; also airports are provided with Dakosy systems. This can be beneficial for their development since they can implement multiple modalities in their systems.
Both ports are also active in implementing the IT-changes as much as possible (Rook, 2015). Hamburg is the leader in this case. Together with Cisco they are planning to make Hamburg a smart city. Since Cisco is a partner of Hamburg Port Authority they will use their development in the port also (Cisco, 2014). Knowledge gained with other implementations of IoT can help them make the port information system even better. Cisco started a project called Seatropolis, which will link the port and the city to one smart hub (Elfrink, 2014).

However, the implementation is still limited to urban services but it shows their eagerness in becoming the first smart hub in the world.

Implementation of Changes

Port-level:

The five efficiency increases will influence multiple stages in the port itself:

The real time exchange of container status updates will increase the reliability of plannings that are made by port actors. These improved plannings can reduce the level of congestion, which is a serious problem. In 2013 the unloading of more than half of the large container vessels worldwide had a delay of more than 12 hours. Nearly a quarter made do with more than 24 hours of delay (JOC Port Productivity, 2014). The port of Rotterdam is no exception. It can happen that sometimes three or four vessels are moored, waiting for a berth to become available (Port of Rotterdam Authority, 2013). This leads to unnecessary waiting time. Vessels arriving in Rotterdam are sometimes forced to wait up to 92 hours (Port Strategy, 2015). This congestion can be prevented by better exchange of information. Diminishing of downtime will also lead to an increased efficiency. The downtime between two ships is now at least six hours (Port of Rotterdam Authority, 2013). With better information available, this interval can be shortened by adapting to most recent developments.

The second change will have effect at terminal level. The increased information can lead to an adjusted stacking order of containers and hereby increase efficiency. In 2013 Rotterdam had the 3rd and 4th most efficient terminals (EuroMax Terminal Rotterdam ECT and APM Terminal) of Europe, Africa and the Middle-East, measured by moves per ship per hour (Appendix 2). Both terminals reached a level of respectively 100 and 99 moves per ship per hour. The lead in this division was taken by terminals in the United Arab Emirates, which are able to execute up to 119 moves per hour. When comparing these numbers it shows that some Arab terminals are able to make 20 percent more moves compared to the top Rotterdam terminals. This shows a huge potential for improvement for terminal operators in Rotterdam. This margin for improvement becomes even larger if one compares the top terminals in Rotterdam to the most efficient terminals in the world: the Asian APM Terminals in Yokohama. These terminals are able to reach a berth productivity level of 163 moves per hour. In comparison this is more than 50 percent more productive than Rotterdam terminals.

This increase in efficiency of terminal handling can also be obtained by the usage of automated terminals. Unmanned terminals are more predictable than human operated terminals. They give more reliable information, such as the estimated time of departure, which can be used for further planning. In addition, the unmanned terminals that can be implemented have the potential to become more efficient compared to human operated terminals. Furthermore, their production is more consistent over the long compared to human operated terminals. This will lead to an increased efficiency-ranking. Rotterdam currently has an almost completely automated terminal in use: the newly built APM Terminal at Maasvlakte II. This terminal is not integrated in the efficiency ranking since it was opened only this year. The unmanned terminal should be able to compete with the top-terminals in the world, and book better results compared to Rotterdam's manually operated terminals. This can cause a lead on Antwerp and Hamburg, of which only Hamburg has a port in the most efficient terminals in the Europe/Middle East/Africa range (Eurogate terminal in Hamburg). The most competitive rival in the Hamburg-La Havre range when considering terminal efficiency is Bremerhaven. Bremerhaven has two ports in the top list.

Fourthly, time can be saved by the formal handling of the freight documentation by the authorization group. Whilst Portbase is the standard communication platform for Dutch based companies, not all ships calling in at Rotterdam are using Portbase. They do not experience the benefits of the use of the PCS yet since they do not use it (Rook, 2015). This can be avoided by making the use of Portbase mandatory for foreign ships, so they will experience the same benefit as Rotterdam-based companies. Furthermore, the Rotterdam based companies will benefit from other information transferred via the PCS. The Portbase usage is already mandatory when entering the newly built Maasvlakte II. The terminal facilities in this part of the port of Rotterdam, the RWG- and APM-terminal, obligates customers to make use of the system. There are no service desks available for handing over the forms manually. This decision by the terminal operators was an enormous boost for the PCS, which is reflected by the increase of the number of messages that were exchanged via Portbase. In addition to the boost it is also good marketing for its usage. The companies that use the system are the ones who need to convince carriers to make use of the system as well (Rook, 2015). Satisfied users will spread the word of the advantages of the use of Portbase. As well as the documentation benefit for customs, the handling efficiency of the authorization group can also be increased. Risk-profiles can be made more accurate due to information about container content, container routes and the opening of containers.

Supply Chain Level

The IoT not only has the potential to change processes within the port. The increased monitoring possibilities caused by the implementation of the IoT can also contribute to a change in the supply chain of container transport. Two main trends at supply chain level can benefit from the developments, which are synchro-modality and the usage of hinterland ports.

Synchro-modality is an upcoming trend in logistics. A customer signs a contract for transportation to a certain place without determining the modalities that will be used. It gives the organizing group, freight forwarders and third party logistics (3PL) the ability to choose between a range of transport modalities at any given time. The transport can be done by multiple modalities. The organizing group will make their transport choices based on costs- and environmental efficiency, as well as time (Walker, 2013). It gives them more freedom to optimize the efficiency of transportation. This will also reflect on their option to bundle cargo from multiple customers. This will make synchro-modality a more sustainable way of transporting (BCI, 2012). In addition, it reduces the unnecessary transportation of empty containers. This transportation of empty containers is estimated to be equal to 25 percent of the total inland transportation of containers (Port of Rotterdam, 2013). Reducing

this amount will result in more sustainable and environmental friendly changes.
Not only the sustainability will increase when using synchro-modal transport. The usage of different modes of transportation can result in significant cost benefits. A case study of Maersk showed a costs saving from seaport to customer of 6 percent (Altena, 2013). However, there are some factors that need to be implemented before synchro-modality will become beneficial and more widely used. At first, Information needs to be able to primarily handle multimodal transportation. Secondly there is a need for new collaboration between parties for transport. Finally. there is the need for complete visibility of products during their transportation, so customers can see where their product is (Daalhuisen, 2014). With two out of three factors being related to Internet of Things-development, its crucial role - the success of synchro modal transport - is being underlined.
Increased synchro-modal transport will have influence on the hierarchy in the port itself (Rook, 2015). Shipping lines with determined routes and terminals will face more competition, which will result in a less important role in a port environment. The organizational group and independent terminal operators will become more influential at port level since they face more opportunities to gain market share. When being more profitable than transportation between traditional shipping lines they can become influential players in the port environment.
Not only will the competition within ports become more fierce, the competition between ports will also rise. Characteristic of the synchro-modal transportation is the lack of long term contracts, since it is able to use each modality if necessary. Freight forwarders and 3PL's have the freedom to use whatever route they want and are not obligated to make use of predetermined shipping routes (Rook, 2015). This will result In more uncertainty of port demand, and a larger market to attract.

This independent port choice could lead to another trend in container supply chain; the usage of inland ports, also called dry ports. Dry ports are inland terminals which are directly connected to one or multiple seaports with high capacity transport means. Customers are able to leave/pick up their units at a dry port as if it is a seaport, making the dry ports an extended gateway to the seaport (Leveque & Roso, 2002). The usage of dry ports has multiple benefits. It is beneficial for the ecological environment, it prevents congestion at the main port by dividing traffic between places, secures hinterland markets, provides better services to carriers and transport operators and enables ports to expand business without the actual need to expand physically (Roso, Woxenius, & Lumsden, 2009). Furthermore it can be cost saving; storage at inland ports can be up to 58 percent less expensive compared to deep-sea ports. It also provides containers where needed for export. Both effects can cause cost savings of 10 percent on total transportation costs (Altena, 2013).
IoT-development is essential for efficient hinterland connections and the success of dry-ports. Information like the time containers given free and cargo specific information needs to be shared when one wants to implement an efficient network (Veenstra, Zuidwijk, & Asperen, 2012). Portbase could be a solution. With its nationwide usage all terminals are operating via the system, making the information exchange possible.

When looking at the three needs that are required to be fulfilled in order to make synchro-modality successful one can see that both the first and the third need are port related to the IT-development given above. When implementing these increased functions synchro-modality can benefit. By having an excelling PCS with a lot of information being visible Rotterdam can become an interesting option as first unloading point, since Information is critical for freight forwarders to make their planning. Furthermore Rotterdam has all hinterland transportation modalities available so there are multiple options for further transportation. Another advantage is the nationwide covering of Portbase, making it able to exchange information needed for the successful usage of dry-ports. All success factors for a good starting point of a renewed supply chain are available in Rotterdam. It would be a good option to implement strategies in its ports. The first steps are already being set with the ECT Gateway Service, which provides multiple gateways across the Netherlands, Belgium and Germany.

If these two trends become reality it will cause the port to change in function. Next to the transformation to an information hub it will also lose its function as a logistic node. Instead its function as transhipment point will become increasingly important (Veenstra, Zuidwijk, & Asperen, 2012). Ports will focus again on its original function as transhipment point. Due to the increased inland shipping and the use of hinterland ports, the distribution parks around the port area will relocate themselves to hinterland locations due to their closeness to customers. This change will alter the hierarchy of port actors.

Threats for development

There are multiple factors which can be seen as a risk in the implementation of an Internet of Things and the development of the Port of Rotterdam to an information hub.

Security Risk

When implementing an IoT-environment and creating an information hub one should seriously consider the security risks. The nature of the data that will be exchanged is confidential company information. In the wrong hands, this information could form a serious security risk. For example, stacking and destination information can be used by criminals to open containers which are at terminal facilities. Falsified e-seals would be an ideal way of smuggling goods without extra control by customs. Furthermore there is the threat of a port shutdown, which will have enormous consequences for the economic world. An example of these threats can be found in Antwerp, where criminals hacked Antwerp's port community system in 2012 (Robertson & Riley, 2015)
Actors in the port are aware of the possible security risks. If a port wants to rely on an internet based network it should make sure it is secure. In this way it will convince the users of the system that it is working well and that it will not cause trouble. However, creating an information hub results in the increase of the information being transferred, whilst also making it harder to protect (Li Cain, 2015).

Support

The Port of Rotterdam can influence port changes to a certain level, but the willingness to change port for actors can make or break the implementation. These actors need to implement the services and make the investments required to make it happen. This can be difficult since the port culture is a conservative world. Many companies are not easily persuaded to change already working systems (Visscher, 2015). Furthermore, not all outcomes can be beneficial for them. An example is that increased transparency in supply chains removes the possibility of using spare time for transport. This creates a smaller margin to operate in, especially in case of delays or events unaccounted for (Rook, 2015). These changes in container transportation will most likely change supply chains in a way not all port actors will applaud. The transparency can force certain companies to work faster. They are not able to maintain spare time since customers will not accept this (Rook, 2015)
Most port actors will need to be convinced to shift to the new technology. The easiest way to get them to make new investments is by showing them the added value of the services. This added value can be displayed by the use of working pilots. When implementing a small pilot successfully, it is easier to convince port actors and gain support for the change to new development. However, one should take the financial position of actors into consideration. Deep-Sea carriers are often larger companies than barge shippers. They need to make the same adjustments to make the system really work. However the financial position of both modalities are different, with heavier charges on the hinterland shipping actors. This different proportion of income spent in investment needs to be taken into consideration when implementing new systems.
Another important factor in gaining support is Portbase. They need to let their platform and

applications convince more customers. The structure of the company can be beneficial for them; since Portbase is neutral and advised by representatives all over the port it can be seen as an independent, non-profit facilitator of the PCS. Due to its Advisory Board it also knows exactly which applications are demanded and which problems actors are facing using Portbase (Rook, 2015) .

The automation of ports can also cause a decrease of the number of jobs in the port itself. The AMP terminal at Maasvlakte II is calculated to replace 200 jobs, which causes insurgence at the FNV trade union (ANP, 2015). Further automation will lead to even fewer jobs in the port, which can cause more resistance by trade unions.

Economic shifts

The port changes that may be made in the future are supposed to make Rotterdam a more attractive port. However, the economic centre of Europe is changing to Eastern and Central Europe (Paardenkooper-Suli, 2014). Rotterdam is able to reach these hinterland markets but there are competitors in this region. Germany has two ports able to receive the largest containerships and so does Poland (Polish Press Agency, 2013). Furthermore, the extended Suez-canal shortens waiting time with 11 hours, making a route through the Mediterranean more attractive (Smal, 2015). Combined with investment in southern-European ports, the port of Rotterdam can be bypassed to supply eastern and middle-Europe (Pagni, 2015). This costs market share which is bad for the competitiveness and the Dutch economy. Furthermore it will discourage other companies to invest in the port. They do not want to make large investments in declining markets, hereby creating a slowly descending circle since the lag can only be fixed by keeping up with the technology or inventing a new innovation.

The invention of a 3D-printer should also be considered when talking about economic shifts. 3D Printers make it possible to manufacture at relatively low costs in almost every place, which can potentially cause a serious decline in trade volume (Wile, 2014). Ocean container business faces a potential loss of 37 percent if 3D-printing becomes a good alternative for traditional manufacturing (Schmahl, Tipping, & Duiven, 2015).

Conclusion

Conclusion

The Internet of Things can have a major influence on the efficiency of container transport. This paper argues that there are five applications of the Internet of Things which can influence the efficiency level of container transportation. The first application is the real-time tracking of containers. Secondly, container information can be used for optimal stacking. Thirdly, the Internet of Things eases the transition to automated terminals. Fourthly, the handling time customs need can be shortened. Finally, the increased data exchange gives the possibility to optimize and change the supply chain.

These applications will result in improved efficiency in all ports. The real-time tracking gives the possibility to port actors to optimize their planning. Live updates about container status can help terminal operators make their schedules as efficient as possible, averting downtime. Furthermore, the adjusting of plannings with real-time data can prevent congestion. The increased information will lessen the unnecessary waiting-time and hereby prevent congestion. This real-time information will be reused when making the stacking planning. By implementing risk factors for delays into the system one can adjust the stacking-order. This will result in fewer unnecessary crane moves. Thirdly, the IoT can boost the implementation of unmanned terminals. The extra information that will be available will help the system develop itself into a more efficient terminal compared to ones operated bu humans. Fourthly, time can be spared by the authorization group. The usage of a PCS allows customs to receive all documentation before the actual entering of the port of Rotterdam. This saves time and reduces the risk of errors. An e-seal, in combination with location path, gives the authorization group a much better possibility to indicate the security risk involved with a container and hereby allocating their time more efficiently. In addition, the increased security indication will not only make the custom handling time more efficient; it will increase the general level of security as well. Finally, the increased monitoring possibilities can cause a change in the supply chain itself. New trends as synchro-modal transport and the usage of hinterland ports benefit from enhanced information exchange. If they both become reality in the supply chain they lead to more efficient and sustainable transportation of containers.

Specifically for the port of Rotterdam, which can be characterized as the largest container port of Europe, with a draft allowing the largest vessel to access 24 hours a day, availability of all transport modalities, and the use of a PCS which is operating nationwide, the increased efficiency can lead to a more competitive position in the worldwide spectrum. Rotterdam is the only one out of the three with Antwerp and Hamburg which is able to receive the largest vessels. Due to the increased vessel sizes this will influence the choice of port. Furthermore, Rotterdam becomes more attractive when considering synchro-modal transport and the use of hinterland ports. All transport modalities are highly available in the ports, giving freight organizers multiple options. Portbase, with its nationwide coverage, provides the benefits of the PCS in Rotterdam all across the Netherlands.
These changes will also alter the port function of Rotterdam. The port will revert back to its

original function as transhipment node instead of a logistic node. Distribution centres will relocate to hinterland ports, closer to the hinterland market. This functional change will influence the hierarchy in the port itself.

However there are threats which need to be overcome before IoT can run its course at full potential. There is a need of capable security of all systems. Non-sufficient security measures can be dangerous for both the economy aswell as for the safety of the inhabitants. Another implication is the support for changes. The port environment is a conservative world, but without support from actors in the port the implementation of the system will not be a success. The necessary development needs to find enough support within the port itself. This can be a tough challenge, since the hierarchy may change. Companies do not want to lose market power, while unmanned terminals can cause stir for labourers due to their potential unemployment.
The last threat is the change in the economic spectrum. New hinterland markets further from Rotterdam can cause a loss in market share. The competition is also fierce, with competitors at a close range, closer to the largest growth markets. Furthermore, 3D printers can influence the amount of manufactured goods being shipped in containers drastically by replacing the need to ship these goods.

In sum, the potential influence of the five aforementioned IoT developments has profound consequences for the efficiency of container shipping in the port of Rotterdam if the three threats can be tackled.

Recommendations:

The Internet of Things in the port of Rotterdam can make the port more efficient. This will make the port more attractive for vessels. Furthermore, the port of Rotterdam has a good position when looking at the implementation of synchro-modality and hinterland transport. Due to its competitive position it should focus on these changes, and try to become the flagship of the changed container chain and port function. A first step can be the obligation of the use of Portbase for all ships calling in at the Port of Rotterdam. This should be done by the Port Authority. The obligation is an example of a measure where short-term results can be booked. Furthermore, it will boost the usage of Portbase by foreign companies. They will experience the benefits and will become more enthusiastic about Portbase and the increased level of information exchange.

The efficiency upgrades are obtained by the usage of new technology by the port actors themselves. As said, this can be hard due to the conservative nature of port companies. One way to create more support among port companies is the use of pilots. The implementation itself should start on a small scale. It gives port actors insight in the technology and the added value of certain services. When pilots prove to be of increased value it is more easy to persuade the companies to make the new investments needed.
Due to the rapidly changing level of IT-development it is essential for Rotterdam to keep

innovating. Good ways to innovate are to cooperate with Dutch universities as Delft and Eindhoven to build applications and analyse where the system can be upgraded. The port of Rotterdam Authority is essential in this process. They need to stimulate innovation and development. Good examples of projects is their participation in World Hackleton and the RDM Centre of Expertise (Inn010, 2015), which are programs in which students and start-ups will be supported to think about innovations in the Port. These groups may help to find new start-ups which will keep the innovation moving. Once again these innovations can be implemented by the use of pilots. Pilots will give feedback about the current state of development and potential problems.

A central role in the future change is being played by Portbase. Portbase needs to be ready to handle the increased amount of data that will be transferred. Furthermore, it should be technically able to work with new applications. It should listen well to its Advisory Board. Since its Advisory Board consists of different actors in the port, they know what changes will be implemented and what inefficient fields are where improvement can be booked.
There also is a stimulating function for Portbase. Due to its neutral company structure it should be able to suit a coordinating function in the implementation of the Internet of Things. By consulting with companies in different stages of the supply chain it can address the need of certain innovation in companies to gain increased value for the whole system. However, it is dubious whether Portbase has enough power to obtain results. That is why a collaboration with the port of Rotterdam authority should not be excluded, since it has more power to effectuate results.

If Rotterdam is able to provide an information exchange network which is outstanding compared to such networks in the rest of the world it should be able to stay competitive. It's two biggest opponents on IT-development will be Antwerp and Hamburg which are currently the second and third largest container ports in Europe. APCS, Antwerp's PCS, is becoming obsolete. More competition can be expected from Hamburg. The port is innovative with the launching of Seatropolis, the first step towards an Internet of Things society on port level. However both ports face difficulties due to geographic location. Out of these three ports Rotterdam is the only one which is able to receive the largest vessels. Furthermore the more inland locations of both other ports result in less efficiency due to tide and congestion problems. This would be an opportunity for Rotterdam, being the most advanced port and able to receive the largest vessels. Its hinterland connections for rail, barge and road transport make it an ideal environment for a shift towards an information hub and transhipment node, making Rotterdam the most attractive port of Europe.

Limitations

The nature of this research is to examine future development and influence. This leads to some limitations. Firstly, the prediction of certain trends and innovations can be made. However, due to its predicting nature there is no certainty this development will ever happen. The conclusions that are made can be seen as well explained concepts. However, there is still uncertainty if it will all develop as outlined.
In this thesis, the largest limitation is the lack of quantitative research involved. Since most developments that are named are relatively new it has as yet not been possible to collect

data and compare the results. A lot of empirical resources are being used, which could be supported better with more quantitative research.
Furthermore it is hard to prove the trends of influencing the supply chain without all the necessary data being available. Yet again, the conclusions that have been made are mainly based on qualitative research, while quantitative sources would have given a better foundation .

The last limitations are the limited resources available about other PCS systems. Therefore the conclusion on their performances are based on one resource, the interview with H. Rook. Since he is from Portbase it is not the most reliable source. However, since it is an important part of this research the choice has been made to include it.

Further Research

The goal of this paper was to give an overview of all the relevant influences that could occur when implementing the IT-development related to Internet of things and intelligent containers. However, there is a wide range of subjects that can be influenced. The scope of this interview was set to give an overview of these influences, without focussing on one in particular. However, all of the influences are worth their while as the main subject for further research. Especially supply chain changes (hinterland ports and synchro-modality) can have significant influence on the container transportation. Their effects could be examined to predict the changes that will occur. Furthermore there is an opportunity for quantitative research to the efficiency increases that are given. There was not much research done to investigate quantitative results from improvements. Case studies can be an outcome to identify the improvements

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Appendices

Appendix 1: Classification of the services according to target group and market sector

Ongeldige bron opgegeven.

Service	Agents	Barge operators	Customs	Empty depots	Exporters	Food & Consumer Product Safety Authority	Forwarders	Importers	Inspection stations	Port authority	Rail infrastructure operator/ -operators/ -hauliers	Road hauliers	Terminals	Skippers	Shipbrokers/ shipping companies
Barge Planning		C		C									C		
Cargo Declaration Export (System Interface)			C												C
Cargo Declaration Export (Web Interface)	A		A										A		A
Cargo Declaration Import	A		A												A
Cargo Declaration Status Report	A		A												A
Cargo Information 2.0							C	C							C
Customs Scan Process			C			C							C		C
Dangerous Goods Notification	A									A					A
Declaration Food & Consumer Products	A					A	A	A		A					A
Discharge Confirmation Report													C		C
Discharge Information	B				B			B			B	B	B		
Discharge List													C		C
Discharge Difference List			C												
Exit Summary Declaration			A							A					A
Information Services Dangerous Goods*											A				
Inland Ports Dues*		A								A				A	
Loading List													C		C
Notification of Arrival ECS Cargo	A		A										A		
Notification of Arrival ECS Containers			C										C		
Notification Bonded Warehouses	A		A												A
Notification Export Documentation					C		C								
Notification Import Documentation		C					C	C				C	C		C
Notification Local Clearance			C				C	C							
Notification SafeSeaNet										A					
Notification Waste Disposal	A									A					A
Pre Arrival Cargo Declaration Import (4h)	A		A												A
Pre Arrival Cargo Declaration Import (24h)	C		C												C
Rail Planning											A		A		
Road Planning				C	C	C	C					C	C		
Statement Harbour Dues Amsterdam	A									A					A
Statement Harbour Dues Rotterdam	A									A					A
Track & Trace ECS					C	C							C		C
Transit Declaration	A		A		A		A	A					A		A
Transport Order								C				C			
Vessel Notification	A		A							A					A
Veterinary Inspection Process	C					C	C	C	C						C
Services in development															
Ship's stores notification	A		A							A					A

A Comprises all segments.
B Comprises dry and liquid bulk.
C Comprises containers.

Appendix 2: Terminal statistics

Top global terminals based on average 2013 container moves per-ship, per-hour on all vessel sizes. (JOC Port Productivity, 2014)

TOP TERMINALS: WORLDWIDE

TERMINAL	PORT	COUNTRY	2013 BERTH PRODUCTIVITY
APM Terminals Yokohama	Yokohama	Japan	163
Tianjin Xingang Sinor Terminal	Tianjin	China	163
Ningbo Beilun Second Container Terminal	Ningbo	China	141
Tianjin Port Euroasia International Container Terminal	Tianjin	China	139
Qingdao Qianwan Container Terminal	Qingdao	China	132
Xiamen Songyu Container Terminal	Xiamen	China	132
Tianjin Five Continents International Container Terminal	Tianjin	China	130
Ningbo Gangji (Yining) Terminal	Ningbo	China	127
Tianjin Port Alliance International Container Terminal	Tianjin	China	126
DP World-Jebel Ali Terminal	Jebel Ali	United Arab Emirates	119
Khorfakkan Container Terminal	Khor al Fakkan	United Arab Emirates	119

TOP TERMINALS: EUROPE, MIDDLE EAST, AFRICA

TERMINAL	PORT	COUNTRY	2013 BERTH PRODUCTIVITY
DP World-Jebel Ali Terminal	Jebel Ali	United Arab Emirates	119
Khorfakkan Container Terminal	Khor al Fakkan	United Arab Emirates	119
Euromax Terminal Rotterdam - ECT	Rotterdam	Netherlands	100
APM Terminals Rotterdam	Rotterdam	Netherlands	99
MSC Gate Container Terminal	Bremerhaven	Germany	98
Eurogate Container Terminal Hamburg	Hamburg	Germany	93
Salalah Container Terminal	Salalah	Oman	91
NTB North Sea Terminal Bremerhaven	Bremerhaven	Germany	90
ECT Delta Terminal	Rotterdam	Netherlands	87
ECT Delta Dedicated West Terminal	Rotterdam	Netherlands	87

Appendix 3: Interview questions H.Rook

1. Wat is Portbase en wat voor functie heeft het in de haven?
2. Hoe is Portbase ontstaat?
3. Wat is de organisatie structuur van Portbase?
4. Wat zijn de exacte voordelen die bedrijven halen uit werken met Portbase
5. Hoe denkt u over een Internet of Things-wereld in de haven
6. Hoe denkt u dat de bedrijven in de haven daar op reageren
7. Hoe gaat Portbase op deze ontwikkeling inspelen?
8. Wat zijn de grootste gevaren van deze ontwikkeling?
9. Wat zijn de grootste concurrenten van Rotterdam?
10. Wat voor invloed heeft een PCS en IoT op de concurrentiepositie van de haven?