THE EFFECTS OF INTEGRATING AUTOMATION ON THE OPERATING COST & CO2 EMISSION OF CONTAINER TERMINALS

MAJOR PROJECT

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Background

Abstract

The purpose of this Major Project is to determine whether automation can decrease operating cost and CO_2 emission for container terminals. The problem addressed is the increase in both operating cost and CO_2 emission for container handling firms due to increased volume of containers coming from Ultra Large Container Vessels. Therefore, both primary and secondary sources of research are obtained and then compared to discover what the effects are of integrating automation on operating costs and CO_2 emission of container terminals. This method of research, the Concurrent Triangulation Method, generates both practical and academic insights. When compared, these findings deliver valuable information on variables such as union pressure, types of automation, CO_2 emission and value creation for ports, to name a few.

In the case of this research it could be concluded that the rise of Ultra Large Container Vessels causes increased container volumes and increased stack heights. High volatility of operating costs is caused by factors such as human failure, miscommunication and weather conditions. These generate delays and inefficient interterminal container transport. The integration of automated processes such as interterminal container transport along a Container Exchange Route operated by Automated Guided Vehicles, can both increase the ability to cope with larger volumes of containers as well as lower the volatility of operating costs. Evermore, this research will also come to conclude that automation can reduce CO_2 emission in container terminals, however not completely without switching to green energy generation in terminal.

Lastly, there are barriers in place for terminals to integrate this type of automation. This is seen in the Port of Rotterdam where union pressure and fear of over-staffing leads to a hold on complete automation until 2020. These barriers can be overcome by a step-by-step integration of automation, as will be explained in the recommendations of this research.

Introduction

The Major Project aims to find a correlation between the integration of automation in container terminals and the effect is has on operating costs and CO_2 emission. This correlation aims to generate useable insights that allow for the creation of a set of recommendations for container handling firms. The scope of the research will limit itself to container transport within container terminals and the automation processes related to the transport of these containers**,** otherwise known as interterminal container transport. This scope includes factors that influence the integration of automation for interterminal container transport. These factors will be named, detailed and explained to the extent that they are of immediate relation to both operating costs and CO_2 emission. Factors that influence the integration of automation but do not directly influence the operating costs and CO_2 emission of terminals will be left out of this scope. This scope was established to narrow the research down to be able to provide a conclusive answer to the main research question of this report, which is:

R.O: ''To establish if the Integration of Automation in Container Terminals can decrease Operational Costs and CO_2 Emission''

The research is positioned against the case study of Spruijt & Rieck about the autonomous transport of containers, this report aims to relate to the operational and environmental benefits of autonomous interterminal container transport (Spruijt, van Duin, & Rieck, 2017). The reason this report was used as a case study for this Major Project is due to the fact that it was conducted in the Port of Rotterdam, which is an good example of integrated automation and in the authors direct vicinity. Furthermore, Spruit's work shows the promise of integrating automation in relation to CO_2 Emission and Operating Costs reduction more than any other sources of literature found on the subject.

Theoretical Framework

With the use of this theoretical framework, the relationship between automation and the reduction of operating costs and CO_2 emission in container terminals will be addressed.

This Theoretical Framework consist of a literature summary, a description of identified variables, a conceptual model, a set of research questions which is followed by a description of the methodology used while conducting the needed research.
The purpose of the Major Project is to answer the research objective, which in turn can lead to valuable insights for container handling firms. Therefore, the related management issue of the report is as follows:

M.I: "Can the integration of automation lower operational costs and help container terminal meet their future environmental requirements?"

The research is relevant since if proven so, automation could lower future operating costs and fulfil environmental requirements of the future.

Literature Overview

For the purpose of writing this thesis, a selection of literature related to the subject was reviewed. A summary of this selection is depicted below in the table:

Title of Article	Author(s)	Source	Summarized findings	Identified variables
Towards an autonomous system for handling inter-terminal container ports.	Spruijt , A., van Duin, R., & Rieck, F.(2017).	EVS30 Symposium	Core insights on the integration of automation & Co2 reduction by automation.	Automation, Co2 Emission, Union resistance, capacity utilization
Strategic challenges to container ports in a changing market environment.	Notteboom, T. (2007).	Journal of Transportation Economics	Insights into strategic challenges - such as the need to be able to accommodate larger port clients with strong bargaining power.	Rise of the ULCV's, Value creation for ports.
Financing Shipping Companies and Shipping Operations: A Risk-Management Perspective.	Albertijn, S., Toepfer, A. C., Bessler, W., & Dorbertz, W. (2011).	Journal of APPLIED CORPORATE FINANCE	Volatile nature op shipping costs for terminals, causes of demand uncertainty.	Volatile operating costs
The Effect of Demand Uncertainty on Port Terminal Costs	Rodríguez-Álvarez, A., Tovar, B., & Wall, A. (2011).	Journal of Transport Economics and Policy (JTEP)	Uncertainties about aspects such as arrival times, have an significant effect on operating costs within container terminals.	Volatile operating costs
Some box terminals are facing 'catastrophic economic failure', warns analyst	Marle, G. v. (2017).	Canadian sailings	Rise of the ULCV's, and the challenges that come along with them for container terminals.	Rise of the ULCV's
Five challenges an route to the Port of 2050.	Port of Rotterdam Authority. (2016, March 30)	Port of Rotterdam Authority.	Understanding the future goals of current ports that have recognized their challenges.	Co2 Emission
		Additional research sources		
Research Methods for Business Students, 7th edition.	Saunders, M., Lewis, P. & Thornhill, A. (2015)	Hard-copy Academic book	Research methods, Research strategies and insights such as how to conduct proper interviews.	x

Figure 1 – Summary of the literature used

This summary is however not extensive literature review. This is addressed in the detailed literature review which can be found in Appendix B. Furthermore, abbreviation of all identified variables and definitions can be found in Appendix A

Conceptual Model

To create an overview, a conceptual model was created to help visualize the various variables. The variables of the research were divided into two groups. Main variables, related directly to effect of automation on operating costs and CO_2 emission. In addition, background variables were determined, these are variables related to the addition effects of automation within container terminals. See figure 2.

Identified Main Variables:	Identified Background Variables:
• Rise of the ULCV's • Union Resistance • Volatile Operating Costs • Level of Automation • Value Creation for Ports • Operating Cost & CO_2 Emission	• Maritime transport • Capacity utilization • Workforce Adaptability

Figure 2 - Variable Description

The conceptual model is based on both the main variables and the background variables. The main variables build towards the research objective of this report, which is to determine whether operating costs and CO_2 emission can be decreased by integrating automation. However, to build towards this research, some background variables will be addressed in order to create a better understanding of the integration of automation. These variables are not directly linked to operating costs and CO_2 emission, but are indirectly linked to the variables influencing the integration of automation and are therefore considered in this research. The identified variables in relation to the conceptual model are depicted below:

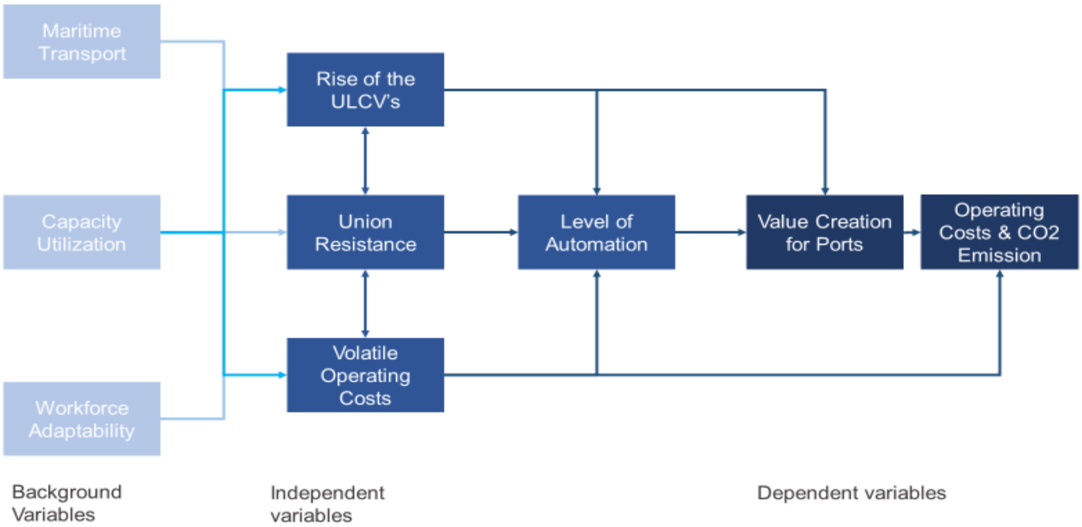

Figure 3 - Conceptual Model

Research Questions

As previously mentioned, a Research Objective was established. The Research Objective aims to deliver valuable information about if and in what ways CO_2 reduction and cost reduction can be realized by integrating automation. The core of the Major Project therefore revolves around establishing a connection between the integration of automation and the reduction of operating costs and CO_2 emission. Based on the Research Objective, the Main Research Questions of this thesis was formulated. Which is as follows:

M.R.Q: Does the integration of automation decrease operational costs and CO_2 emission for container terminals?

The Main Research Question is a causal question. The purpose here is to see if there is an established relationship between the integration of automation and the reduction of operating costs and CO_2 emission. Based on the main research question, 3 SMART research questions were derived to build towards answering the main research question. The three Research Questions are as follows:

1. ***Is there, in the last ten years, an established relationship between CO_2 emission reduction and the integration of automation processes? – Descriptive***

2. ***Is there a relationship between the integration of automation and the volatile nature of operating costs by container terminals? – Causal***

3. ***In what ways can automation help container terminals cope with the increased use of ULCV's to reduce the increased operating costs that come along with the required facilities? – Exploratory***

These three Research Questions are directly linked to the conceptual model. See figure 4.

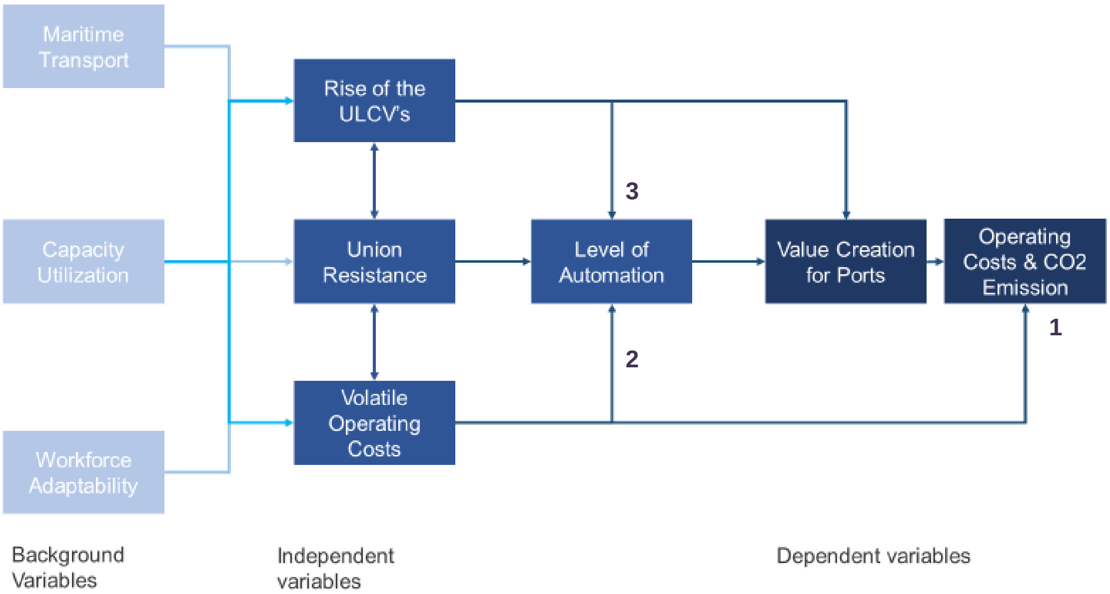

Figure 4 - Conceptual Model in relation to Research Questions

The questions highlight the relationships between several variables of the research. Research Question one aims to find out if there is an relationship between the level of automation and the effect on CO_2 emission reduction. This blends in with Research Question two and three. Research Question Two seeks to find a relationship between the integration of automation and the volatile nature of operating costs in container terminals. Background variables, such as Capacity Utilization and Maritime Transport are related to the volatility of operating costs, which than in turn is related to the Level of Automation to see if there is an established relationship.

Finally research question three, which revolves around what ways of automation can help terminals cope with the increased use of ULCV's. Here the background variables influencing the rise of ULCV's are defined, which are Maritime Transport and Capacity Utilization. Next, different possibilities of automation are analysed to come up with an exploratory search to see which types of automation would be best suited to reduce operating costs due to the rise of the ULCV's.

Methodology

For the purpose of this thesis, a methodology was defined to answer the research questions. However, prior to answering the research questions, a research strategy had to be determined. Based on insights gained from 'Research Methods for Business Students', the 'Concurrent Triangulation Design strategy' was chosen (Saunders, Lewis , & Thornhill, 2015). This method entails the combination of gathering qualitative and quantitative data in the same phase of research. The data gathered is then combined and compared to one another (Saunders, Lewis , & Thornhill, 2015).

The reasoning behind the use of this method is that the method helps overcome the weakness of ones set of collected data with the strengths of another set of collected data. In the field of container terminals and automation, most data will be quantitative data collected through literature analysis. However the data will most likely have its shortcomings, as not all needed aspects will have been addressed in existing literature. This cannot be compensated with a survey due to the nature of this research. However, expert interview can be conducted to gather deeper qualitative insights about the required subjects. In addition, qualitative data will be collected through observations in the field. These observations will revolve around visiting the port of Rotterdam. Based on all of the above, the research strategy of Concurrent Triangulation Design has been chosen.

Next, a methodology for answering each and every one of the Research Questions was chosen. As follows:

1. ***Is there, in the last ten years, an established relationship between* CO_2 *emission reduction and the integration of automation processes? – Descriptive***
    - *For this Research Question the grounded theory approach will be used. The abundance of literature about the subject being the main reason. In addition, expert interviews will help shape a practical understanding of the effect of automation on* CO_2 *emission.*
2. ***Is there a relationship between the integration of automation and the volatile nature of operating costs by container terminals? – casual***
    - *For this Research Question the grounded theory method will also be used. Again in combination with expert interviews about the nature of the volatile operating costs. Evermore, the observations in the Port of Rotterdam will be conducted to help create an even greater understanding of the volatility of operating costs.*
3. ***In what ways can automation help container terminals cope with the increased use of ULCV's to reduce the increased operating costs that come along with the required facilities? – Exploratory***
    - *For this Research Question the main approach will the collection of insights by expert interviews. These interview aim to deliver new data on possible new approaches to reducing the increased operating costs caused by ULCV's.*

The combination of expert interview, observations and literature analysis is in coherence with the chosen research strategy of Concurrent Triangulation Design (Saunders, Lewis , & Thornhill, 2015).

The Research

The research itself was conducted by means of literature analysis and expert interviews. The collected primary research in the form of export interview is summarized. The transcripts and detailed findings of which can be found in the designated appendices. Next, the secondary research is compared to the findings of the primary research. Here, the similarities and differences aim to generate the most valuable insights of this research.

Description of the Conducted Primary Research

CO_2 Emission related to Automation Processes

The first Research Question:
''Is there ,in the last ten years, an established relationship between* CO_2 *emission reduction and the integration of automation processes?''

This research question required expert interviews which could deliver insights into CO_2 Emission and their relation to automation processes. For this, I got into contact with Monique van der Palm, managing director and owner of M Restart. M Restart specializes in recruitment and project support for oil & gas and renewable energy in the maritime industry (M Restart, 2018). Here, the link between direct and indirect CO_2 emission of containers terminals proved to be the most interesting insight. The full analysis of the findings of the interview can be found in appendix C, as well as the transcript of the conversation held.

Volatility of Operating Costs

The volatility of Operating Costs for container terminals relates to the second Research Question:

''***Is there a relationship between the integration of automation and the volatile nature of operating costs by container terminals?"***

To get a further understanding into the volatile nature of operating costs of container terminals, an interview was held with Mitch de Kloe, who is a member of ''de Koninklijke Roeiers Vereniging Eendracht''. De KRVE is responsible for towing in the container vessels as they come into port. The reason for interviewing an associate of the KRVE, being that this interview was able to create personal insights in how sensitive the container vessels are to delay due to many factors that are at play in container terminals. The men of the KRVE are on the ground and involved in all steps of terminal operations; therefore they obtain proper understanding of what goes on in the terminals. The findings and transcript of this interview can be found in Appendix E.

Types of Automation

What types of automation can be used related to the third research Questions:

''In what ways can automation help container terminals cope with the increased use of ULCV's to reduce the increased operating costs that come along with the required facilities?''

To find answers to this research question I needed someone who has experience with the rise of ULCV's For this I was able to have a lengthy 1.5 hour interview Andre Kramer, CEO of Kramer Group. He is directly involved with the effects of ULCV's on a daily basis. The most interesting findings of this primary research proved that the link between theory and practise is different in many aspects and that there are many barriers in place for the integration of automation across container terminals. Evermore, being in the terminal allowed me to observe the processes at Kramer Group first hand in the form of observations. The findings and transcript can be found in Appendix E.

Comparison with the Secondary Research

In consensus with the Concurrent Triangulation Method, during the acquisitions of the primary data through interview and observation, secondary qualitative data is also analysed (Saunders, Lewis , & Thornhill, 2015). In this chapter the insights from secondary data are displayed on the basis of the literature analysis, where they are compared to the data from the expert interviews.

CO_2 Emission related to Automation Processes

In this chapter primary findings about the reduction of CO_2 emission are compared with the secondary research about CO_2 emission from both Spruijt (2017) Crane (2016) and the Port of Rotterdam (2016). Was it most interesting in this comparison is that the primary data offered different perspective of CO_2 emission. Where the literature focusses more on direct CO_2 emission in terminals, the interview with Mrs van der Palm (2018) shows the effects on indirect CO_2 emission of container terminals.

Looking at the similarities however, we see that both the literature from Spruijt (2017) and the primary findings concur about the facts that the integration such as the use of AGV's can cause a reduction in tail-pipe emission of CO_2 otherwise caused by trucks conducting interterminal container transport (Palm, 2018) (Spruijt, van Duin, & Rieck, 2017). In addition both parties also highlight the fact that emission reduction is increasingly important for the entire maritime industry (Crane & Matten, 2016) (Spruijt, van Duin, & Rieck, 2017) (Palm, 2018). Evermore, the literature from the Port of Rotterdam (2016) and Spruijt (2017), focus both on becoming 100% climate proof by 2025 and achieving a 50% reduction in CO2 emissions by 2025 as compared to 1990. This concurs with the primary data that show the seriousness in reaching these goals. Namely, by explaining that there are several projects in place to reduce the carbon footprint, such as CO_2 storage in offshore gas fields (Palm, 2018).

Differences between come however in the effect automation in container terminals have on indirect CO_2 emission. The literature only addresses factors that cause CO_2 emission to be reduced in ways of limiting pipe-tail emission. This is due to the fact that electric AGV's are classified as Zero-Emission vehicles (Spruijt, van Duin, & Rieck, 2017). However, the primary research shows that this is only direct CO_2 emission reduction, not taking into account indirect emission coming from having to power the AGV's. In short the electricity to power the AGV's comes mainly from coal-based powerplants (Palm, 2018). Displacing the emission from terminal to power plant, not concretely lowering it. Only when terminals generate their own green electricity to power the AGV's, will it effectively limit CO_2 emission (Palm, 2018)

Concluding from this comparison is that both sources claim that CO_2 reduction can be achieved with the integration of automation processes. However, these reductions in CO_2 emission are relatively insignificant if terminals do not generate their own green energy to reduce their carbon footprint.

Volatility of Operating Costs

In this chapter the volatility of operating cost is assessed by comparing both the literature of Carlo (2015) Albertijn (2011) and Rodríguez (2011) with the conducted Primary Research, an interview with a member of the Koninklijke Roeiers Vereniging Eendracht (Kloe, 2018) (Rodríguez-Álvarez, Tovar, & Wall, 2011) (Albertijn, Toepfer, Bessler, & Dorbertz, 2011) (Carlo, Roodbergen, & Vis, 2015).

Was it is most striking about this comparison is that both Rodríguez (2011) and Mr de Kloe (2018) confirm that container terminals are highly subject to delays. Furthermore, where Rodríguez (2011) digs further into the way terminals cope with these delays in scheduling, Mr de Kloe (2018) helps confirm where these delays actually come from. Evermore, Alvertijn (2011) relays some of these delays with the financial implications the have to shipping companies and terminals (Albertijn, Toepfer, Bessler, & Dorbertz, 2011). Binding these findings together can help shape broader understanding in how terminals could best cope with these delays which lead to high level of volatility in operating costs (Kloe, 2018) (Rodríguez-Álvarez, Tovar, & Wall, 2011).

Evermore, the presence of a huge amount of factors that are in play at container terminals, lead to delays and high levels of unproductiveness. Events such as terminals being occupied by vessels, delays due to weather and inefficient communication between terminal and vessels. (Kloe, 2018) (Rodríguez-Álvarez, Tovar, & Wall, 2011) (Albertijn, Toepfer, Bessler, & Dorbertz, 2011). Especially the correlation between Rodríguez (2011) and Mr de Kloe (2018) about the delays coming from adverse weather conditions is intriguing. Rodríguez (2011) goes further in depth and relates to an study by the Drewry Shipping Consultants, that showed that over 40 % of ships coming from twenty-three selected trading routes, arrived one or two days later than planned due to adverse weather conditions (Rodríguez-Álvarez, Tovar, & Wall, 2011) (Drewry Shipping Consultant, 2006). This was confirmed by Mr de Kloe (2018), who explained that weather conditions cause delays on a daily basis in terminal operations (Kloe, 2018).

In addition, Rodríguez (2011) also explains the effects of ships having to que due to a terminal being occupied by other ships, causing massive delays and even ships rerouting to other terminals (Rodríguez-Álvarez, Tovar, & Wall, 2011). These delays effects are so profound that they highly influence the volatility of the operating costs of all parties involved. Which is a massive concern for the parties involved, since high volatility also directly effects cash flow and profitability (Albertijn, Toepfer, Bessler, & Dorbertz, 2011).

Mr de Kloe (2018) highlights other factors causing delays of ships coming into port, such as engine problems and miscommunication between terminal and vessel. Rodríguez (2011) explains that if these delays become a regular occurrence, terminals gain a strong initiative to minimise delays in processing cargo (Kloe, 2018) (Rodríguez-Álvarez, Tovar, & Wall, 2011). There is a room for improvements to limit these delays. Rodríguez (2011) further explains that such improvements lead to value creation for ports in the way that they create lower volatility of operating costs by reducing docking times. Improvement such as AGV automation can limit delays. However AGV automation is not absent of delaying factors. Low levels of flexibility of AGV as of now asks for step-by-step integration of automation processes, in order to have a significant effect on operating costs (Kloe, 2018).

Integrated automation, helps make the terminal more reliable to shipping companies, which gives the terminal a stronger bargaining position compared to competitors, and allows for port value creation (Notteboom, 2007) (Rodríguez-Álvarez, Tovar, & Wall, 2011).

Rodríguez (2011) goes further into such solutions for container terminals to minimalize these delays, by explaining that terminals who invest in both fixed and variable factors of production, such as automation processes, allow for the catering of the uncertainty of demand caused by these delays. However, Rodríguez (2011) further explains that the satisfaction of stakeholders cannot be neglected with these investments, otherwise operational efficiency can be the costs of this (Rodríguez-Álvarez, Tovar, & Wall, 2011). This again confirms with the primary findings, showing that on the ground personnel have a huge impact on the factors causing delays (Kloe, 2018).

Concluding, the sources shows that demand uncertainty, caused by the combination of delay factors that terminals cope with have a significant effect on costs for the parties involved (Kloe, 2018) (Rodríguez-Álvarez, Tovar, & Wall, 2011). These costs can be quantified as operating costs for container terminals. Therefore the analysis show that the volatility of operating costs for container terminals is high and caused by the combination of delay factors occurring in terminals.

Types of Automation

In this chapter we follow up on the primary data on what types of automation can be used in container terminals. The interview conducted with Mr. Kramer showed the different types of possible automation process which can be integrated in container terminals. See appendix E. In the case of the types of automation, the literature of Spruijt, van Duin & Rieck and the research of Duinkerken was most intriguing (Spruijt, van Duin, & Rieck, 2017) (Duinkerken, Evers, & Ottjes, 1999). Evermore, literature from Marle (2017) provided insights into the rise of the ULCV's (Van Marle, 2017).

A notable similarity with Mr. Kramer is the rise of the ULCV's. Both Spruijt (2017), Marle (2017) and Kramer (2018) confirm that there is an increased use of ULCV's in the maritime industry. In the literature it was expected that 36 new ULCV's would come into service in 2017 (Spruijt, van Duin, & Rieck, 2017). Compared to Kramer's (2018) experience of an 10 % in container volume, confirms the increased volume resulting from the increased use of these ULCV's, which in turn leads to increased operating costs (Port Technology, 2016) (Kramer, 2018). Another similarity is found in the fact that both Kramer (2018), Marle (2017) and Spruijt (2017) confirm that these ULCV's only dock in selective ports, from which smaller barges are needed to transport containers hinterland and to different ports (Van Marle, 2017) (Spruijt, van Duin, & Rieck, 2017) (Kramer, 2018). This leads to congestion, which comes from the changing role of ports to that of a transition hubs. This congestion leads to longer waiting times which in turn leads to higher operating costs (Spruijt, van Duin, & Rieck, 2017) (Kramer, 2018). To solve this increased volume in containers and container within port, both Spruijt (2017) and Kramer (2018) look at the integration of automation (Spruijt, van Duin, & Rieck, 2017) (Kramer, 2018).

A difference shows that the literature goes further into depth on the container flow within the Port of Rotterdam (Spruijt, van Duin, & Rieck, 2017). Research by students from the Hogeschool of Rotterdam show that 21% of arrived containers stay within the Port of Rotterdam and the surrounding Harbour Industrial Cluster (Moving@Rotterdam, 2012). Furthermore, about 70% of these transportation remain within the same area of the port and are mostly displacements between the entities themselves (Spruijt, van Duin, & Rieck, 2017). This confirms the reports of Kramer (2018), that the main bottleneck is the lack of efficient transportation of containers between competing terminals (Kramer, 2018).

The literature goes in depth about the planned construction of the CER, also looking into the future possibilities of the CER. As Spruijt (2017) explains, the CER line will be an MTS manned operation that will be used to transport containers within the Port of Rotterdam (Buiscar Cargo Solutions, 2018). At the first stage where the line is manned by MTS systems it will have an capacity of transporting a proximally 500.000 containers per year (Spruijt, van Duin, & Rieck, 2017). Evermore, the CER will be a closed track which allows the move to autonomous vehicle transport. The move to AGV's, is expected to lead to an increased capacity of 1.200.000 container per year (Spruijt, van Duin, & Rieck, 2017) (Tilema, Buning, Van Duin, & Spruijt, 2017). This CER line will lead to the elimination of interterminal transportation of containers by trucks and limit the height of which containers have to be stacked due to faster interterminal transportation (Spruijt, van Duin, & Rieck, 2017).

However, to be able to integrate such interterminal AGV transport on the CER line, the coordination of these automated traffic flows need to be perfect. The research of Duinkerken (2014) into the adoption of TRACES, an Traffic Control Engineering System, contains valuable insights in how this AGV transport can be realised on a technical side (Duinkerken, Evers, & Ottjes, 1999). Especially, the physical capacity of the infrastructure and the prevention of deadlocks by integrating TRACES could go a long way into realising the use of AGV on the CER line (Duinkerken, Evers, & Ottjes, 1999).

To define the use of these AGV's, the SEA International has defined certain levels of autonomous driving (SAE MOBILUS, 2018). There are six levels, ranging from zero to five. For the CER both level 4 or 5 are achievable, where still human interaction is applicable to the AGV vehicles but the vehicles themselves move unmanned (SAE MOBILUS, 2018) (Spruijt, van Duin, & Rieck, 2017). However, according to the literature, due to interference by several market players creating their own vehicles, the SEA levels of autonomous driving are expected to not completely be applied in the case of a CER. Both union pressure and fear of overstaffing amongst Terminals, mix of both manned and unmanned vehicles on the CER is deemed best for the foreseeable future (Spruijt, van Duin, & Rieck, 2017) (Kramer, 2018).

Lastly, the barriers of the AGV implementation. The main barriers identified are union pressure, interterminal competition and fear of over-staffing. However, there is a striking difference between both sources on the basis of over-staffing. Sources confirm that both union pressure and interterminal competition is a big barrier for the integration of automation. The difference lies however in the fear of overstaffing. According to Kramer (2018), terminals such as ECT lower the integration speed of AGV's in fear of over-staffing. However, the literature suggests that this variable is of less concern due to the aging and the limited inflow of new dock workers (Spruijt, van Duin, & Rieck, 2017). Evermore, this excess of staff is countered by the need of more ICT staff to maintain the AGV's operating systems. However, this does not solve the effect on employment among container drivers. But arguably, due to the limited inflow of less educated dock workers and the aging of the current generation of dock workers, the effect on employment by the switch to AGV's is limited (Spruijt, van Duin, & Rieck, 2017) (Kramer, 2018).

Concluding, the rise of the ULCV's causes more volume in containers due to the transition from selective ports to container hubs. Here congestion, increased stacks heights, and non-automated interterminal container transport lead to increased operating costs for terminals. To combat this, forms of integrating of automation such as the CER line, can drastically lower the ULCV effects. Individual integration of proposed RED by terminal owners can lead to even further reduce operation cost, as mentioned by Kramer in appendix E. However, integrating fully autonomous AGV transport which leads to the increased capacity of interterminal container transport and lower stack heights, has its barriers to be overcome. Union pressure, interterminal competition and fear of overstaffing leads to the adoption of step-by-step integration. Firstly, MTS systems to be followed by AGV's on the CER.

Conclusion & Recommendations

Conclusion

In the conclusion of this thesis, the answers to the research questions are summarized and explained.

Research Question 1

The first research questions aimed to answer whether there is a direct link between the integration of automation in container terminals and CO_2 emission reduction. The answer is that there is a relationship between and that the integration of automation processes. Namely, AGV interterminal container transport, which reduces CO_2 emission in container terminals. The research also answered the questions whether CO_2 emission is of a concern to container terminals. It was highlighted that CO_2 emission is a fashionable subject that is being addressed in all types of initiatives in the Port of Rotterdam.

However, according to the research, the elimination of pipe-tile CO_2 emission is just part of the problem. Indirect CO_2 emission, the non-green generation of power to propel the AGV and electric cranes, drastically lowers effective CO_2 emission reduction. Only when container terminals start producing their own green energy to power the AGV's, can the integration of automation lead to effective all round CO_2 emission.

Concluding, there is an relationship between integrating automation and CO_2 emission reduction, however it is a limited effect relationship. It reduces CO_2 emission, but it is severely limited due to lack of green energy generation in container terminals.

Research Question 2

To answer the second research question, whether there is an relationship between the integration of automation and the volatile nature of operating costs. This research shows the simple fact that there are a huge number of variables at play in the operations of container terminals. Some of these variables cannot be influenced, such as weather conditions. However, several of these variables are also due to human failure and miscommunication. The large number of these influencing factors are the reason why delays occur, and therefore why operating costs are highly volatile. In addition, the research shows that terminals can generate real added value and competitiveness by reducing this uncertainty in delays and costs, which developes into demand uncertainty for container terminals.

However, the expert interview shows that automation has a long way to go to be completely effective into lowering this volatility, since the system in place cannot completely replace human interference and are not yet as flexible to changes as is required. Furthermore, experts in the field add that a step-by-step integration of automation is at this stage the best way of integrating it, due to the barriers and technological restraints.

Concluding, there is a large amount of variables at play in container terminals which causes a high level of volatility of operating costs. Step-by-step integration of automation can help limit the delay and costs some of these factors caused by human failure and miscommunication. Confirming the relationship between the volatility of operating costs and the integration of Automation in container terminals.

Research Question 3

Finally, to answer wat types of automation are best suited to be integrated in container terminals to reduce operating costs coming from ULCV's.

The research shows that the rise of the ULCV's is definitely a occurring factor for container terminals. There is a sharp increase in the use of these UCLV's which causes congestion and increases in container volume. Because of this, operating costs increase due to increased interterminal container flows. Furthermore terminals, experiences delays due to stack heights and an increase in waiting times.

Types of automation such as AGV transport along a CER can eliminate some these delays, increase container capacity and limit stack heights. However, there are barriers to integrating these types of automation. The main barriers are union pressure and fear of overstaffing by container terminals. However, literature shows that the aging of the dock workers limits the effects of this variable for the future. Evermore, some container terminals are relucted to invest in completely autonomous interterminal transport in fear of losing out on trade volume to competitors. In addition, the research explains that union pressure is a real barrier, so much so that in the Port of Rotterdam the CER will remained by manned MTS vehicles until at least 2020.

In conclusion, the research shows that a the integration of automation in the form of AGV transport on a CER is the best way on integrating automation in container terminals.

Main Research Question

Concluding this entire research, the Main Research Question is answered.

M.R.Q: Does the integration of automation decrease operational costs and CO_2 emission for container terminals?

Namely, the integration of automation can decrease operational costs and CO_2 emission for container terminals. This can be achieved by integrating AGV transport of interterminal container transport along a CER, especially if combined with integrated of RED's at terminal level. This lowers the CO_2 emission. However this effect is limited if container terminals do not generate their own green energy. This type of automation lowers operational costs, since it limits the volatility of the operating costs.

The integration of AGV automation is possible, but it has its barriers and requires a step-by-step approach to overcome these barriers. Automation holds the future for high demanding, sustainable and low-cost container terminals.

Recommendations

In this section of the paper we look at the possible recommendations for container terminals in their effort to integrate automation in interterminal container transport. Based on the research, these recommendations embody both the integration Container Exchange Route and Autonomous Guided Vehicles. Furthermore, recommendations are provided on how to integrate and why to do so.

First of all, it is highly recommended for container handling firms to jointly integrate an interterminal Container Exchange Route, operated by AGV's. This CER is an interterminal track that is purely designated for the exchange of containers between terminals and container handling firms. The reason why the integration of a CER is recommended comes from the findings of the research that clearly show the benefits of the CER. Most importantly, these are lower stack heights due to a reduced need for storing empty containers, lower waiting times and less congestion due to reduced interterminal barge transportation. These all limit operating costs for container terminals. Furthermore, it is recommended to switch to AGV's in order to limit CO_2 emission. However, on the basis of CO_2 emission, to be able to comply with the requirements of the Port of Rotterdam to achieve climate readiness by 2050, generation of green energy by container terminals to power the AGV's is highly recommended.

Evermore, it is suggested to integrate this automation on a step-by-step basis. As the research shows the barriers for the integration such as union pressure and resistance from terminals who fear over staffing, offer constraints for the full integration of automation. Instead what is recommended is that container handling firms address these issues by slowly making the move to a fully automated CER. Similar to what is happening in the Port of Rotterdam currently. The CER is to be operated by manned MTS vehicles until 2020, afterwards the use of AGV's is to be integrated. This is both limiting the pressure from unions, as well as allowing terminals the time to establish their own generation of green energy to power the AGV's. This allows terminals to truly reduce CO_2 emission. This step-by-step integration will reduce operating costs every step of the way. As explained in the research, this is achieved by reducing stack heights, congestion of smaller vessels and delays and costs coming from human failure.

In addition, it is recommended for individual container handling firms to invest in the construction of RED's. This is due to the fact that RED's go hand in hand with an automated CER. The integration of RED increases capacity utilization and reduced stacks heights for individual terminal. Furthermore the use of robotic electric cranes also reduces CO_2 emission. The CER becomes more effective as well since AGV will not have to wait for their designated containers. The combination of these two types of automation reduces the need for needles middle steps in the process of moving container from ship to ship an terminal to terminal. Reducing both operating costs and CO_2 emission.

In conclusion, both in the Port of Rotterdam as well as in major container ports in the world that handle ULCV's and large volumes of containers, it is recommended to integrate an automated CER using AGV's. This helps container handling firm to reduce operating costs, reduce CO_2 emission and paves the way to ever larger capacity.

Final chapter

Discussion

In this final chapter we aim to take a critical look at the outcomes of this research. Both an critical evaluation of the work done as well as a description of possible bias and shortcoming of the author.

Primarily, this critical evaluation will come in addressing the shortcoming of this research. Both the primary research and the secondary research were conducted and analysed simultaneously. Shortcomings of this approach are the inability to dig deep into the literature before conducting the primary research. The benefit here being the ability to let the primary findings shape the way the literature is analysed and therefore coming with more up-to-date, practical conclusions. Critically, the work done only consisted about the comparison of primary and secondary research, and therefore was limited to comparison findings.

Evermore, possible bias in this research comes from the primary research all revolving around the Port of Rotterdam. Justification for this decision come from the locality of the author, being close to the Port of Rotterdam. Furthermore, the Port of Rotterdam is currently undergoing moves to automation process, as discussed in the paper, and therefore offered significant benefit. However, internationally, other factors and barriers for the integration of automation might be missing in this research. Evermore, locational bias such as the behaviour of maritime personal, environmental awareness and terminal operations might differ in other ports around the globe. For the sake of the limitations research, the findings of the primary research was generalized and perceived to be the same in different ports around the world.

Evermore, it is recommended for further research to look into the practicality of automation process in container terminals in other regions of the world. The research could be strengthened with more primary research coming from these other terminals. In addition, comparing this to more in depth sources of literature about the working of automation container transport, such as the TRACES operating system described by Duinkerken (1999), could provide evermore tangible insights for container terminals. In addition, personal shortcoming of the author include the litterateur analysis, more sources on the operating of AGV's and the pressure of unions could strengthen the research and provide a stronger basis for the comparison with the primary research. Evermore, more in depth look at RED's can aid the research's practicality.

Lastly, a deeper look into the generation of green energy by container handling firms can truly strengthen this research. The research explains that the reduction of CO_2 emission is limited until terminals generate their own green energy, however is does not explain how this is to be achieved. An addition to this work where this is researched and detailed can be of real value to the entire justification of this research.

Appendixes & Bibliography

Appendix A – Abbreviations

Abbreviation	Description
ULCV	Ultra Large Container Vessels
KRVE	De Koninklijke Roeiers Vereniging Eendracht
AGV	Autonomous Guided Vehicle
KPM	Koninklijke Pakketvaart Maatschappij
MTS	Multi Trailer System
CER	Container Exchange Rood
ECT	Europe Container Terminals
M.R.Q	Main Research Question
R.O	Research Objective
RED	Robotized Empty Depots

Appendix B – Extensive Literature Review

This appendix contains an extensive literature review, where the identified variables of this research are explained.

Spruijt's (2017) article about integrating automation in the port of Rotterdam provides insights into autonomous container transport. First of all, the use of automated transports considerable reduces employment among drivers, slightly compensated by the need for more ICT staff to maintain the autonomous vehicles. This allows for a considerable reduction of costs. However, complete automation is unavailable in the port of Rotterdam till at least 2020. This is due to union resistance, which take the standpoint that carriage of containers is port work and should thus be conducted by port workers. Union resistance is a variable to be considered in this research since it could be hindrance to every port that looks to integrate automation (Spruijt, van Duin, & Rieck, 2017).

Furthermore, the use of automated transports within terminal Increases capacity utilization. Evermore, sharing of capacity is also available with the use of automation as Spruijt (2017) explains, this also contributes to increasing capacity utilization. Therefore capacity utilization can also be identified as a variable for this research. Next, the use of automated transports enables the change to Zero-emission (Spruijt, van Duin, & Rieck, 2017). Which is an important aspect of the container handling industry and therefore also an important variable of this research, namely CO_2 emission.

The Notteboom article (2007) highlights several strategic challenges ports are coping with. In chapter four, the scale increase in vessels size is addressed. This section shows that larger ships have a lower costs per TEU-mile than smaller ships. Therefore, shipping companies are constantly seeking to enlist ever larger vessels into their fleets (Notteboom, 2007). This direct links to the research variable: the rise of the ULCV's. Evermore, Notteboom's article (2007) also highlights the strong bargaining power of port users and the concept of value creation. In chapter 5.2, the essence of value creation for port customers is explained. In short, due to the strong bargaining power of port users, port authorities need to distinguish themselves. This can be done by focusing on different aspects within the ports. With the rise of megacarriers, focusing on aspects such as extensive transportation and communication networks can create the needed added value for container terminals (Notteboom, 2007). This report, among other things, aims to see if automaton can create this added value for ports. Thus, value creation for ports is also considered a variable for this research.

Next articles in the journal of Applied Corporate Finance and the Journal of Transport Economics and Policy (JTEP) highlighted the volatile nature of operating costs of shipping companies (Albertijn, Toepfer, Bessler, & Dorbertz, 2011) (Rodríguez-Álvarez, Tovar, & Wall, 2011). These violative operating costs are a challenging aspect of container handling industry. Since in periods of low demand, costs such as staff, maintenance, insurance, administration and etcetera remain constant, which have large effects on profitability and cash flows of shipping companies (Albertijn, Toepfer, Bessler, & Dorbertz, 2011). In addition, due to research by the Drewry Shipping Consultants in 2006, uncertainty about arrival times of ships has a significant effect on operating costs in the container terminal industry, increasing their volatility (Drewry Shipping Consultant, 2006)(Rodríguez-Álvarez, Tovar, & Wall, 2011). Evermore, with the use of automation, volatile operating costs can perhaps be reduced for container terminals. Therefore, I believe that volatile operating cost to be an important variable to this research.

The following literature by Marle (2017) showed the challenges associated with rise of the ULCV's. ULCV's require container terminals that can meet the new commercial and operational requirements that come along with these larger vessels. Therefore ports have to invest in the ability to accommodate these larger vessels (Van Marle, 2017). The rise of these ULCV's is directly linked to rising operating costs, volatility of these operating costs, and CO_2 emission. Therefore, the rise of the ULCV's can be identified as an important variable for this research.

Lastly, an article of the port of Rotterdam (2016), shows the link between CO_2 emission and future requirements of the port. Furthermore, sustainability is an upcoming aspect of the terminal industry. In the Port of Rotterdam, pressure to reduce CO_2 emission is increasing. The port has the initiative to make the port completely sustainable by 2050 (Port of Rotterdam Authority, 2016). This is directly linked to Spruit's literature about the integration of automation that enables the move to Zero-emission ports. Therefore this article shows the importance CO_2 emission has as a variable to this research.
Based upon the literature review, the direction of the research was visualized into a conceptual model.

Appendix C – Interview Findings & Transcript - M. van der Palm

In this appendix the interview with the managing director of M Restart, Monique van der Palm is presented in the form of an analysis of the interview findings as well as an transcript of our conversation.

Interview Findings - Monique van der Palm

First off, Mrs van der Palm (2018) and I spoke about CO_2 emission itself, and how much of a concern CO_2 emission actually is for the future of container terminals and the maritime industry as a whole. The answer that I was provided with is that it most certainly is a pressing concern and a ''fashionable topic'' in the industry over the last ten years, as Mr van de Palm (2018) puts it. Not only in container terminals but in the maritime industry as a whole, parties are looking into possibilities to reduce CO_2 emission. Such examples given by Mr van der Palm (2018) are gas to H2 (Hydrogen) conversion and offshore gas fields for CO_2 storage. Furthermore, we discussed that there is definitely a need for plans to be drawn up to reduce the carbon footprint in container terminals. However, Mrs van de Palm was not aware of any ongoing plans in the container industry to do so, increasing the urge for CO_2 emission reduction initiatives (Palm, 2018).

When asking about the the integration AGV's (Autonomous Guided Vehicles) and whether these to Mrs van der Palm's opinion could actively reduce CO_2 Emission. The following answer contradicted my expectations. Mrs van der Palm concluded that the integration of automation could definitely decrease CO_2 emission in the container terminals. This being due to the fact that the integration of AGV's would eliminate a large portion of trucks, forklifts and container shifters running emitting CO_2 while transporting containers. Furthermore, these vehicles are running idle when delays occur, resulting in extra pollution that is not contributing to active operations. In addition, AGV's do not emit CO_2 at all, active or when idle (Palm, 2018).

The turning point that contradicted my expectations came however in Mrs van de Palm (2018) arguing that the integration of AGV's this way would reduce CO_2 emission, but the effect will remain minimal if container terminals do not produce their own green energy (Palm, 2018). This was something I had not thought of myself. Mr van der Palm (2018) continued to explain that this is due to the nature of CO_2 emission in the terminal, just making the process more streamlined and reducing emission in the container itself wont hugely effect CO_2 emission of the entire terminal. The power to drive the AGV's will have to come from somewhere else, and in the case of the port of Rotterdam that will most likely be power coming from a coal power plant (Palm, 2018). If terminals were to generate their own green energy to power the AGV's, real change can be made on the carbon footprint the container terminal leave behind (Palm, 2018).

Evermore, we discussed the pressure coming from the Port of Rotterdam to reduce CO_2 emission. Mrs van der Palm explained that the Port of Rotterdam is undergoing an number of projects aimed at reducing power consumption and thus CO_2 emission. Such projects are aimed at solving the previously mentioned problem of generating green energy in the Port of Rotterdam itself. These included wind turbines and solar panels that are currently being installed in both the Maasvlakte I and Maasvlakte II (Palm, 2018).

Lastly, the interview opened up room for Mrs van der Palm (2018) to explain her own opinion about what future initiatives can be undertaken in the Port of Rotterdam to reduce CO_2 emission and whether automation has a place in these. As mentioned before the use of automation in the sense of AGV's can be a contributing factor to CO_2 emission, evermore when the terminal generates its own green energy. In addition Mrs van der Palm (2018) explained to potential of solar panels, terminal offering plenty of open space for them to be installed. Evermore aspects as better facilitation of forklifts can be a way of saving CO_2 emission by reducing needed trips. Furthermore, more container transport by other means than trucks, such as AGV's or inland vessels and trains can significantly reduce CO_2 emission, since a large portion of container transport takes place interterminal (Palm, 2018).

Concluding of this interview it is clear that Automation in the form of AGV's can definitely lead to CO_2 reduction. However, these innovations need to have the right support according to Mrs van der Palm (2018), such as self-provided green energy, to be of real contribution to CO_2 emission reduction. Evermore, initiatives to provide this green energy, such as solar panels and wind turbines, are already underway and hold real promise for the future (Palm, 2018).

In this appendix my interview with Monique van der Palm is transcribed. Mrs van der Palm is an expert in sustainable and renewable energy in the maritime industry and was therefore able to give me tangible insights about the effects of automation on CO_2 reduction.

Interview Transcript - Monique van der Palm

Julian: First of all thank you for taking the time out of your schedule to answer my questions. It is extremely appreciated and will help to take my thesis to a higher level.
Without further a due, let's get down to it.

Actual interview

1 - Julian: Regarding CO_2 emission in the container terminals, do you consider CO2 emission to be one of the main future concerns over the last ten years?

Respondent: ''Not only in Container Terminals but in Container Transport, Energy production, Gas to H2(Hydrogene), that is also the reason why governments around the North Sea are looking into using old offshore gas fields for CO_2 storage.''

2 - Julian: To what extend is CO_2 emission already being reduced in container terminals that you aware of over the last ten years?

Respondent: ''I am not aware if any plans are already drawn up but as reducing emissions in general is a fashionable subject there must be plans drawn up to reduce their carbon footprint which relates to the production of CO_2.''

3 - Julian: Do you consider Automation processes, such as the integration of AGV's (Autonomous Guided Vehicles), capable of reducing CO_2 emission?

Respondent:'' Unless Container Terminals start producing their own green energy the effect of AGV will be minimal. Due to AGV's being powered by coal power plants generated energy. Off course the logistic process on the terminal will be even more streamlined but it is already a fine tuned process. You will not have Forklifts/Container shifters and Trucks(less) waiting, running idle, burning diesel and that will reduce CO_2 emission at the Terminal.

4 - Julian: Have you notices pressure by the Port of Rotterdam to reduce CO_2 Emission ?

Respondent: ''Port of Rotterdam has many project relating into reducing power consumption and thus CO_2. Port of Rotterdam is installing Solarpanels and Wind Turbine Generators on both Maasvlakte I and II. Ships are required to connect to shore power which is "cleaner" than power produced by on board generators

5 - Julian: Can you think of any other measures of reducing CO_2 emission for container terminals ?

Respondent: ''There are several ways to reduce CO_2 emission. Terminals are usually large open areas which are a perfect spot for installing Solar panels roofs. Transport on the terminal is done by forklift type machines so you could build a roof high enough for the forklifts to operate. Same is applicable for small WTG's, install a small WTG in combination with a light mast, that way you do not loose space and you produce power. Possibly switching from diesel to LNG for forklift machines if not already done. Another possibility is for the people consume less, there will be less containers required to move around, when people buy more locally made or grown produce less containers will be necessary. Another possibility is to reduce the speed of unloading a vessel. Container vessels already started sailing slower after the oil went up above a $100 per barrel, this was done to reduce fuel consumption and thus CO_2 of the vessel during transport. A significant CO_2 reduction can be made if more containers are transported by inland vessels, AGV's or trains and reducing the number of polluting trucks required.

Special thanks to Mrs. van der Palm for her insights into CO_2 Emission & Automation.

Appendix D – Interview Findings & Transcript - M. de Kloe

In this appendix the interview with a member of the KRVE, Mitch de kloe is presented in the form of an analysis of the interview findings as well as an transcript of our conversation.

Interview Findings - M. de Kloe

First of all, a summary of the factors that are at play in the processes of container terminals, from the ships coming into port to all of the activities related to unloading and loading of the ships, will help shape a good understanding of how many things are prone to failure. Factors such as: engine problems of vessels, stubbornness of captains to dock starboard instead of port, weather conditions which disable cranes to unload vessels, Criminals who hide themselves in container stacks to try and acquire contraband hidden in containers and Randsomwhere attacks (which is the dumping of containers loaded with bulk good without known destination) just to name a few (Kloe, 2018). Human error is a big factor as well, such as truck drivers being at the wrong location or having to wait for them to arrive due to delays in interterminal transport. The red line of the insights acquired from my interview with Mr. de Kloe (2018) is that terminals have a huge amount of factors that need to be considered which can cause delays and operational failure (Kloe, 2018). All of these lead to a high level of unexpected failures accruing on a daily basis. I asked Mr. de Kloe (2018) whether it happens that everything goes without fault, he replied rarely. This high level of expectancy leads to the high level of volatility of failure, delays and eventually costs.

Moreover, the dockworkers of the KRVE are ordered when a vessel is on his way to tie the vessels into the port. The dockworkers receive an ETA, which lasts for two hours. If the vessel does not come into port within these two hours, the vessel is cancelled and re-ordered when the vessel is ready. During this standby time, vessels, agencies and terminals apply full-rate charge (Kloe, 2018). This means, delays are extremely costly to all parties involved. High volatility of delays therefore causes high volatility of operating costs.

By discussing the Integration of Automation to combat these factors causing delays, Mr. de Kloe (2018) explained that transport of containers on AGV's could help reduce some delays on container terminals. According to Mr. de Kloe (2018), factors caused by human error can be eliminated. In addition, truck drivers that arrive late, with the wrong containers or at the wrong location can be eliminated with autonomous vehicles. However, Mr. de Kloe mentions: ''Automation also has its downsides and flaws. An example being when the KPM2 terminal has prepared the AGV's for unloading a ship that is planned to dock starboard. However, due to whether circumstances or stubbornness of the captain, the ship can decide to dock port side. This results in the whole system needing to switch over to this change. The automated system is not able to quickly adjust since all the drive paths of the AGV's had to be adjusted. This has happened often and it shows how many factors are at play in container terminals'' (Kloe, 2018).

Lastly, the interview with Mr. de Kloe (2018) sheds light on his opinion of automation processes for the future. He agrees to the fact that automation processes such as container transport by means of AGV's is definitely capable of reducing delays and costs. Due to time and development these automated systems will become better and better and coping with human flaws that occur in container terminals. Although some aspects due require human interaction on the ground, HQ based electric crane operators have explained to Mr. de Kloe (2018) that cameras have a limited field of view and operators need to be in contact with people on the ground to know what is going on. Evermore, AGV's need to integrated step-by-step since systems need to be developed in case of unexpected changes happening in the terminal, such as ships coming in port instead of starboard.

Concluding from this interview is that there is an huge number of influencing factors when it comes to container terminal operations. All of these factors make the business highly prone to delays and failures. Integration of Automation can be an answer to some of these human failures and delays. However, these also come with limitations. My finial practical insight gained from the interview with Mr. de Kloe (2018) was that this integration has to be a step-by-step approach in the eyes of on the ground employees. Due to high level of complexity and variables that are at play, current developments are not yet up to the task of coping with all of these variables (Kloe, 2018).

In this appendix my interview with Mitch de Kloe, member of de Koninklijke Roeiers Vereniging Eendracht, is presented. The reason for interviewing an member of the Roeiers, being that this interview was able to give me personal insights in how sensitive the container vessels are to delay. Furthermore, this interview was able to provide more background in what such delays have for an effect on stationary personnel.

Interview Transcript - M. de Kloe

Julian: First of all thank you for taking the time out of your schedule to answer my questions. It is extremely appreciated and will help to take my thesis to a higher level.
Without further a due, let's get down to it.

Actual interview

1 - Julian: Do you often experience delays when it comes to containers vessels making it into port, and what factors influence these delays?

Respondent: ''Yes, this is mostly due to the large amount of factors influencing the efficiency of a port. Variables such as a docking position still being occupied, engine issues, bad weather conditions, towing vessels who are not present and miscommunication between the parties involved. Going into depth about whether conditions, when windspeeds higher than 50 kilometres an hour are detected, the cranes go up and all loading and unloading procedures are halted. Ransomwhere attacks are also variables that are at play in the container terminal industry. This entails container vessels which are loaded with random containers of bulk goods, mostly coming from china, which have no known destination. Finding out who order such containers and where they are needed to go takes up a large amount of time causing significant delays. Evermore, it is prone to happen that contraband is hidden in containers, which individuals than try to recover by hiding in container stacks. When these individuals are spotted, the whole terminal is shut down while authorities are dispatched, causing huge delays.

Concluding, there are just a huge amount of factors coming together in a terminal when it comes to possible delays. There are just so many things that can go wrong. These cause delays.''

2 - Julian: What are the effects on dockworkers when these delays occur?
Respondent: ''All of the dock workers on site are affected by these delays. This is due to the fact that if one activity delays, all of the other activities have to wait. For example, if the right containers are not on sight the whole operation is put out of action and everyone is put on standby. For example we as Roeiers are ordered to take a ship into port. A certain ETA is put out on the arrive of the ship. It's normal for a 2 hour window to be set up in case of delays. If the ships takes longer than 2 hours due to any factor the order is cancel and re-ordered when the ship is ready. These 2 hours of waiting are costly and a direct waste of money for terminal and ship.

3 - Julian: When these delays occur, what is the effects on the costs, does everyone get payed through these delays?
Respondent:'' Everyone order to take care of the vessel, from it coming into port, the personnel on ground ready to unload the ships and the operators, everyone continues to get payed through these delays. It rarely happens that everything goes perfect and that there are none to minimal delays''

4 - Julian: Can some parts of these tasks be automated un your opinion, to reduce these waiting times?
Respondent: '' There are definitely parts than can be automated, such as the AGV transports that are already integrated at KPM2 and ECT. These can significantly reduce loading and unloading times as well as making the process less dependent on human failure. If the track runs smooth and the AGV's arrive on time the unloading goes faster than before with truck drivers. However, automation also has its downsides and flaws. An example being when the KPM2 terminal has prepared the AGV's for unloading a ship that is planned to dock starboard. However due to whether circumstances or stubbornness of the captain, the ship can decide to dock port side. This results in the whole system needing to switch over to this change. The automated system is not able to quickly adjust since all the drive paths of the AGV's had to be adjusted. This has happened often and it shows how many factors are at play in container terminals.

5 - Julian: Should some parts of the terminal process be automated to your opinion, why / why not?
Respondent: ''AGV's tracks can be automated and with time will become better and better with handling all the factors that are at play in a terminal. However, human interference on the ground will always be necessary. Crane operators feel the wind and weight of containers and are able to adjust based on aspects automated system are not yet possible of comprehending. Furthermore, crane operators of KPM2 which are housed inside the HQ have been expressing that cameras can only cover so much field of view where humans are capable of seeing issues and immediately acting on it when something happens in the terminal.
Another aspect that that comes to mind is cyber-attacks, KPM2 suffered a severe cyber-attack where their entire automated terminal was deadlocked for a number of days. This resulted in all of their ships having to dock at reviling terminals. This costed KPM Terminals millions. One of the reasons why not everything should be automated, and why to Mitch his opinion things should be done step by step.''

Special thanks to Mr de Kloe for his insights into port operations.

Appendix E – Interview Findings & Transcript - A. Kramer
In this appendix the interview with CEO of Kramer Group, Andre Kramer is presented in the form of an analysis of the interview findings as well as an transcript of our conversation.

Interview Findings - Andre Kramer

First of all Mr. Kramer spoke about the noticeable increase of size of container vessels. According to his accounts the last couple of years the volume of container transport has risen with a proximally 10 percent for his terminal (Kramer, 2018). This concurs with the literature review that stated the rise of these ever larger container vessels, otherwise detailed as ULCV's

(Notteboom, 2007). But more on that in the secondary research chapter. The interview with Mr. Kramer explained that the shipping industry can be compared with the airline industry. Due to ever larger capacity, larger forms of transportation are required. These in turn require more facilities and take longer to load and unload. Where airlines need longer fuelling time, and where the loading of suitcases takes longer, so does this apply to shipping. The ULCV's need longer time to be bunkered, which is there term for fuelling, evermore they need to be unloaded and loaded with new containers. The larger the vessels, the longer this takes and the more facilities are needed (Kramer, 2018).

Mr. Kramer also detailed the fact that these large vessels only dock in selective ports due to their size. This means that only a hand full of terminals come in to contact with these large vessels. However, the smaller vessels that are needed to transport these container hinterland are also coming to these large ports where these ULCV's are docked. The coming together of these vessels leads to congestion, one of the biggest factors that currently influenced container transport according to Kramer (Kramer, 2018). These congestion moments are described by Mr. Kramer as Peak moments. Contesting these peak moments is known as Peak Shaving in the industry (Kramer, 2018). According to Kramer there are several solutions to peak shaving, such as AGV transport tracks and the construction of a Robotized Empty Depot (RED). This will be further detailed later on in this chapter.

In addition to contesting peak moments, the rise of the ULCV's also lead to other challenges for container handling firms. One of this is the height of container stacks. The larger capacity of these ULCV's lead to more containers that need to be transported and stored. The way containers are stored is in large stacks in designated areas in container terminals. However, as Mr. Kramer explains, the increased height of these stacks due to increased number of containers, leads to several problems. The higher the stack, the more containers need to me removed and relocated when a container from the stack is requested, this costs time and therefore causes increased operating costs (Kramer, 2018). The reason being that empty containers are placed at the top of these stacks. Logically so, due to the fact that empty containers at the bottom make containers stacks instable and prone to falling over. This is one of the biggest factors leading to high operating cost, namely the cranes can only load the container when the right container has arrived from its stacked location (Kramer, 2018). When I asked about the consequences on CO_2 emission Mr. Kramer explained that more vehicles are needed to store these containers in stacks leading to increased CO_2 emission according to Mr. Kramer. He adds however that increased CO_2 emission is combated with the addition of AddBlue, an fuel mix which limits the emission coming from fossil fuel driven container handling vehicles. Evermore, electric cranes are already integrated in Kramer Group's terminal to limit emission even more (Kramer, 2018).

In addition, Mr. Kramer spoke about possible solutions to the issues of Peak Shaving. To be successful at Peak Shaving, according to Mr. Kramer facilities such as an automated AGV line between terminals could go a long way in reducing both congestion and stack heights. As Mr. Kramer explains in the interview:

''The top of the container stacks are formed by empty containers, these in turn need to be removed before the filled containers can be loaded. Concepts such as an interterminal docking station, where container can be directly transported from one terminal to another via AGV, could eliminate much of these issues. Currently in Mr. Kramer's terminal, containers that need to go to a ship in neighbouring ECT Terminals go from ship to an Multi Trailer System. On the MTS they arrive at ECT, where they are carried to a certain block. Here, a crane puts them on an AGV which takes in to the designated ship. An direct AGV link could prevent all this according and since the containers are directly put on the AGV toward the ship docked in the ECT Terminal. This limits both stack heights which enhances productivity and lowers operating costs'' (Kramer, 2018).

The use of Automated Guided Vehicle and Multi-Trailer Transport to connect terminals is also discussed in the literature analysis and will be compared to these primary findings in the secondary research chapter (Spruijt, van Duin, & Rieck, 2017).

Evermore, the interview created insights into the pressure of unions and the form of competition that limit these development. What was striking here is that competition between terminals is a big factor. According to Mr. Kramer one of the biggest reasons why the AGV line between his terminal and ECT is not being constructed is that ECT Terminals is relucted to invest since they are afraid some of their capacity might shift to Kramer Group's terminal. Since with the AGV line ships can potentially dock at any terminal due to the fact that their containers can be efficiently transported if they are needed in another terminal (Kramer, 2018). In addition, ECT Terminals employs a large amount of people, these people are organized in unions. These unions do not like the idea of an AGV line since this will eliminate the in-between steps which are still conducted by manned vehicles. Evermore, ECT Terminals fears that they are left with a large amount of staff with nothing to do if the AGV line is constructed. Laying them off causing more negative effects than a more efficient AGV line (Kramer, 2018). However, some changes are already happening according to Mr. Kramer, The development of an CER (Container Exchange Route) which is operated by MTS vehicles is in the works and will provide interterminal container transport. However, all terminals connected signed a social accord due to union pressure where they agree that the MTS vehicles will remained manned by dock workers (Kramer, 2018).

Concluding this interview, Mr Kramer and I spoke about why such innovations are so crucial. In the Container handling business, the biggest factor to cost in the fixed costs. Once you break even, every extra container you handle turns a 90 % profit. This leads to any deduction in operating cost can lead to a massive impact on profit (Kramer, 2018). Lastly, Mr. Kramer mentioned an very interesting way of automation container terminals which he was currently under consideration. This is the previously mentioned RED. In such a RED, Mr. Kramer explains that the distance between stacks of containers can be considerably reduced due to the overhead automated cranes that handle these containers. No needed drive routes on the ground which leads to a huge increase in capacity utilization. Furthermore, far less human interference is needed on the ground to remove containers from stacks which leads to less operating costs. Evermore, the cranes are electric and leave no need for fossil driven container vehicles to remove the containers from stacks, considerably reducing CO_2 emission.

This RED combined with the AGV track would considerably reduce operating costs and CO_2 emission according to Mr. Kramer, to him this is the best future integration of automation for container terminals (Kramer, 2018).

Interview Transcript - Andre Kramer

Julian: First of all thank you for taking the time out of your schedule to answer my questions. It is extremely appreciated and will help to take my thesis to a higher level.
Without further a due, let's get down to it.

Actual interview

1 - Julian: Is there an noticeable increase in container vessel size in the terminal industry, specifically the adoption of Ultra Large Container Vessels?

Respondent: ''Most definitely, this increase in vessels size even lead to an unexpected increase of 10 % in container transport for us at Kramer Group. According to Mr. Kramer, the shipping industry can be compared with the airline industry. Ever larger airplanes are introduced to meet higher needs of capacity. Same goes for the shipping industry where ever larger vessels are needed to meet higher capacity. These vessels only dock in selective ports and come together in one terminal where their container need to be processed. Smaller ships are needed to transport these containers. This coming together of larger an smaller vessels leads to congestion which is one of the main focus points of terminals these days, limiting this congestion.''

2 - Julian: What are the most noticeable effect of the increased use of these ever Ultra large Container Vessels for terminals?

Respondent: ''As mentioned before the moments op high congestion, called peak moments, are of the highest concern to terminals. Contesting these peak moments in called Peak Shaving in the industry. Evermore, the Hight of container stacks is a big effect of these larger vessels.

Because of the high capacity of these ships, containers coming of them need to be stored in stacks of container placed on top of each other in the terminal. When a container is needed which is at the bottom of such a stack, lots of time is lost removing the container from the stack. This is very cost inefficient for terminals. This is one of the biggest factors influencing operating costs, namely, cranes can only load the ships until they receive the right containers.''

3 - Julian: Do these problems that come from the increased capacity of ULCV's require certain facilities from terminals to cope with?
Respondent: ''In order to successfully cope with this problem and form successful Peak Shaving certain facilities are needed. Mr. Kramer explains that the top of the container stacks are formed by empty containers, these in turn need to be removed before the filled containers can be loaded. Concepts such as an interterminal docking station, where container can be directly transported from one terminal to another via AGV, could eliminate much of these issues. Currently in Mr. Kramer's terminal, containers that need to go to a ship in neighbouring terminal ECT go from ship to an MTS. On the MTS they arrive at ECT, where they are carried to a certain block. Here, a crane puts them on an AGV which takes in to the designated ship. An direct AGV link could prevent all this according to Mr. Kramer.
In addition, because of this the stacks remain at a reduced height, which highly increases productivity and capacity utilization.''

4 - Julian: Is there a high form of competition among the terminals in the terminal industry, for the sake of value creation for the entire port?
Respondent: ''Yes there is, terminals are afraid of losing capacity to one another. Furthermore, some terminals are relucted to invest in interterminal transport because than shipping companies can shift capacity to better performing terminals even if there ships dock in another terminal since the container can be efficiently transported. However according to Mr. Kramer, a move to more automation will benefit al terminals in the long run and increase their value as a port in general.
There is however an agreement to enhance interterminal container transport in the form of MTS track, called the CER (Container Exchange Route). However, due to union pressure and the fair form big terminals such as ECT who are afraid that they will be stuck with too many employees, have agreed to the CER track be manned by dock workers. This was agreed upon by all terminals in the form of a social accord. ''

5 - Julian: Is there a pressure to reduce CO_2 emission for you as a terminal owner, and are there efforts being made to reduce CO_2 Emission?
Respondent: ''Yes, this concern is also brought to bear by the increased capacity of larger vessels. However, efforts are being made to combat this, Cranes in the terminal are already electric and most of the container lifters. Also those container vehicles who are still powered by fossil fuels have been integrated with Add Blue, a form of less polluting fuel.''
RED
6 - Julian: On the basis for operating costs, do you see an increase in operating cost to these larger vessels and can automation help prevents this to you opinion?
Respondent: ''To biggest factor in terminals are fixed costs, variable costs such as operational costs. The more you automated, the less variable costs. This can be of huge impact in the container terminal business. Due to the fact that when you reach the Break-Even Point, every container you process after that is 90% profit. This is why lowering these operational costs by even a bit can be of huge impact. ''

7 - Julian: Are there facilities that you would like to see automated in your terminal and the port of Rotterdam as a whole?
Respondent: As mentioned before, the creation of a direct AGV track between terminals can eliminate time and costs on a large scale. Evermore, Mr Kramer explains his ideas about an Robotized Empty Depot, where automated cranes transports containers in the depot that can be placed very densely to one another. This depot hugely effects capacity utilization and lead to far less operational cost by needed less human interference and storage space for containers. Combined with the previously mentioned docking station and AGV track, his terminal would be 100 % ready for the future.

Special thanks to Mr. Kramer for his insights on automation and UCLV.

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