CHALMERS
UNIVERSITY OF TECHNOLOGY

Mapping barriers in intermodal transportation

Identifying mitigation potential of digitalization for barriers in Gothenburg port logistics

Master's thesis at Challenge Lab

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CHALMERS UNIVERSITY OF TECHNOLOGY
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Preface

This thesis is conducted at Challenge Lab where the focus is on sustainability and finding strategic solutions to complex problems that relate to the regional goals of the ‘Climate strategy 2030’, wherein this thesis will have a focus on the thematic area of mobility. The research is divided in two parts, ‘Phase 1’ and ‘Phase 2’. The first phase, ‘Phase 1’ outlays the foundation of this thesis describing the beginning of the research process, including tools and techniques used, to reach a finalized research topic and questions. ‘Phase 2’ continues the research process by exploring the research questions indicated to have an impact on society including elaboration of theory underpinning the complex research problem with its following results, discussion and conclusion. The research process, with a continuous flow throughout ‘Phase 1’ and ‘Phase 2’ are to result in the reach of a consensus in what the research has contributed with to society.

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Abstract

The world is experiencing an ever-increasing exploitation of resources and the demand of goods is affecting the global trade routes causing increased pressure on an efficient and sustainable transportation system. This raises questions on how to provide and apply innovative solutions to organize a functioning supply chain through port logistics to increase performance of the transport system. The purpose of this research is to map existing barriers faced to intermodal transportation in the perspective of Gothenburg's port logistics. Furthermore, to explore whether any digital technologies have mitigation potential to increase the connectivity between the different transport modes, such as rail, sea and road. To pursue this aim, evident barriers and digital technologies, such as blockchain, cloud logistics, big data, sensors, automation and Internet of Things (IoT), are investigated and a proposal of the technologies that have mitigation potential are provided. This is supported by answering the following research questions:

- *What are the barriers intermodal goods transportation faces today when trying to develop sustainable mobility flows in port logistics?*
- *How can digital technology act as mitigation for existing barriers?*

The process of collecting data included the Delphi method, a systematic literature review, to research existing barriers in literature, and semi-structured interviews. Stakeholders from the local supply chain of port logistics and researchers from the city of Gothenburg contributed with their knowledge in both semi-structured interviews, a dialogue workshop and a Delphi data collection form. After analyzing the collected data, it was discovered that there are many existing barriers, found both in literature and during interviews, including some potential digital technologies that can be implemented for mitigation. However, the transport industry is old-fashioned and actors in the supply chain lack incentives to apply digitalization since the system works sufficiently as it is. To overcome these hindrances, emphasis must be put on increasing incentives in the industry for digital application by mitigating the greatest barriers identified as cost and price of transport, lack of reliability, capacity and communication. Automation of operations in the industry appears to be the most promising digital tool that could influence the industry by subsequently increasing incentives for digitalization. It was also found that by emphasizing the importance of digitalization with its many applications and collaboration between actors, stakeholders in Gothenburg port logistics could be influenced, thus bringing forward intermodality, i.e. sustainable transportation. It is therefore concluded, that actors need to communicate to enhance collaboration, use digital tools to mitigate barriers and increase utilization of existing capacity to cope with tomorrow's societal demands. Consequently, the intermodal transportation system needs to prove its reliability by increasing its digital applicability in creating efficient transport, connecting everyone to a fair price.

Keywords: intermodal goods transportation; barriers; digital technology; port logistics; Delphi method

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Gabriella Eriksson and Marina Yaruta, Gothenburg, June 2018

Abbreviations

3PL	Third-party logistics provider
AGV	Automated Guided Vehicle
APMO	Average Percent of Majority Opinions
ASC	Automated Stacking Crane
AI	Artificial Intelligence
DW	Digital Watermarking
EC	European Commission
ETA	Estimated Time of Arrival
EU	European Union
GDP	Gross Domestic Product
GPS	Global Positioning System
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IS	Information Systems
IT	Information Technology
ITS	Intelligent Transport Systems
JIT	Just-In-Time
Laas	Logistics-as-a-Service
MLP	Multi-Level Perspective
NFC	Near-Field Communication
OECD	Organization for Economic Co-operation and Development
QR	Quick Response
RFID	Radio Frequency Identification
RoRo	Roll-on-Roll-off
SCM	Supply Chain Management
SDGs	Sustainable Development Goals
TEU	Twenty-foot Equivalent Unit
UN	United Nations
WSN	Wireless Sensor Network

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1

Introduction

Mobility has differing definitions depending on the area the research is being conducted in. According to Flügge (2017, p. 1), "mobility is all about freedom" where, as a human or object, one has the ability to freely maneuver in different geographies. The present state of society with all its digitalization enables one to take "chances and transforming constraints into opportunities." Mobility, however, has its challenges and there is a need to maintain a healthy global economy, environment and participation in trade. This can be an issue since world trade volumes are slowly increasing and the need for efficient hubs, such as ports, are imperative. The infrastructure is already heavily burdened by increased turnover of goods, it could be imagined that the burden may increase in the future along with the growing population (Flügge, 2017). As society is becoming larger and more developed the environmental circumstances have rapidly begun to change. The industrial revolution could be noted as the starting point of the rapid change and presently humans are said to be the "main driver of global environmental change" where all activities that are performed by humans have consequences (Rockström, Steffen, Noone, & Scheffer, 2009, p. 472).

Traditional mobility methods must be revitalized to give a new approach and become adaptable for the entire world, as according to Flügge (2017, p. 9) the future realizes "mobility to be a major focus for the next decade and beyond". Infrastructure, e.g. sea, rail and road transports worldwide, have a need to be transformed to cope with the expected increase in goods flow and the demand for transportation. In the region of West Sweden, the 'Climate strategy 2030' and transport strategy for Gothenburg 2035 highlights the importance of sustainable transportation and sufficient infrastructure to cope with the expected increase of goods transportation while targeting the goal of decreasing the climate impact (Hellberg, Bergström Jonsson, Jäderberg, Sunnemar, & Arby, 2014; VGR, 2016). For goods transportation to maintain a sustainable flow throughout the supply chain of port logistics, efficiency needs to be improved and existing barriers mitigated. Pertaining sustainable port logistics is difficult as physical infrastructure can prove to be hard to change, therefore the regional strategies of West Sweden aim to move intermodal goods transportation within its system to change the goods flows.

Interpolating intermodal transportation into port logistics is a necessity for creating a more efficient and sustainable logistics sector. However, there are a lot of challenges faced to intermodality, including the constant competition with road transport (Monios, 2014). Moreover, it is closely related to the shipping industry as its main roots originate from port logistics, where most of import and export takes place. Consequently, intermodal transport and its challenges can often be approached from a ports perspective (Brewer, Button, & Hensher, 2001). Furthermore, intermodality involves various modes of transport, which drives the need to integrate the intermodal links into the current logistics system to facilitate modal shift. This as there are many challenges that might have an impact, such as transit time and flexibility.

Therefore, it is essential to develop, modify and link the existing operations in the logistics sector to make intermodal goods transportation a more favorable option compared to road (Monios & Bergqvist, 2017). This by, consequently, increasing reliability and security in the interface operations, i.e. in-between the various transport modes of intermodality.

Nonetheless, sea transport is considered to be the most sustainable transport mode (Lind, Brödje, Haraldson, Hägg, & Watson, 2015). The overall effect depends on its integration in the intermodal transport supply chain and the collaboration with other transportation modes at the interfaces. Therefore, various improvements at these interfaces need to occur, such as route optimization and information sharing. This could be accomplished through an open promotion of better collaboration and implementation of standardized digitalization, which can enable more transparency, efficiency and real-time information sharing (Fiorini & Lin, 2015). Thus, this research is conducted to further discover the challenges that intermodal transportation faces today and what kind of digital technologies that may contribute to their respective mitigation.

1.1 Purpose and research question

The purpose of this thesis is to investigate the barriers that intermodal goods transportation faces today including the reasons behind not fully utilizing the capacity that exists. Furthermore, the research will be conducted to explore if any digital technology can be used to mitigate existing barriers, to increase connectivity within the concept of intermodal goods transportation. The thesis will focus on a participatory and co-creational approach to identifying barriers and any mitigation potential of digitalization where stakeholders such as researchers and businesses will contribute with insight in the industry of intermodality; road, rail, and sea. The data obtained from stakeholders, via interviews and the use of a Delphi approach, will be evaluated and gathered to identify barriers including digital technology developments. The transitions in the system of intermodality will be approached to, in the end, conclude any propositions for implementing a digital technology to ease and increase the connectivity. The purpose of the thesis is supported by the research questions:

- *What are the barriers intermodal goods transportation faces today when trying to develop sustainable mobility flows in port logistics?*
- *How can digital technology act as mitigation for existing barriers?*

1.2 Scope

The scope of this thesis is to investigate the collaborative ecosystem of intermodal goods transportation and to map the barriers that exists in-between the different transportation modes. The modal shift needed to increase the exchange from road to rail and sea transportation are implemented by identified mitigation and possibly a digital technology.

1.2.1 Aim

The aim of this master thesis is to map existing barriers of intermodal goods transportation to find out whether a digital technology can be used to increase connectivity in-between the different modes of transport. Consequently, the goal is also to develop possibilities for future efficiency and incentives for moving road transports to rail and sea, by using “the right type of transport for the right type of goods”. Currently, moving goods transports from road is the aim of the ‘Climate strategy 2030’ for the region of West Sweden, where the statement is that for

the total emissions of greenhouse gases are to be reduced by 80 percent by 2030 compared to the levels of 2010, one challenge is to increase intermodal transportation. When barriers are identified, the next step will be in researching whether any digital technology can be implemented as a solution to mitigate existing and future barriers. The research will be conducted by looking into literature and interviewing technology companies and related stakeholders from business and academia. However, the aim is not to present one final digitalized solution, but rather to describe the different applicable digital technologies which after a workshop with stakeholders will contribute to several possible solutions for the different identified barriers to facilitate an efficient goods flow within port logistics and consequently intermodal transportation.

1.2.2 Limitations

The limitations in this master thesis will firstly be between transportation of goods and people, where the focus will be on goods. Intermodality can be seen from different perspectives where the difference lies in the connection pattern between different transportation modes. There are likely to be many synergies between goods transport and personal transport, thus to make this thesis comprehendible both aspects are not considered. Therefore, it has been concluded that the research will only include goods transportation and its intermodality related to port logistics.

The intermodal aspects of goods transportation will be limited to road, rail and sea in the region of West Sweden due to the unlimited application opportunities for a digital technology in a global scale including its applicability to other industries. The amount of different digital technologies that can be applied to existing barriers are various therefore they are limited to concern blockchain, big data, IoT, cloud logistics, sensors and automation, because they are the pre-dominant technologies on the market and mentioned in the industrial reports by DHL and PWC (DHL, 2016; Tipping & Kauschke, 2016). The main perspective will be on the interface of port logistics, where the goods end up from sea and then the connections in forwarding it from the port on to intermodal transportation. Port logistics includes the whole process of operations conducted in the port and includes different actors i.e. ocean carrier, freight forwarder, land transport carrier, goods owner and port operator. Stakeholders, related to port logistics, participating in our research will also be limited to the area around Gothenburg, as we are situated in the city while also focusing on the ‘Climate strategy 2030’ and transport strategy for Gothenburg 2035 which are applicable in the regional context. The stakeholders will also only be related to the port logistics supply chain, mentioned earlier, which the actors acting in the decided interface will be acquainted with. This will probably impact on the generalizability of mapping the barriers and possible applicable technology developments, but generally the intermodal industry of freight transportation looks similar on a global level.

1.3 Thesis outline

The thesis is divided in two phases, ‘Phase 1’ and ‘Phase 2’, where the first phase is conducted during four weeks at the Challenge Lab and the second phase is construed with self-work until the hand-in of the final thesis work.

‘Phase 1’ introduces backcasting with its methodology and related tools of two perspectives, outside-in and inside-out. For example, self-leadership, dialogues, leverage points and so on. In the beginning the Challenge Lab learning environment is briefly described and hence the description of the four-week process is explained. In the end, results part of ‘Phase 1’, the outcome of the backcasting process is presented with the research question as the final output.

‘Phase 2’ process is based on the outcome from the previous phase and examines the research questions more in-depth with a focus on the theory and method used to obtain the results of the whole research process which is envisaged in the end. The whole process is elaborated, with the results at hand, by discussing the findings and concluding whether the research questions is authorized. To further elaborate the desired future of the thesis, proposals for further studies will be specified.

Phase 1

Challenge Lab is divided into two parts, where the first part, ‘Phase 1’, describes the four first weeks of the process. In this phase the focus lies in creating and developing a common understanding within the group, based on the theoretical background and methodology provided. This to empower the group, in a co-creative way, to identify possible sustainability challenges in the current system, both on a global and regional scale, to proceed in discovering a promising research project. The process is to assemble the theoretical background and methodology focused on in Challenge Lab to find a specific research questions that will be explored during the second part, ‘Phase 2’, of this thesis.

2

Challenge Lab

Challenge Lab is an environment where lab-based learning engage and empower students in challenges which create value in complex systems to facilitate societal transitions towards sustainability (Larsson & Holmberg, 2018). Today's society is complex and according to Geels (2005) transitions in societal functions that are fulfilled by sociotechnical systems, consisting of elements such as knowledge and regulations, can be highly complex as systems of innovation. In other words, technology and society work together to create a future with the co-evolution of elements wherein a small shift in the system can contribute to large changes overall (Meadows, 1997). To achieve these transitions, collaboration between different actors are needed. Here the students, of different nationalities and with shared vision, act as change agents where self-reflection and value creation is the starting point of trust creation, which is imperative when people are to open up (Flood, 1998). Students tend to act neutral with a non-threatening and challenging approach to many complex challenges that society is faced with. Therefore, the triple helix together with the knowledge triangle, see *Figure 1*, can be applied to increase the attraction by deepening "the collaboration and co-creation" between all actors involved (Holmberg, 2014, p. 97).

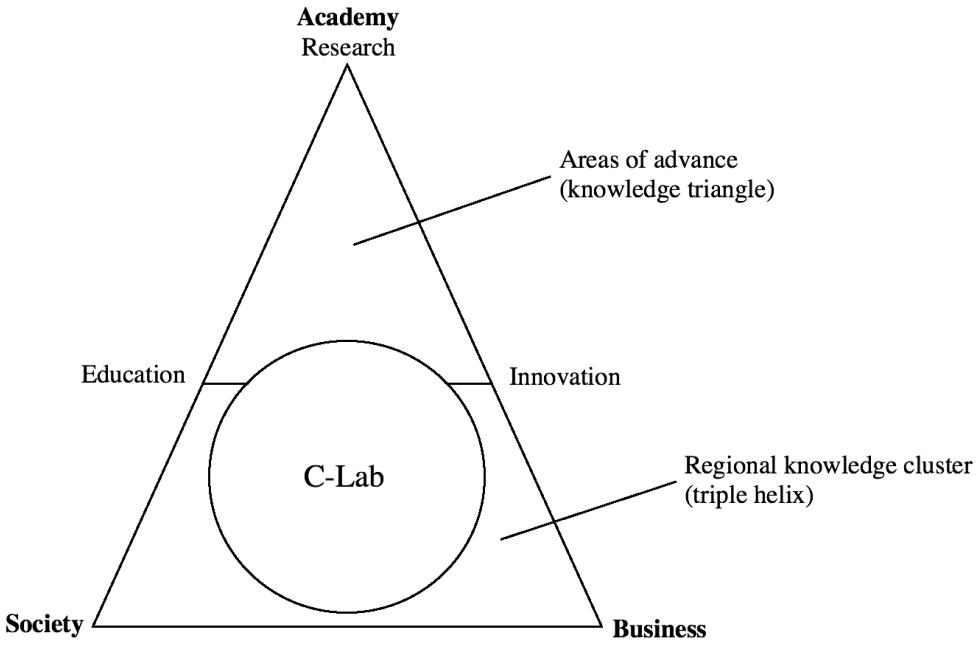

Figure 1: Challenge Lab in the middle of the triple helix and knowledge cluster (adapted from Holmberg (2014))

The triple helix has three cornerstones; academia, business and society, in where opportunity is given to students to develop "unique capabilities in working across disciplines with a sustainability-driven approach" (Holmberg, 2014; Larsson & Holmberg, 2018, p. 7).

Furthermore, the areas of advance are created to enable a neutral ground for potential transformation where interdisciplinary cooperation, between educational departments, is facilitated. The aim is to empower collaboration and integrate "the three drivers of a knowledge-based society", i.e. external stakeholders (society and business), with "the three corners of the knowledge triangle: education, research and innovation", i.e. academia (Holmberg, 2014, p. 95). Consequently, the students in Challenge Lab can evolve and strengthen the educational dimension by combining research, education and innovation to take on the sustainability challenges of today. This by also engaging external stakeholders within the regional knowledge cluster of West Sweden to facilitate cross-boundary engagement. Moreover, for students to become resourceful change agents, the lab gives access to different methods and tools which includes backcasting, in two perspectives of inside-out and outside-in, self-leadership, dialogue facilitation and tools to generate self-awareness of one's own values and strengths.

A quote from the founder of Challenge Lab that represents the mind-set in the lab as well as an inspiration throughout the master thesis process:

"Think big, start small, act now, fail fast and learn fast" – John Holmberg

3

Theoretical framework

In ‘Phase 1’ the process of identifying issues in the current system is conducted using the theoretical framework of backcasting. Within backcasting different tools are used to gain an insight in the perspectives of inside-out and outside-in. Together this will contribute to a holistic view of the challenges impending.

3.1 Backcasting

The transition from industrialized societies into societies where there is a balance between societal actions and the natural environment, are “highly topical issue and a real challenge to man” (Dreborg, 1996, p. 813). This transition into more sustainable developed societies are a very complex process that requires a methodology that can be applied to solving complex issues. Backcasting has a normative nature which in correlation to today’s societal concerns considers desirable futures focused on sustainability, the “normative concept of sustainability”, and it is particularly useful when there is a complex problem (Holmberg & Robert, 2000; Vergragt & Quist, 2011, p. 747). The normative nature of backcasting can be considered as normative scenarios or backcasting scenarios. In these scenarios, the understanding of future challenges of the systematic nature are more straightforward and assumptions of the need of systematic transitions, which are essential to reach a desired future. This can be put in contrast to trend extrapolations, forecasting and strategic scenarios which only attempt to predict where the world is headed based on what is happening today.

According to Dreborg (1996, p. 816) backcasting can be a useful methodology:

- “when the problem to be studied is complex, affecting many sectors and levels of society;”
- “when there is a need for major change, i.e. when marginal changes within prevailing order will not be sufficient;”
- “when dominant trends are part of the problem – these trends are often cornerstones of forecasts;”
- “when the problem to a great extent is a matter of externalities, which the market cannot treat satisfactorily;”
- “when the time horizon is long enough to allow considerable scope for deliberate choice”

3.1.1 Sustainability

Relating to the backcasting foundation and its focus on sustainability problems with a desired future in mind, the definitions of sustainability can be as numerous as there are complex challenges. One is stated by Vergragt and Quist (2011, p. 748) that "it is a systematic multidimensional concept that encompasses the environment, human well-being, equity, human development, and the economy" with a long-term societal goal. Developing a sustainable vision could help empower society to create an increasingly stable environment where, in turn, society can be enhanced. A society can invest in a sustainable future which can be envisioned on many scales, regional and global. Thus, a vision of a sustainable future can be destroyed by the closed related dystopias, the future society wants to avoid. Nevertheless, "humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987, p. 16). Here backcasting can used to identify how the undesirable futures can be eluded (Vergragt & Quist, 2011).

According to Holmberg and Robert (2000, p. 291) backcasting can be used when "planning towards sustainability". The method and tools applied will in a systematic way increase the possibility that complex issues concerning the whole ecosphere can be handled in a coordinated approach. This, with the support of a framework set by principles for sustainability, i.e. system conditions, will continue developing societies within the boundaries of nature. These boundaries are the sustainable development without the destruction of "the ecosphere's ability to sustain" an equilibrium (Holmberg, 2015; Holmberg & Robert, 2000, p. 299). The four principles contemplating the system conditions are presented in the article by Holmberg (1998, pp. 33-34) where the preconditions are that "for a society to be sustainable, nature's functions and diversity must not be systematically":

- "Subject to increasing concentrations of substances extracted from the earth's crust"
- "Subject to increasing concentrations of substances produced by society"
- "Impoverished by over-harvesting or other forms of ecosystem manipulation, and"
- "Resources must be used fairly and efficiently in order to meet basic human needs worldwide"

These principles for sustainability can be applied to the dimensions of sustainable development, where three of the dimensions; ecological, economic and social, are conditions that cannot be deteriorated if they are to collectively guarantee that human needs and well-being are to be fulfilled in the future (Holmberg, 2015). Envisioned by Holmberg (2018) in the sustainability lighthouse, see *Figure 2*, the future human needs is also highlighted as a dimension to consider in addition to the other four of sustainable development.

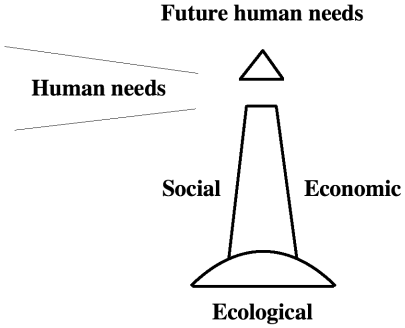

Figure 2: The sustainability lighthouse (adapted from Holmberg (2018))

The United Nations (UN) 17 'Sustainable Development Goals' (SDGs), see *Figure 3*, together with the planetary boundaries by Rockström et al. (2009) are foundations to define sustainability criteria upon, and in which the backcasting process depends on to attack complex sustainability issues in society (Madeley, 2015). Those sustainable development goals that apply and are relevant to this thesis regarding mobility are identified as '9: Industry, innovation and infrastructure', '11: Sustainable cities and communities' and '12: Responsible consumption and production'.

Figure 3: The 17 SDGs (UN, 2018)

In addition to the SDGs, see part 4.1.2 for further explanations, the planetary boundaries defined by Rockström et al. (2009) are a framework that can be used to envision a status-quo Earth by maintaining a Holocene state, i.e. when environmental change occurs naturally, and enabling human development as the Earth has a regulatory capacity. The planetary boundaries are set to define the operating space for humanity, in where the Earth's system is kept unchanged. To grasp and envision the state of the Earth, it is important form an outside-in perspective to maintain a sustainability perspective. Rockström et al. (2009, p. 472) have described the planetary boundaries, which are nine thresholds for processes critical for the stability of Earth's resilience; biodiversity loss, change in land use, global freshwater use, biogeochemical flow boundary, stratospheric ozone depletion, ocean acidification, climate change, chemical pollution, and atmospheric aerosol loading.

3.2 Backcasting – the process

Backcasting can be defined as "generating a desirable future, and then looking backwards from that future to the present in order to strategize and to plan how it could be achieved" (Vergragt & Quist, 2011, p. 747). The process of backcasting relates to the definition and is divided in four steps, see *Figure 4*, where it is systematically performed in a step-by-step approach (Holmberg, 1998). The methodology consists of a set of tools that are divided into two perspectives; outside-in and inside-out.

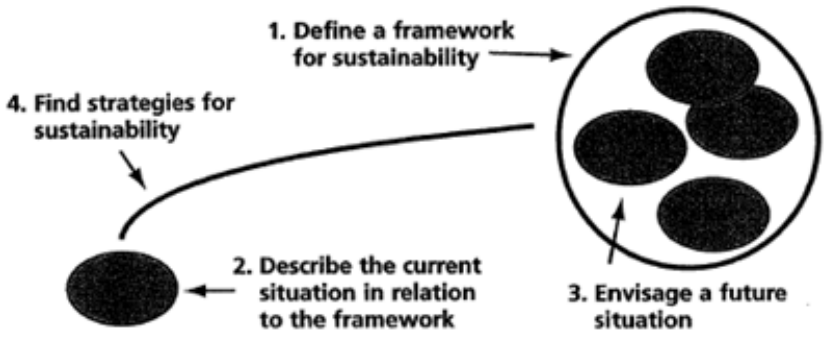

Figure 4: The backcasting approach (Holmberg, 1998, p. 33)

1. In the first step, the framework of backcasting is defined with criteria for a sustainable future. It is imperative that the criteria are properly defined and continuously developed, otherwise the process will start off in the wrong direction.

2. The second step includes the description of the current situation, with regards to the problems at hand. The current issues and circumstances must be thoroughly scrutinized with regards to the framework created. In this way, a clear map of the present will become visible. This step is a vital starting point for the process as the desired future scenario is compared to this.

3. Thirdly, this step uses the framework created, including the current situation knowledge, as a foundation to create possible future solutions. However, a broader perspective can be useful when creating new business ideas which contemplates that the future solutions should not be too specific.

4. Lastly, in the fourth step strategies to move from the current situation to the desired future is created. In the article by Holmberg and Robert (2000, p. 307) the importance to create a strategy that is viable in the future and that contributes to short-term gains, sometimes described as the "lowest hanging fruits", is highlighted.

In step four, apart from the short description above, there are four questions to consider. These questions should be combined to create measures for possible implementation to achieve a sustainable future (Holmberg, 1998, p. 39).

- "Will each measure bring us closer to sustainability?"
- "Is each measure a flexible platform for the next step towards sustainability?"
- "Will each measure pay off soon enough?"
- "Will the measures taken together help society to make changes at a sufficient speed and scale to achieve sustainability without too many losses for humans and other species during the transition?"

A benefit of using the backcasting methodology is the creation of awareness of the problems at hand, with the possible result of innovative solutions. Thus, it will only contribute to this if humans are able to transform problems into challenges which Holmberg and Robert (2000) claim is feasible. They also argue that business is not only about making money but also about avoiding unnecessary costs today and in the future.

To cope with these implications and complex issues, techniques and tools applied to the backcasting process can be used to receive a holistic perspective of the problem at hand. Outside-in and inside-out perspectives, described in the forthcoming text, can be used to gain an improved foundation to take a deeper approach to the challenges impending within the system recognized as unhealthy or unsustainable.

3.3 Outside-in perspective

The outside-in perspective is used to create an understanding of the global sustainability challenges faced to global and local systems. Tools and methods used during 'Phase 1' to visualize this perspective are systems thinking (Meadows, 1997, 2008), the multi-level perspective (Geels, 2002) and design thinking (Söderberg, 2014).

3.3.1 Systems thinking – leverage points

To understand systems, it is imperative to see the relationship between structure and behavior. When that relationship is visualized then individuals can start to understand the system, i.e. where the poor results are created and what can be done to shift into better patterns (Meadows, 2008). A rapidly changing world that is becoming more complex is demanding needs for finding ways to manage and adapt to the complexity of it, i.e. by thinking in systems. According to Meadows (2008, p. 2) systems thinking "is a way of thinking that gives us the freedom to identify root causes of problems and see new opportunities". Having that in mind, there are places, leverage points, within complex systems, e.g. Earth, wherein small shifts can create big changes overall, as Meadows (2008, p. 145) states "leverage points are points of power" (Meadows, 1997). The leverage points are not intuitive and sometimes individuals tend to push the change in the wrong direction resulting in a system more complex than before.

3.3.2 Multi-level Perspective

The multi-level perspective (MLP) is one way in observing complex systems where transitions are conceptualized as system innovations through the interaction between technology and society (Geels, 2005). The MLP is based on a foundation that transitions are non-linear processes in complex systems and results from interaction between different developments in three levels. These levels are "analytical and heuristic concepts to understand the complex dynamics of sociotechnical change" i.e. system innovations (Geels, 2002, p. 1259; 2012). The three levels are niches, socio-technical regimes and exogenous socio-technical landscape, see *Figure 5*.

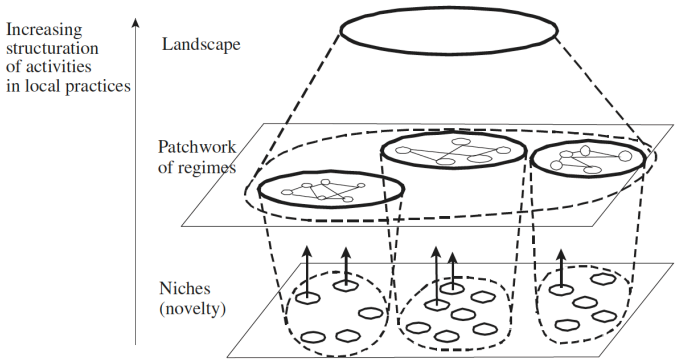

Figure 5: Multiple-level perspective; macro-level (landscape), meso-level (regime) and micro-level (niche) (Geels, 2005, p. 684)

In the niches, micro-level, there are three identified and continuous social processes; learning processes (on many dimensions), expectations/visions and networks (for support). Innovations emerge in this level resulting from special demands and existing small markets where support of new, and even radical, innovations are encouraged. The hope is that these new innovations are to be used in the regime level or even replace it, as niches are often geared to the problems of the existing regimes. According to Geels (2012, p. 472) niches are "crucial for transitions" as they provide "the seeds for systematic change".

The socio-technical regime, meso-level, results in technological trajectories as a regime consists of different actors who tend to move towards the same goals, or along the same trajectories towards incremental improvements of innovative activities (Geels, 2002). The different dimensions e.g. technologies, regulations, infrastructures etc. result in socio-technical systems that are aligned, changed and reproduced by actors. In the meso-level, changes occur relatively slow, but predictably within a certain direction resulting in stable trajectories (Geels, 2012).

In exogenous socio-technical landscapes, macro-level, changes are difficult, even impossible, and actors have no direct influence. A landscape is a wider concept that refers to the hindrance in sociotechnical development in the exogenous environment e.g. climate change, globalization etc. (Geels, 2005). The technological trajectories, mentioned in meso-level, consists of deep structural trends that are imbedded in the landscape which sets the sense of being a level "beyond the control of individual actors" (Geels, 2002; 2012, p. 473).

3.3.3 Design thinking

Design thinking can be challenging to understand, this as the design is not considered a product rather a process in which iterations and different stages of learning-by-doing are common (Söderberg, 2014). Therefore, the process is open for divergent opinions and approaches in how to proceed, but important to emphasize is that there is not enough time to interrupt the process every time something occurs and consequently a plan is needed. The plan consists of three phases, see *Figure 6*; pre-study, development and verification.

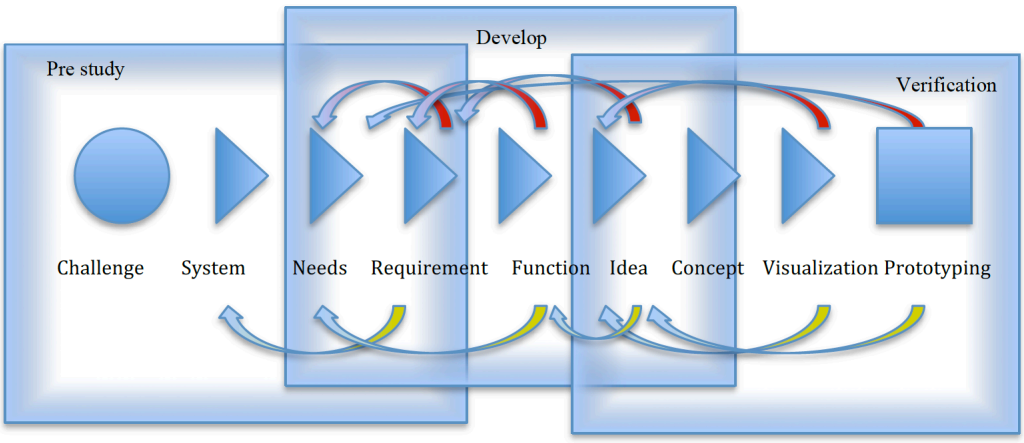

Figure 6: Design thinking process (Söderberg, 2014, p. 2)

The pre-study consists of people's own experiences and knowledge to identify the challenges, creation of systems, formulate the needs and requirements of a product or service. Continuing to the development phase, the findings from the pre-study is becoming tangible and brainstorming or discussions can be a useful tool to not miss any important ideas. The development also ends with a concept, which will be used in the verification phase. In the last

phase, verification of the developed concept is done by e.g. creating different scenarios, models etc. The verification is conducted throughout the process to maintain and improve quality, but also to continuously involve stakeholders in dialogues throughout to acquire the top result (Söderberg, 2014).

These three phases can be compared to the four phases that Lawson (2006) has adapted from a handbook. The four phases themselves are not necessarily sequential and it is important to consider the transitions between them. In *Table 1* the phases are visualized, and it becomes clear that e.g. gathering information in phase one is not manageable if there is not sufficient knowledge about the problem explained in phase two.

Table 1: Phases of the design process (Lawson, 2006, p. 32)

Phase 1 – Assimilation	The accumulation and ordering general information, including related information to specific problem
Phase 2 – General study	Investigation of the problem and possible solutions
Phase 3 – Development	Development and refinement of a possible solution identified in phase 2
Phase 4 – Communication	Communication of solutions to stakeholders in or outside of the team

The design process by Lawson (2006) and Söderberg (2014) are almost identical, since the latter used extracts from the first. Both state the importance that the design process is individual for each designer, unpredictable jumps between the phases are imminent and the result for the process will consequently fluctuate.

3.4 Inside-out perspective

The inside-out perspective has the potential in bringing people together by using self-leadership (Ryan & Deci, 2000; Stewart, Courtright, & Manz, 2011) and tools for dialogues (Isaacs, 1993; Jewell-Larsen & Sandow, 1999; Sandow & Allen, 2005). To create co-creation processes within a group of people the need of trust and group dynamic is needed. This is created with self-leadership where people identify their own values, strengths and visions which contribute to self-awareness including trust enhancement within the group.

3.4.1 Self-leadership

It is important to highlight that there are both individual and collective leadership, where self-leadership on an individual level can increase the work performance and better response affective (Stewart et al., 2011). In contrary collective leadership, or team level self-leadership, is moderated by contextual factors such as autonomy and decision-making possibilities in the organization.

Depending on in what social context and conditions an individual is developed within, will reflect whether they are proactive and engaged, or passive and alienated (Ryan & Deci, 2000). Therefore, it is important for individuals to assess their own self-motivation and mental health where the outcome relates to “competence, autonomy and relatedness” which when satisfied enhances self-motivation, and vice versa (Ryan & Deci, 2000, p. 68). Facilitating motivation can increase individual performance by setting goals related to self-leadership.

In collective leadership it is imperative that the individuals of the group see the whole system, without focusing on the points in the complex setting which is of advantage to themselves. The outcome usually ends up in arguments on whose perspective or view is the right. Therefore, helping individuals to envision the larger system is essential to grasp the understanding of the complex challenges. Senge, Hamilton, and Kania (2015) pinpoints that when organization has the collective understanding of leadership, then they can start sharing by collaborating between organizations with additional solutions to larger complex challenges as otherwise would not be evident.

3.4.1.1 Mission statement

A mission statement defines "the nature, purpose, and role" of an individual where the process of defining one's own statement requires the individual to actively negotiate "the meaning of words, phrases, and concepts" (Keeling, 2013, pp. 30-31). The statement is to reflect the individuals' values and to mirror upon their actions with other human beings i.e. in their daily life the mission statement should be reflected in communication and interaction with other people (Keeling, 2013). The mission statement should be built upon four qualities that are to envision the individuals' possibilities, challenges, strengths and individuality (Khalifa, 2012).

3.4.2 Dialogues

In the article by Sandow and Allen (2005) it is mentioned that both organizations and the global economy are rapidly shifting as knowledge becomes an even more important source of capital. There is an increased need to exchange knowledge within and between organizations to gain a competitive advantage while working towards sustainability, however this can be a challenge for many companies. In addition, organizations are moving towards being more informal (collaborative working environments) than formal (hierarchies), but change takes time. Both Argyris (1977) and Isaacs (1999) present solutions for organizations that are having trouble creating an environment that encourages collaboration. For example, one can provide organizations with effective collaboration skills to gain competitive advantages on the market while creating a platform for development.

To increase knowledge and information sharing in organizations, dialogues are an important tool and part of the learning process. Isaacs (1993) states that there are some factors that organizations need to overcome. For example, there are complexity in challenges that organizations handle today and therefore, individual competence or intelligence is not sufficient enough. Another factor is that organizations have goals in trying to encompass collective thinking which tend to backfire, creating counterproductive results instead. "Dialogues is an attempt to perceive the world with new eyes, not merely to solve problems using the thought that created them in the first place" (Isaacs, 1993, p. 30). Therefore, dialogues can be seen as a vital source to effectiveness and competitive advantage wherein individuals tend to "create, refine and share knowledge through conversation" which increases trust (Isaacs, 1999, p. 2).

It is not only important for individuals to be able to share knowledge, but also to collaborate with other individuals in creating a platform where exchange becomes natural, this as knowledge is capital. Jewell-Larsen and Sandow (1999) highlights the importance in collaboration, which begins with listening, to achieve creativity and innovation which is imperative in system transitions, this is illustrated in *Figure 7*.

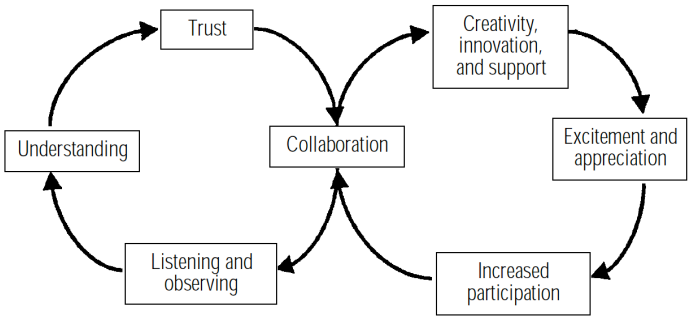

Figure 7: Collaboration process (Jewell-Larsen & Sandow, 1999, p. 19)

If individuals do not listen or observe, they tend to decrease collaboration and social separation is generated. Social separation can in contrary to social capital, improved by collaboration, result in redundancy, lack of trust etc. illustrated in *Figure 8* (Sandow & Allen, 2005).

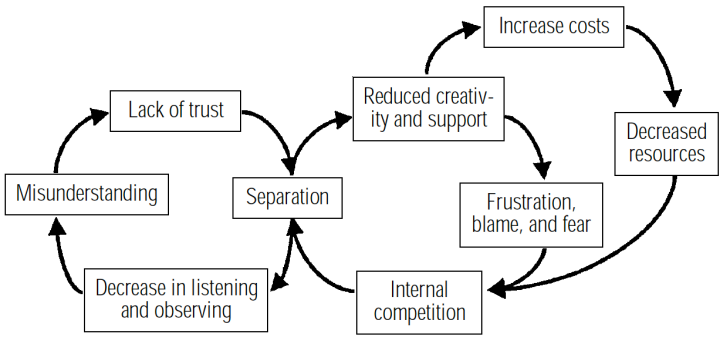

Figure 8: Internal competitive process (Jewell-Larsen & Sandow, 1999, p. 19)

3.4.2.1 The fishbowl set-up

In dialogues a method called 'the fishbowl' can be used to facilitate workshops, conferences and meetings. The method is an alternative to increase engagement of the participators as according to Arivananthan (2015, p. 1) will most notably give "a spontaneous, conversational approach to discussing issues". The set-up of the method is, see *Figure 9*, to focus the attention of all participants to discussions among three to six people, where the others' become observers or even after a rotation can become a part of the discussion. The method is easily adapted to various scenarios and is seen as a helpful means in discussing controversial issues while still keeping interactivity. Important to highlight is that this method needs a facilitator or moderator to steer the discussions (Arivananthan, 2015).

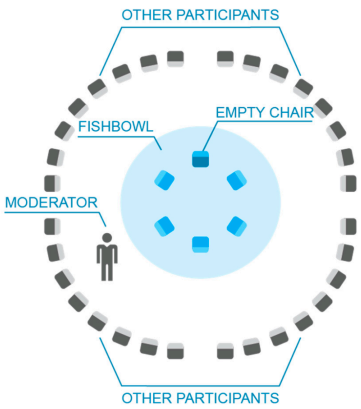

Figure 9: The fishbowl (Arivananthan, 2015, p. 3)

4

Method

In the method part of 'Phase 1' only step one and two of the backcasting method was utilized and will therefore only be the steps conveyed here. The two different steps will be applied to the backcasting process conducted at Challenge Lab, in the context of this year's master thesis and with the different perspectives of outside-in and inside-out considered.

4.1 Backcasting – Step 1

The first step of the backcasting process was conducted amongst all 15 students at Challenge Lab, to make sure that everyone felt that they contributed to the defined criteria for sustainability. The broad perspectives from the students depending on cultural and academically backgrounds gave the group a wide foundation to build the criteria's on. Relating to the different backgrounds of all group members, a self-leadership workshop was conducted to understand one's own values and strengths, but also weaknesses. Connecting to the self-leadership workshop, a mission statement workshop focused on using the individual values to create a personal statement in which you decide to relate to in everyday challenges as well as interactions. All activities in step one will be furtherly explained in the perspectives of outside-in and inside-out.

4.1.1 Inside-out

In the report 'Common causes' by Crompton (2010, p. 8) there are challenges defined as "bigger-than-self problems" which cannot be individually solved as there is no energy in society to act upon the problems. The challenges identified is global poverty, climate change and biodiversity loss. Individuals in civil society lacks the self-interest, resources and energy to invest in others' misfortune. In the report it is highlighted that people need more knowledge of the challenges faced to society, as then a demand for action would be more likely. Thus, it is stated that emotional evidence, cultural values, is more imperative than hard evidence, conscious awareness, in making decisions. During the 'Phase 1' all students conducted a self-leadership workshop to understand one's own values, strengths and weaknesses, and to create a mission statement to have as a guide when interacting with others.

4.1.2 Outside-in

In smaller groups the sustainability criteria were created and for everyone to feel participative in the creation, an exchange between the discussions in the four pillars of sustainability; well-being, ecologic, economic, and social, were conducted. To define the criteria for sustainability the UN SDGs was kept in mind. The goals are one direction in visioning or defining a sustainable and desired future from an outside-in perspective. The 17 SDGs, see *Figure 3*, were decided upon in 2015 and would accordingly stimulate action in areas of great importance

related to humanity and the Earth, giving prosperity to all (Madeley, 2015). In the last decades many endeavors have been taken to reduce poverty and stimulate the economic growth to increase development for all mankind, without success. Therefore, a new attempt was decided upon in 2015, that over the next fifteen years the actions of increasing sustainability and development should be accomplished.

4.2 Backcasting – Step 2

The second step of the backcasting process was performed in the whole group, where workshops was used in engaging people that related to the thematic areas; mobility, circular economy and urban futures, and who were a part of the system. The thematic areas chosen to be studied were based on the report 'Climate strategy 2030' adopted by VGR (2016). The workshops focused on people that was connected to the region of West Sweden and Gothenburg, and specifically to projects related to our three thematic areas, to gain a deeper knowledge of the system. Included in the pre-work before the dialogues, to enhance the outcome, a literature research was conducted where the 'Climate strategy 2030' and transport strategy for Gothenburg 2035 were read including other sources related to the areas of interest. The literature found was compiled and discussed in groups before dialogues. All activities in step two will be furtherly explained in the perspectives of outside-in and inside-out.

4.2.1 Inside-out

Dialogues were conducted during 'Phase 1', but before them the researched information from the internet on the areas of interest (thematic areas) was used to identify the current situation by reading and discussing. The information gathered was used to understand the current situation to be able to identify the gaps which defined the challenges to reach the envisaged future. The found challenges was used in the dialogues to see if the stakeholders saw the same or other challenges to the system, and if any ongoing projects or processes could be identified to them. In addition, material from dialogues conducted in the fall of 2017 during the 'Leadership for Sustainability Transitions' course, *ENM145*, and 'Towards sustainable shipping', *SJO851*, at Challenge Lab, before commencement of 'Phase 1', was also used to further identify gaps and challenges.

In the dialogues with different stakeholders, see *Table 2*, a fishbowl setting was discussed to be used, but the group ended up sitting in one ring with two facilitators. The discussions in the group consisted of arguments for and against the fishbowl concept as there were only 15 students and very few stakeholders at each dialogue. Therefore, one ring with two designated secretaries, felt necessary to not miss out on any important information, and two persons facilitating, but still integrated, in the dialogues. During the dialogues the persons interested in a specific thematic area had prepared questions which increased efficiency in the flow throughout the discussions as a consistent theme was conversed.

The decision in having one ring resulted in a structured dialogue and a process in which each thematic area got information. The information was compiled in the three different groups where challenges were added to the thematic boards. The participating organizations in the dialogues can be seen in *Table 2*.

Table 2: Organizations participating in the dialogues

Dialogue 1 - Circular economy
First to Know AB
Dialogue 2 - Mobility, Circular economy and Urban futures
County Administrative Board
Johanneberg Science Park
IVL
Chalmers University of Technology
Dialogue 3 - Circular economy
City of Gothenburg
Dialogue 4 - Circular economy
Chalmers University of Technology
Dialogue 5 - Mobility
Skjutsgruppen
Akademiska Hus
City of Gothenburg – Traffic office
Dialogue 6 – Urban futures
Kajodlingen

4.2.2 Outside-in

The current situation was analyzed using MLP with regards to the three levels; niches, regimes and landscapes. Information from the literature research and dialogues was used to map all the challenges in each of the thematic areas. This was an iterative process where leverage points were defined, redefined and discarded. All students used their values and differing backgrounds to further refine the leverage points concerning their own interest, to make a qualified choice of topic. When the focus of interest was aimed to specific leverage points, the process of pair formation was started, and all students managed to create thesis pairs with a common interest. This year's Challenge Lab generated seven thesis pairs and one conducting the thesis alone, since there was one drop-out during the second week of 'Phase 1'.

5

Results

The outcome of 'Phase 1' were to result in a defined research question, but the results will also include the outcomes from the backcasting process beginning with the first step where sustainability principles were created.

5.1 Sustainability principles

The group defined sustainability principles, criteria for sustainability, based on the four dimensions of sustainability; well-being, ecological, economic and social. Three of the dimensions utilizes key words related to the different topics, whereas the dimension of ecological uses sentence description inspired by Holmberg (1998) and Rockström et al. (2009). All dimensions have inspiration from UN's SDGs described in the article by Madeley (2015).

5.1.1 Well-being

- Subsistence; clean water, home, employment, nutritious foods, sufficiency, clean air, food security, security
- Health; Recreation, access to healthcare services, weather, green spaces, food health
- Balance; Relaxation, work/life, interaction/solitude, demand/supply
- Purposefulness; sense of purpose, love, appreciation, respect, contribution
- Belonging; community, family, freedom, acceptance, culture, acceptance of diversity, personal independence, positive social interaction, identity (being aware/belonging)
- Self-fulfilment; space for self-expression, self-improvement/development, recreation for personal development and opportunity to pursue happiness, spirituality
- Self-awareness
- Autonomy; deciding one's own fate, ownership of your time, freedom, independence
- Knowledge; access to knowledge and information, education for broader connectedness and for creating global participation, (free) education
- Equity

5.1.2 Ecological

General: Meeting the needs of the Earth today, without comprising on its ability to meet the needs of tomorrow

- Alterations made in the Earth's crust and biosphere should be reversible
- Serve the environment; preserve, protect, and restore/regenerate
- Substances should be produced/extracted in a way that they can be degraded or reabsorbed by the Earth within reasonable time

5.1.3 Economic

General: Long-term vision, conscious consumption, fair distribution, and transparency

- Natural capital; efficiency, substitutability, and sufficiency
- Man-made capital; sharing, maintenance, dematerialization (moving from products to services), flexible and adaptable systems
- Human capital; shared and accessible knowledge, collaboration should increase
- Financial capital; growth indicators, fair distribution of wealth, responsible investments

5.1.4 Social

- Horizontal relations (interactions within and between groups); co-operation (helping each other), trust, empathy, acceptance, openness, communication, learning, participation, respect
- Vertical relations (interactions with institutions); transparency, awareness, responsibility, accountability, integrity, alertness, adaptability, trust, respect, representation
- Equity/Justice; equal rights and opportunity (legal and normative), fairness, power balance, impartiality, consciousness, inclusion, equal access – education, freedom and safety, welfare, freedom of movement

5.1.5 Identified gaps and challenges

When the criteria for sustainability was created, the challenges related to the different thematic areas were identified by looking at the gaps between the current situation and the desired future. All gaps and challenges identified will not be introduced in this thesis as it is beyond the scope of it. Therefore, the gaps and challenges related to the thematic area of mobility, area of this thesis, and more profoundly the challenges resulting from the 'Phase 1' process concerning topic of this thesis are presented in *Table 3*.

Table 3: Example of identified gaps and challenges

Challenge	Topic	Identified gap
Collaboration between actors	Communication	How can we explore the possibilities of collaboration between emerging actors competing to gain market share i.e. knowledge and information sharing etc.?
Efficiency of transportation system	Intermodality	How can intermodal connections be transformed to become more efficiently, environmentally and economically feasible?
Long-term development of mobility sector	Infrastructure	How can we create a long-term view of infrastructure development considering the rapidly changing mobility needs and technologies that ought to contribute to adaptability, reasonable investments and flexible systems?
	Freight transportation and Intermodality	The region wants to keep consolidating Gothenburg as the logistics center of Scandinavia without encroaching on sustainability, quality of life and accessibility. How can this be conducted without inflicting on its possibilities relating to the current issues of bottlenecks in the system and a higher demand for goods?

5.2 Dialogue outcome

The dialogues covered all thematic areas, more or less, and with previous research on these areas, they strengthened group's knowledge about the situation in West Sweden. In this thesis the thematic area focused upon is the mobility. During the dialogues, see *Table 2*, mobility was mentioned in dialogue two and five, thus key findings presented will be from these two dialogue sessions.

5.2.1 Dialogue 2 – 23rd January

The presentation and dialogue involved a coordinator of sustainable mobility who is working on identifying gaps in the implementation of sustainable mobility and developing the work, which is being done already. During the presentation a few actions to achieve sustainable mobility goals were brought up. First action suggested was to start up new projects which could help bringing in new actors into the market, especially private actors because the mobility area usually only involves public actors. Challenging politicians was another action that was brought up to be an important step in reaching the people that make the decisions in order to have your propositions heard and hopefully implemented into the process. It was also mentioned that Sweden has technology neutral policies which makes it hard for all actors related to the mobility industry to be advantageous on the market. The conclusion was that Sweden is a small market and depends on what is happening in the rest of the world.

Sustainable mobility implies decrease in pollution. Therefore, a polluter pays principle was mentioned as a very good approach to reduce emissions in our region which has a large car industry. Besides all the mitigation actions, demand needs to be considered and the drivers that direct the demand need to be identified. So far, cars have been preferred over cycling and walking, and the drivers for this preference should be found and redirected. Another issue discussed was the densification of the cities in where the regional planning appears to be behind. Question is whether cars should be dominating the current business models as in Gothenburg the locations of big market places, for example IKEA, makes it accessible for cars but not as much for public transportation.

Electric vehicles were also discussed during the dialogue. Electric buses and cars are emerging on the market with new and innovative technologies, whereas trucks are not at the same stage of development. When it comes to electric cars, one of the major issues are the charging facilities especially in the apartment areas. Another issue is the city planning, where different actors want different things and there appears to be lack of communication. It was stated by one stakeholder that long-term planning is a vital denominator in reaching success.

5.2.2 Dialogue 5 – 25th January

In this dialogue a few topics on mobility were brought up, many of which has already been mentioned in dialogue two. The previous Challenge Lab master thesis "Electromobility in Gothenburg: A backcasting approach for developing a strategy towards electrified and sustainable transportation in the future" from 2016 was mentioned in the dialogue, as in this research there was a discovered gap between the CO_2 emissions, the traffic target and the actual reality of the current situation. This gap strongly suggests that in order to be able to reach such ambitious goals public transportation, cycling and walking needs to be prioritized much more. When looking into the possibilities for electric road transportation, a few challenges were found. One of the main challenges brought up was that the electrical private transportation

needs access to parking and charging infrastructure, thus there needs to be a sufficient implementation strategy for electro mobility in the city to cope with a rapid changing society.

5.3 Leverage point

In 'Step 2' of the backcasting process, the leverage point was reformulated and refined a couple of times before it reflected the actual point in where to intervene in the system to create a sustainable change, but also to be seen as valid to continue exploring:

> *Identifying barriers to intermodal transportation in port logistics and mitigate them by using digital technology to create a collaborative platform to increase efficiency regarding the insufficient connectivity of intermodal goods transportation*

5.4 Research question process

The ongoing process and refinement of the leverage point resulted in a research question that focused on mapping barriers of intermodal goods transportation. The leverage point relates mostly to the social dimension of the sustainability dimensions referring to barriers encountered, but also in some extent to the ecological since a sustainability aspect concerning that the possible solution(s) could serve the environment. However, the system of intermodal goods transportation could also be affected by economical changes by evolved business opportunities and/or lower or increased costs.

The perspectives considered in the leverage point were mainly a result from common interests and did not depend significantly on academic backgrounds. The leverage point is focused on barriers in intermodality within port logistics, where a maritime as well as logistics perspective is considered. The focus and perspectives chosen by both researchers relates to their interest in exploring something innovative and profound. They study 'Maritime Management' and 'Industrial Ecology', where the set goals for conducting master thesis are very wide.

With the perspectives in mind, we gathered information and literature about previous and ongoing projects related to mapping barriers of intermodal goods transportation. The research conducted resulted in increased understanding that the leverage point had a research and societal attentiveness, i.e. a hot topic. To further understand the topic, meetings with different stakeholders were conducted, one with a researcher's perspective and one with an entrepreneurial perspective. The results from the meetings showed us that from both perspectives, there is an interest in the results and to further take the research in looking in possible digitalized strategies for mitigating existing and future barriers. Port of Gothenburg, our main stakeholder, pin-pointed the importance in creating an improved goods flow through the port by increasing the connectivity in-between the different intermodal transportation modes.

After the two meetings with stakeholders, the researchers gained even more interest in the barriers and decided to focus on those connected to port logistics to see possible mitigating strategies and potential. The port perspective and Gothenburg are a very interesting ground to begin researching the thesis on, as according to a researcher met in an initial interview, *Stakeholder A* (see *Table 5*), the City is a forerunner in implementing intermodality into the supply chain logistics.

5.4.1 Research questions

The processes during ‘Phase 1’ resulted in a research question:

> *What are the barriers intermodal goods transportation faces today when trying to develop sustainable mobility flows in port logistics?*

The above research question will be investigated further by addressing the second research question:

> *How can digital technology act as mitigation for existing barriers?*

The research questions and the scope of the final research for this thesis are presented in the introduction. The formulation of the research questions lays as the foundation for the next phase, ‘Phase 2’, which follows directly after the discussion of this phase, ‘Phase 1’.

6

Discussion

‘Phase 1’ was a challenging process as most of it was conducted in the whole group of Challenge Lab students. Many differing perspectives and backgrounds made it difficult to reach consensus, however being a big group contributed with extensive knowledge sourcing from diverse academic areas and cultural insights. The trouble in finding consensus was especially obvious when the group started to define sustainability criteria. Everyone had varying opinions and it was challenging to gain a collective result without making it too general resulting in a very open application of the criteria. Key words tend to be very open for one’s own interpretation making it difficult to correctly apply them to individual work. The generality could perhaps have been mitigated by continuing, in a group, to evaluate the key words and construct actual principles not entirely open for self-interpretation. Furthermore, the overall process of this phase opened up opportunities for personal growth with eye opening experiences which led to new levels of self-awareness. Also, the general foundation of the backcasting process used throughout this phase strengthened the understanding of working with sustainability issues and will be utilized in future projects.

The generality, not only in the sustainability criteria, was a continuous issue throughout the process of ‘Phase 1’. In the dialogues most stakeholders held every presentation including the discussions at a very general level which affected the continuous work with identifying leverage points. All leverage points gathered within the thematic areas became overwhelming and a collective distress with reducing them became a hardship. As a group we turned it around and made an effort in defining more specific leverages to make it easier to define a topic of interest, this could probably have been avoided by conducting more thorough research of the stakeholders present during the dialogues including strategies that act as a common ground for the thesis.

To deviate from the fact that defining leverage points was difficult, our research topic and following questions did not result from what stakeholders mentioned during the dialogues during ‘Phase 1’. Rather it emerged from self-interest, the dialogues in the fall and knowledge about the logistical issues in the port concerning bottlenecks and inefficient goods flow including the studied ‘Climate strategy 2030’ related to the region of West Sweden.

Phase 2

In this part of the thesis, ‘Phase 2’, elaboration of the research project and exploring of the research questions begin, which was the outcome from the process during ‘Phase 1’ that underlies the following phase with its foundation. The phase will start with giving the theoretical background of intermodal goods transportation and features of digital technology, including its mitigation potential for existing barriers to support efficiency in intermodal transportation. Continuously, the used methodology and results of the research will be presented. After a discussion of the findings the thesis will end with a conclusion with suggestions for further research.

7

Theory

In this part, the foundation for our investigation of existing barriers are described where Step 2 of the backcasting method is used to envisage the current barriers in intermodal goods transportation. The current state is explored along with different strategies adopted in the region of West Sweden including articles that are related to our thesis, which will make it more tangible. Furthermore, the actors involved in the supply chain of port logistics will be further described. In excess of what is described, the theory of digital technology developments and its areas of application will be elaborated by using Step 3 in the backcasting process. It builds up a theoretical foundation to be able to envision the gap and starts with a desired future in mind.

7.1 Sustainable transportation

According to the Intergovernmental Panel on Climate Change (IPCC), the global greenhouse gas emissions need to be decreased by 40 to 70 percent from the emissions in 2010 by year 2050 (IPCC, 2014). Hence, it means that the goods transport sector is responsible for about 40 percent of the transport sector's greenhouse gas emissions (Macharis, Baptista, Woxenius, & Van Lier, 2014). Goods transport generally have reduced potential to decrease greenhouse gas emissions due to the fact that industrial vehicles and transports using renewable resources have less potential for improvement compared to passenger transport (McKinnon, Browne, & Whiteing, 2012). Using biofuels is a possibility in trucks and ships, however sustainable production of biofuels is limited. Other measures examined that can contribute to usage of fossil fuels in the transport sector are modal choice, i.e. use of intermodal transport, equipment and fuel choice (Dekker, Bloemhof, & Mallidis, 2012). Even though there has been progress in producing oil and gas from unconventional resources to balance out the energy scarcity, it will unfortunately hold back the transition to low-carbon economy and risks increasing emissions. It is clear that the logistics industry, including intermodal goods transportation, has a great challenge to overcome regarding reduction of greenhouse gas emissions while maintaining the economy with a continuously increasing demand for goods transportation. There are, however, some actions that can help mitigate a total reduction of fossil fuel use and carbon dioxide emissions for the logistics sector. Some of these levers are:

- Less products transported
- Reduced volume of goods
- Reduced distance production-consumption
- Increased load factor and vehicle capacity (Macharis et al., 2014, p. 5)

There are three categories of options that can contribute to decreasing the carbon dioxide emissions in the logistics sector, hence intermodal transportation is a valuable option, see *Figure 10*. The technical options are connected to measures for the vehicle and operational levels that affect driving or decrease influence of the driver on the fuel consumption of the

vehicle (Macharis et al., 2014). Operational measures are related to actions that progress the handling of driving, an example being eco-driving courses or devices that give feedback to the driver. Thus, the driver can manage and sustain the driving style that in the future can be achieved with Intelligent Transport Systems (ITS) applications as well as a better utilization of intermodal transport. This application can contribute with predictive cruise control, route management and traffic management systems (Dekker et al., 2012). Logistical options for a more sustainable supply chain include levers such as optimized distribution networks where emissions are taken into account and speed of delivery is reduced. Furthermore, additional levers are low-carbon sourcing, manufacturing, reverse logistics and recycling that make use of returned goods and waste processing through optimization (Macharis et al., 2014). These options can all be connected to the adaptation of intermodality that represents sustainable transportation, which will also reduce congestion, improve mobility and improve traffic flow management (Uddin, 2013).

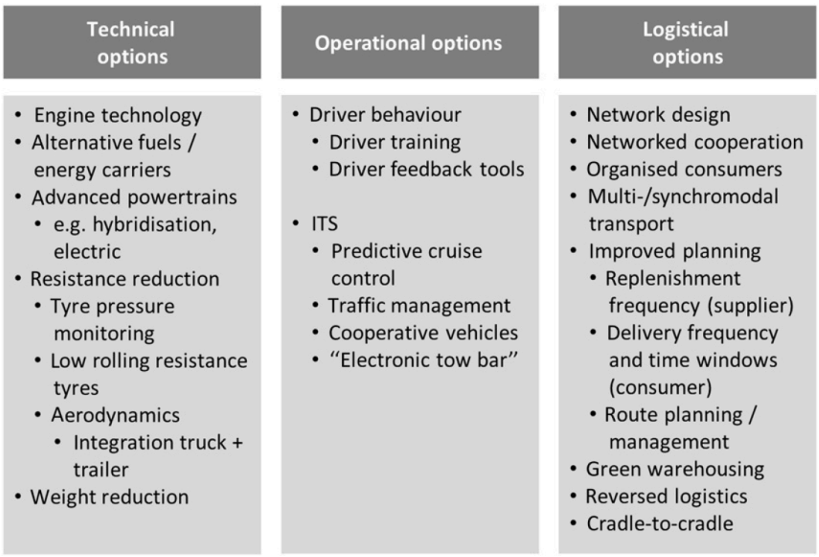

Figure 10: Three categories of options for reducing carbon dioxide emissions in logistics (Macharis et al., 2014, p. 7)

In the Freight Transport Logistics Action Plan, developed by the European Commission (EC) in 2007, there are some levers for modal shift, such as development of green transport modes for goods transportation, mitigation of barriers in the utilization of rail and water-based solutions (McKinnon et al., 2012). This plan revolves around how logistics can perform sustainably and contribute to a cleaner environment, maintain the energy supply and safe transportation while also improving the efficiency and sustainability of goods transport (Rushton, Croucher, & Baker, 2017). Modal shift, however, is argued to be a complicated measure since it requires good understanding of the transport users and decision makers' preferences (Bask & Rajahonka, 2017). To enable long-term efficiency some actions can be considered, such as promotion of e-freight, simplification of transport chains, standardization of vehicle dimensions and loading, and green transport corridors for goods (Rushton et al., 2017).

Promotion of environmentally sustainable transports, especially intermodal involving rail and sea, has developed over the past few years. However, research highlights that further development of sustainable options within intermodality, such as inland waterways, are needed, but it has been slow in comparison to all other transport modes (Bask & Rajahonka, 2017). Nevertheless, intermodal transportation is seen as a sustainable option of transportation.

7.1.1 Intermodal transportation as a sustainable mode

According to the Organization for Economic Co-operation and Development (OECD, 2003) 'Glossary of statistical terms' intermodal transportation is defined as "movement of goods (in one and the same loading unit or vehicle) by successive modes of transport without handling of the goods themselves when changing modes". Another description is made by Monios (2014) stating that intermodal goods transportation is keeping goods in the same loading unit while transporting it in-between different modes of transportation. From the early days when rail developed, wooden units were utilized and when metal containers emerged in the market for the first time, intermodal transportation became increasingly prevalent. The evolution of the container changed the market especially in ports where stevedores' work transformed from labor-intensive to more automated activities. Ships could therefore be unloaded in hours instead of days, being at sea for a longer time resulting in a more profitable industry. Shipping and ports changed their logistics and hence globalization in the industry evolved since ships could sail for a longer time out at sea and be in port for shorter periods of time (Monios, 2014). With an increasing number and size of ships calling ports at shorter intervals, the rise of intermodal transportation, "the land leg" conducted by all modes of transport, increased the domestic traffic (Monios & Bergqvist, 2017, p. 5; Roso, Woxenius, & Lumsden, 2009). Hence, a large sea inflow with a proportional land inflow generates various factors that can critically impact the land transportation as well as the functionality of the seaport (Roso, 2013).

The modal shift to intermodal transportation has been a strategy for governments to reduce emissions and to increase economic growth changing the logistical pattern and consequently reducing congestion (Monios, 2014; Roso, 2013). Hence, institutional challenges need to be recognized as there sometimes are business reasons why an intermodal transport service is not flourishing (Monios & Bergqvist, 2017). In addition to emission reductions and economic growth, applying modal shift to goods transportation can also give better access to global trade routes. However, the transport industry faces many challenges and one of them is road haulage where the operational reasons as shorter distance and imbalances in demand make road transport more efficient, but consequently impacting wrong features such as congestion and emissions in society. Nevertheless, according to Caris, Macharis, and Janssens (2008) intermodal goods transportation has been highlighted as a mode known for issues concerning the environment, congestion and traffic safety, forcing actors in the supply chain to reconsider traditional logistics transports to increase speed in the transportation system. The supply chain of intermodal transportation is visualized in *Figure 11*. The logistics of the transport supply chain are increasingly pressured by the target of the transport industry in becoming sustainable. In addition, the industry has a goal to deliver products throughout the supply chain to the end-customer at an "appropriate service level and quality, with the lowest possible cost" (Strandhagen et al., 2017, p. 359). Consequently, the supply chain is faced with various obstacles, which needs to be overcome to help meet the global sustainability challenges.

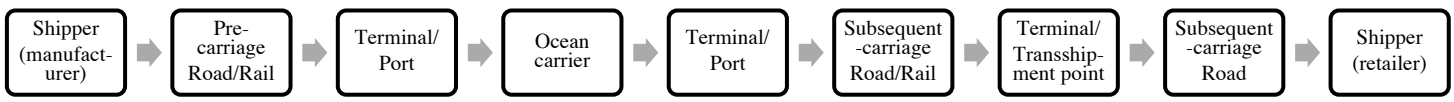

Figure 11: Supply chain of transportation from shipper to retailer (adapted from Bendul (2014, p. 25))

The environment is a reoccurring topic on the agenda in both national as well as international context where the trend of growing carbon dioxide emissions needs to be reduced. Therefore, the focus in logistical systems have been to find sustainable transports. The logistics sector has

the main role to contribute to reductions of greenhouse gas emissions and in decreasing the dependence on fossil fuels. The set challenge is that by year 2050 the logistics sector should have reduced its fossil fuel use and carbon dioxide emissions by 50 percent. If the volume of goods will increase according to estimations made in global trade, consequently the transport sector, i.e. each unit of transport, needs to reduce carbon dioxide emissions by over 70 percent (Macharis et al., 2014). Suggested from a European perspective "to reduce the environmental impact of transportation is the shift in transport modes" where faster modes are to change to slower and less polluting options such as rail and maritime transport (Eng-Larsson & Kohn, 2012, p. 37).

Intermodal rail/road solutions are highlighted as promising to reduce the environmental impact from transportation. However, there are barriers for such implementation as a rail/road option would result in increased transit time, lower reliability related to delivery due to inadequate rail connections, higher risks of damage to goods by increased movements as well as reduced flexibility (Roso, 2013). These barriers present intermodal transportation with the challenges of being a preferred transport choice even if it is seen as a sustainable option. Hence, the common goal for actors in the supply chain is to increase the use of intermodal transportation. Consequently, the decision on changing mode for transportation to intermodal will influence "the eventual performance of the system" (Eng-Larsson & Kohn, 2012, p. 39).

The evolvement of faster trading between ports has led to an increased amount of goods in global routes, which has put more demands on transportation. Green transport solutions i.e. sustainable transportation options, and various choices of different transport modes within intermodality have emerged to offer efficient and effective goods flow throughout the supply chain. Consequently, the modal choice that stakeholders have to make is becoming increasingly difficult since there are various barriers impacting their choices. In the following subsections of intermodal transportation the prerequisites for making a modal choice, imperativeness of choosing a sustainable transport option and barriers in the intermodal sector will be described.

7.1.2 Modal choice

The rapid global industrialization and a constant rise of goods demand increase the utilization of different transport modes i.e. intermodal transport; sea, road, and rail (Hwang & Ouyang, 2014). From a global perspective, the goods are being transported to greater distances due to the vast locations of low-cost manufacturing production plants and factories. Therefore, many companies have adopted a concept of focus factories, which means some of them only have one global manufacturing plant, as the goods generally are not consumed at their place of production (Román, Arencibia, & Feo-Valero, 2016). As a consequence of the greater transport distances, long-distance modes of transport have become of greater importance in order to maintain and develop efficient logistics operations around the world (Bontekoning, Macharis, & Trip, 2004).

Even though the logistics sector offers a few options for transportation, road freight transport remains the presiding modal choice in many countries. *Figure 12* shows a continuous increase in the use of road transport, whereas rail transport has continued to be constant during these years (Rushton et al., 2017). Nevertheless, intermodal transport is seen as a competing mode with traditional modes of transport such as road, since the demand for transport of goods grows along with transportation flows, which requires a cooperation of different modes (Bontekoning et al., 2004).

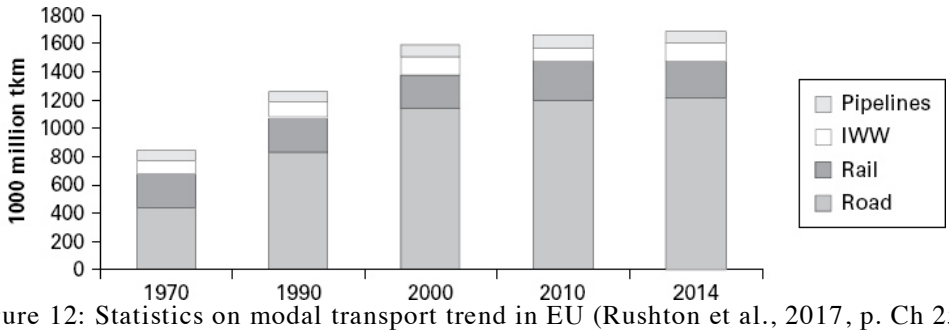

Figure 12: Statistics on modal transport trend in EU (Rushton et al., 2017, p. Ch 25)

When choosing the most appropriate mode of transportation within intermodality, it is done in a four-stage process. These four stages are operational factors, transport mode characteristics, consignment factors, and cost and service requirements as shown in *Figure 13*. Making a modal choice is not simple, a lot of trade-offs and different aspects need to be methodologically considered (Rushton et al., 2017).

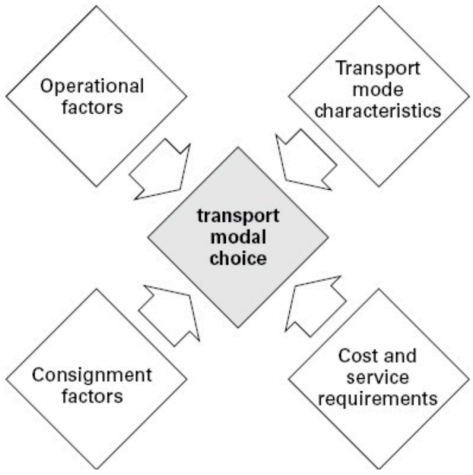

Figure 13: Modal choice framework (Rushton et al., 2017, p. Ch 25)

Some important attributes, in addition to the economic ones of cost and time, are the qualitative elements that need to be considered when choosing mode of transportation. These are, but not limited to, availability of the cargo, speed of the transportation, risk for delay, reliability, flexibility, infrastructure availability, characteristics of the goods, and risk of loss and damage (Cullinane & Toy, 2000; Witlox & Vandaele, 2005). When it comes to cost, sea freight is the dominant choice when it comes to bulk goods, or large packaged shipments going long distances especially if the speed of the delivery is not important. Speed of the sea transport on the other hand is quite slow for reasons such as the turnover time in the port along with the transport time itself. Another important aspect to keep in mind is the need for double-handling of the goods, as sea freight still uses slow handling methods in comparison to container systems and Roll-on-Roll-off (RoRo) systems. Double-handling also increases risk of damage to the cargo, which should also be kept in mind (Rushton et al., 2017).

There are many different analytical models used to figure out the main attributes for modal choice and what factors drive the decision making. However, it is important to keep in mind that there are different trade-offs between these factors and that the decision making is up to many different actors such as shippers, receivers, freight forwarders, and transport and logistics providers (Román et al., 2016).

As awareness of climate change and other environmental issues grows along with globalization, environmental sustainability is becoming a competitive advantage in the industries and logistics sectors. Congestion and pollution as a result of increased goods transportation by road have encouraged policymakers to actively promote a modal shift (Witlox & Vandaele, 2005). Many actors are involved in the development of sustainable transport and new policies have been established to promote sustainable transport such as rail and waterborne intermodal transportation. These sustainable options are a hope to phase out the most widely used modes for transport such as road and air, which are the least environmentally sustainable modal choices (Bask & Rajahonka, 2017).

7.1.3 Intermodal transportation barriers in literature

When it comes to literature on intermodal goods transportation, there are many barriers considered. In addition to the barriers that are highlighted most frequently in literature, the supply chain faces other various challenges. The actors in the supply chain, i.e. shippers, carriers, and society, have differing perspectives, which underpins their decisions when choosing intermodality (Eng-Larsson & Kohn, 2012). Society has the sustainability perspective, whereas carriers have a production perspective and shippers focus on the business perspective. However, they all have the common goal in overcoming barriers to utilize intermodal transportation more efficiently and effectively, which is shown in *Figure 14*.

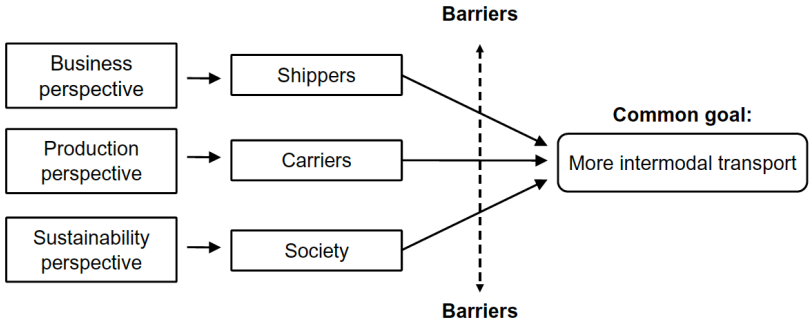

Figure 14: Perspectives and actors involved in intermodal transportation (Eng-Larsson & Kohn, 2012, p. 38))

Choices made by the different actors are not solely decided in isolation, but rather in the context of supply chain or logistics, in which different levels of hierarchy affect the final decision. Decisions made, commonly logistical, impact the organizations at different levels creating opportunities as well as boundaries for everyone involved in the process. The outcome of the decision-making process, i.e. final decision on change of transport mode, is therefore driven by some overarching factors shown in *Figure 15*, external pressure, business strategy and logistics strategy.

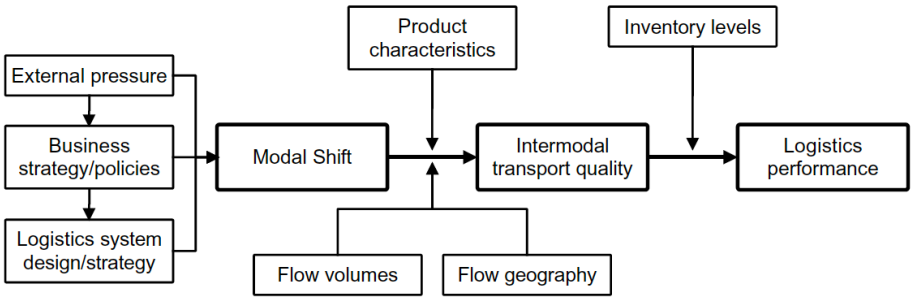

Figure 15: Contextual changes and operational factors (Eng-Larsson & Kohn, 2012, p. 41)

- ‘External pressure’ can be examples varying from change in consumer awareness, stricter environmental legislation, increased fuel prices and emerging demand on green solutions, such as green products or transportation.
- New ‘Business strategies’ where organizations have adapted consumers’ demand on e.g. greener solutions as society becomes more aware.
- ‘Logistics strategies’ are closely related to the chosen business strategy chosen by the organization, as shippers depending on the strategy and available resources can choose between different logistical systems, i.e. direct, hub-and-spoke, central warehouse, Third party logistics providers (3PL), etc. The chosen system will also depend on the level of demand on a product, such as high vs. low.

For actors within the transport industry it is imperative to make the right decisions when choosing transport mode. The decisions made in regard to modal choice can impact the performance of the logistics system (Eng-Larsson & Kohn, 2012). Therefore, the barriers that intermodal transportation is faced with need to be identified in order to create an efficient goods flow throughout the supply chain of port logistics to make utilization of sustainable transport options more integrated. In literature a lot of barriers are highlighted and consequently some of them are mentioned more frequently than others. However, the barriers that are emphasized in this chapter are cost, time, reliability, flexibility and communication. The identified barrier will be discussed based on reviewed literature.

Cost has been raised as one of the key barriers that the intermodal transportation sector is facing. According to Sommar and Woxenius (2007), due to increasing awareness about environmental issues, fuel prices have increased, which is a challenge for shippers with the continuous rising demand of goods. With pressure from the cost and volume of transported goods, transport time and punctuality become more and more of a vital parameter and due to these demands for performance and competition, intermodality struggles with becoming more utilized. Woxenius and Bergqvist (2008) and Behrends (2015) both discuss the issue of increased costs and price for transport due to increased demand, bigger ships and ports where the hinterland is not catching up with the fast evolving bottlenecks in the transportation sector. The price for transport is increasing also because of the additional movement of goods and the need for extra goods handling in the interfaces of modal change. Cost for transport plays a big part in the competition between rail and road, which is stated by Behrends and Flodén (2012), where rail only gains a competitive advantage when large volumes are being transported over long distances. This, however, is not often the case since most goods volumes are transported over short distances and/or are too small to fill up a whole train. Elbert and Seikowsky (2017) also points out that cost of transportation is a decisive factor when it comes to decision making for the choice of transport mode. Shippers tend to choose the cheapest route for goods transportation and this backfires on the intermodal rail/road transport option. Thus, road transport is most often the main preference as it is the cheapest and also due to the fact that there is still an absence of a well-developed rail infrastructure, which restricts the flexibility for intermodal transportation.

Transit time is often considered as one of the main values for the customers, as it considers the whole supply chain of transportation, i.e. the transport from shipper to receiver. A number of articles, such as the ones written by Elbert and Seikowsky (2017), Eng-Larsson and Kohn (2012) and Behrends and Flodén (2012) discuss how time is a barrier for intermodal transportation. Elbert and Seikowsky (2017) point out that decision makers for the mode of transport are willing to accept risks of loss or damage to the goods as long as the transit time is faster, which once again suggests that shorter shipment time is the key competitive advantage.

Consequently, the mode of transport with least transport time tends to be chosen and unfortunately for intermodality, transit time increases due to the interchange of transport modes in the intermodal chain. Therefore, conventional methods used to move goods between the different transports need to change to decrease the transit time. Sommar and Woxenius (2007) and Woxenius and Bergqvist (2008) discuss the increase of lead time for intermodal transportation, which also appears to be due to the increased demand, larger cargo and larger ships, which causes the intermodal operations to lag behind the fast expansion.

Reliability is another key barrier for the intermodal transportation chain discussed in literature. This barrier is an aspect that goes both ways, it is important for the customers as well as for the shippers. Elbert and Seikowsky (2017) claim that some actors will choose the mode of transport where the service provider can ensure reliability of transport and that the goods will be delivered within the agreed time frame. Consequently, as the customers want to have certain guarantees when they purchase transportation. Behrends and Flodén (2012) discuss how due to unreliable quality of transport the possibilities for a modal shift are limited and it is further supported by Bergqvist and Monios (2016) with the discussion of the importance of improving transport reliability for intermodal transportation to become an obvious choice. In addition to transport owners' reliability requirements, shippers also need to have reliability from their customers, which is an issue in the intermodal transportation due to many factors, such as scheduling and planning.

Flexibility is an additional competitive advantage that road has over intermodal rail/road transport according to Elbert and Seikowsky (2017), who argue that with increased demand for goods transportation and Just-In-Time (JIT) concept, it keeps the road transportation at the front. This is also supported by Reis, Meier, Pace, and Palacin (2013) article, which states that road transportation is more flexible than rail transportation. Flexibility of the intermodal transport appears to, according to Eng-Larsson and Kohn (2012), be lowered in the time perspective due to the management of scheduling and communication. Monios and Bergqvist (2017) and Bergqvist and Monios (2016) discuss flexibility while comparing it in the rail and road transportation, which appears to be the main contrast. Rail is struggling in catching up with the competitive advantage the road transportation currently has and that is making the adaptation of intermodal rail transport more difficult. Therefore, a lot of improvement needs to occur in the current transport management especially at the modal interfaces for it to move forward.

Communication between different actors in the logistics sector is one of the most important barriers that lead to the mitigation of all others. According to Bergqvist and Monios (2016), there needs to be an established trust, information sharing, process integration and synchronization of decisions to reach sustainable collaboration, which will increase intermodal transportation. Monios and Bergqvist (2017) also argue that the horizontal collaboration is not enough anymore in order to develop intermodal transportation. It is discussed that there is a need for vertical collaboration as well between shippers, rail operators and 3PLs in order to create a more efficient transportation system. Communication issues rise also due to inadequate information sharing between actors, which partly depends on the competition between these actors, thus leading to resistance in sharing valuable information as stated by Heaver (2011). This competition, however, needs to be overcome since without collaboration and trust, intermodal transportation development will not occur.

There are more barriers that affect actors' decisions in their choice of intermodal goods transportation, but those discussed are the ones which are predominantly mentioned in

literature. These barriers affect the whole supply chain and the decision making, which not only concerns the system of intermodal transportation but also the separate transportation modes, such as port logistics, which plays a big part in the intermodal sector.

7.2 Port logistics

Ports are "bi-directional logistics systems" considering the operations connected to the receiving and shipment of goods both from sea and from land i.e. the regulator of goods flows (Panayides & Song, 2009, p. 136; Rodrigue & Notteboom, 2009). Port operations transformed when the container revolutionized the market and those operations performed for a variety of substances contemplate ports as a complex system (Monios & Bergqvist, 2017). In the interface between different transport modes, ports are imperative for the continuous shipping of goods (Lee & Cullinane, 2016). The distribution from ports takes place on land (rail/road) or inland waterways where the flows usually tend to seek the routes where costs are low and where intermodal transportation has efficient and reliable connectivity. Regarding connectivity, the supply chain of operations and settings in a port will be considerably affected by location, reliability and capacity (Rodrigue & Notteboom, 2009). Ports have a logistics system approach that consists of combining transport with other components, i.e. purchasing, storage, production, inventory management (Fejfer, Wright, & IOCS, 2015). The logistics system makes ports into centers of distribution where movement of goods and services is optimized throughout the supply chain. In excess of providing an optimized goods flow there are opportunities for ports to add value to goods, which defines them as trade gateways and logistics and distribution centers. In port logistics it is imperative that there is organizational cooperation and efficiency to create intermodal capabilities that encompass an efficient goods flow and integration into the supply chain.

Maritime transport is the backbone of international trade and hence a driver in globalization where a large volume, about 90 percent of world trade, including high value goods are transported by sea (Hall, Comtois, & Slack, 2011; Lee & Cullinane, 2016; Valdor, Gomez, & Puente, 2015). The amount of goods transported to worldwide ports is increasing and the demand is steadily growing, questioning sustainability considering the environment and trade as many operations are carried out in port areas. According to Roso (2013, p. 140), the efficiency of seaports is threatened by congestion in the land transport segment resulting from the ever-increasing goods flow, which might quadruple by year 2030. Ports are an important part in the whole supply chain including the global logistics since they handle nearly 90 percent of the goods volumes transported globally (Song & Parola, 2015). The importance of ports has emerged in recent years as it contributes with two factors relating to value and development. Ports are a value creation tool for actors involved in port logistics supply chain and for the impact port-related activities have on the development of society regarding the environmental, social and economic factors. Economic and strategic importance for society are apparent as ports facilitate the major activities of import and export, fostering economical boosts that can be seen on local, national and regional levels. The economic boost also fosters competitiveness among actors in the global supply chain (Song & Parola, 2015).

The increased goods flow on a global scale puts ports in a situation where port development of infrastructure, in the form of re-building or newbuilding, is needed, consequently there are concerns from both environmental and social perspectives (Monios, 2014; Rodrigue & Notteboom, 2008). Complex environmental legislation and increased awareness in society make ports, including terminal operators, undertake complex planning and time-consuming processes that can eventually perform an adaptability to higher demand of effective ports with

larger capacity. Though, there is only enough infrastructure to cope with a certain amount of goods, at some point ports cannot be developed, which consequently leads to congestion. In supply chains, impact on economic systems due to congestion can be devastating related to the scarcity of seaports and their intermodal capacity (Rodrigue & Notteboom, 2008). Ports are becoming more integrated with shipping lines where an entirely vertical integrated system is created, and goods are delivered from port via vessel to port within the same company. According to Monios and Bergqvist (2017, p. 4), the inland part of the continuous transportation of goods from the port is the "new battleground", thus more complex than the sea transport. The complexity with inland connections has given modern ports a logistical ecosystem, where operations are conducted in an "increasingly complex and sophisticated transport and logistics environment", see *Figure 16* (Wilmsmeier, Monios, & Lambert, 2011, p. 161).

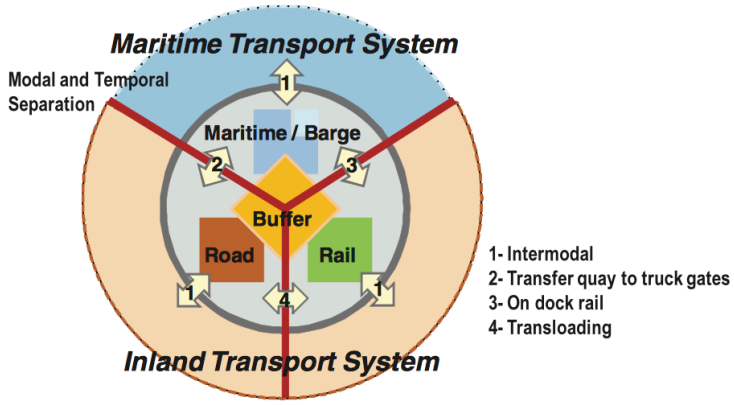

Figure 16: Maritime and inland transport system (Rodrigue & Notteboom, 2009, p. 166)

For the past decades there has been profound restructuring in port logistics related to the global incorporation of markets, resulting in more competitiveness and where the emerge of private stevedoring companies dramatically reformed the port ecosystem including the environment and businesses. Due to intensive port restructuring port managers are forced, depending on bargaining power of stakeholders (such as carriers, logistical service providers, terminal operators) and pressure from different societal groups, to face the problems of "responding proactively to market dynamics and local community stakes" (Song & Parola, 2015, p. 189). In port logistics there is simultaneous activities that create value, but important to highlight is that most actors also tend to focus on their own interests and objectives (Fejfer et al., 2015). According to Song and Parola (2015), port adaptability is imperative to preserve its competitiveness, satisfying various stakeholders by democratization of port management and to stay in a dynamic environment for operating and growth potential. The organizational complexities of today's port logistics, as ports are a multipart organization, forces port management to handle different stakes and goals of various stakeholders to achieve consensus.

The supply chain of port logistics can be divided into three channels, logistics, trade and supply (Bichou & Gray, 2004). Interactions in-between these three channels make it challenging to specify what function different actors, related to ports, conduct in the system. According to Bichou and Gray (2004), the logistical channel consists of actors related to the efficient progress of goods within the supply chain, i.e. ocean carrier, freight forwarders, port operators and land transport carriers. In the trade and supply channels the actors are the ones with ownership of the goods transported through a system, where the trade channel is more focused on the type of industry (e.g. oil, chemical, grain) and the supply channel's focus is the actual firm or company. A port has an imperative role in the integration of the three channels since there are many actors within port logistics, but mostly in the logistics channel.

Figure 17: Supply chain of port logistics within the box (adapted from Bendul (2014, p. 25))

In *Figure 17* the supply chain of port logistics is visualized where it shows the trade, supply and logistics channel throughout the whole transportation of goods, from manufacturer to retailer. Within the dotted box, the ocean carrier, port of destination and land transport carrier are represented. The port of shipment only acts as the part of the supply chain that load the ocean carriers, i.e. ships, with the goods on its subsequent voyage to its destination. Therefore, the port of shipment is in no direct connection to the port of destination and its respective operations conducted, hence not a part of the port logistics supply chain. The three actors, ocean carrier, port of destination and land transport carrier, all have a direct connectivity to the port operations from either the sea or land, a prerequisite, which establishes their belonging to the port logistics supply chain.

7.2.1 Actors in port logistics

The actors involved in port logistics and the different channels of logistics, trade and supply are ocean carriers, land transport carrier, freight forwarders and port operators. Shippers are also connected to the supply chain of port logistics since they are generally either the customer or receiver of the goods transported. Ports integrated into the supply chain should have the target to "serving the needs of the final customers" since all operations conducted in the port add value to the surrounding infrastructure and its actors utilizing the port (Stevens & Vis, 2016, p. 262).

Shippers: Oxford (2016) generally defines a shipper as an organization that exports goods, which they own, to another country by sea or air transport. The shipper normally consists of the manufacturer or retailer, contemplating the ones who want to ship the goods or consequently wants to buy the goods. Ergun, Kuyzu, and Savelsbergh (2007) suggest that the pressure on shippers to reduce costs while keeping a high logistics performance lead to smaller inventories. Consequently, any problems in production can therefore result in that no buffers are available for giving customer their short lead times. To gain a transport solution at a low cost, shippers collaborate with carriers, e.g. ocean carriers, in an effort to remove hidden costs, i.e. those costs that none control individually.

Ocean carriers: Generally, ocean carriers have long-term schedules or contracts and the vessels owned by the carriers have the advantage of economies of scale, resulting in a possibility to carry a large volume of goods. Consequently, the transportation will be conducted at a low cost per unit and distance (Bendul, 2014). Nevertheless, ocean carriers face many challenges from various weather conditions, but also that maritime transport moves at a slower speed.

Port terminals and operators: Port terminals are according to Reis et al. (2013, p. 23) "the most substantial intermodal facilities in terms of traffic, space consumption and capital requirements". Terminals are also defined as "a specialized facility where ocean vessels dock to discharge and load cargo" or as "places where the movement of freight (and also passengers) pauses or stops for a modal interchange or a value-adding activity, or both" (Reis et al., 2013, p. 23; Rodrigue & Notteboom, 2009, p. 167). The port can consist of many types of terminals e.g. RoRo, container, passenger, and bulk. Often the container terminal is the more vital part of

the ports' terminals since circulation of the system in the interface between maritime and inland transport is conducted with containerized goods. Those container ports that are called "the new generation of container ports" are often operated solely by a handful of globalized terminal operators, such as APM Terminals (Monios & Bergqvist, 2017, p. 4).

Terminals, marine and inland, and their operators have a focus on "utilization of investment-intensive" technology, i.e. equipment used in the terminals (Bendul, 2014, p. 28). Competition between different terminals is common, but the competitive agenda usually does not concern tangible port infrastructure, instead value-adding services (Rodrigue & Notteboom, 2009). Long-term storage is an important service that brings value to the port and there are some other factors that customers consider when choosing which port to use. These factors are customs' processes and time for transfer to the intermodal transport system. Moreover, there are strategic planning problems for operators concerning design of terminals, as capacity needs to balance with demand (Caris et al., 2008). The design needs to reflect upon the amount of equipment, capacity of storage facility, how operations are conducted at the terminal and the layout of the terminal. In addition, the terminal operator also needs to struggle with the capacity challenges concerning labor, i.e. having sufficient personnel at the terminal when needed.

Land transport carriers: Transport carriers for land transportation need to provide and utilize the transport capacity that exists in an economically feasible way. The actors for land transport are rail and road.

Road carriers have the focus on supporting their services by providing delivery on time, which constitutes from utilizing transport capacity within a time frame where scheduled delivery and collection of goods are imperative (Bendul, 2014). Congestion, higher costs for energy and tolls increases the importance for planning transport to overcome the high fixed costs. Furthermore, regulations for road carriers are numerous, such as cabotage, restrictive driving times, emissions, which impacts their target systems for efficient road transportation.

Rail carriers have various challenges they need to address, such as costs for specific investments, but also scheduling of the rail service (Bendul, 2014). The biggest challenge is the political aspects where investments on the railway infrastructure are not prioritized, but also that public and passenger transport on rail are dominant over goods transportation.

Freight forwarders: Integrated logistics providers, or freight forwarders, supply their customers with intermodal transport solutions, which include a whole concept of transporting goods from supplier/manufacturer to receiver/retailer (Monios, 2014). Related to market promotion, this concept of being an integrated logistics provider is dominant, making customers more interested in being sustainable. Therefore, the focus changes to provide customers with environmentally sustainable transport solutions that are cost-efficient. As intermodal transport services include different transport agents there is a freight forwarder, which encompasses managing those various agents, with the aim to receive the most out of the transport service provided (Reis et al., 2013). Synergies are generated when a freight forwarder manage the whole transport chain for customers, which reduces the waste, or inefficiencies, normally produced, hence increasing the overall performance of the intermodal transport. Physical movements between terminals are normally contracted out by forwarders while keeping consolidation of cargo in-house (Bergqvist, Falkemark, & Woxenius, 2010). Important to highlight is that all freight forwarders do not possess equal skills, this as there are different organizational processes for production of intermodal transport services. Freight forwarders tend to have the same foundation, which they

base their service on, but the processes are executed differently ending up in different performances (Reis et al., 2013).

The different actors involved in the supply chain of port logistics are imperative for the uninterrupted flow of goods throughout the port to the subsequent carriage of goods on land or sea. The shipper, ocean carrier, land transport carrier, freight forwarder and port all have important roles in facilitating an efficient goods flow. Freight forwarders have the overarching view of the whole supply chain where the shipper is the customer and carriers perform the transport, meanwhile the port act as a connection in-between sea and land. An integrated approach involving all actors, contemplating the use of intermodal transportation, i.e. having the goods in one unit during the whole transport without repacking, gives the benefit to incorporate port logistics into the supply chain, expecting everyone to cooperate. However, the research is limited to a port logistics focus since ports act as a connecting hub where all carriers assemble, to either unload or load goods. The hub concept, import and export of goods, is therefore of central importance for successful integration, this as port infrastructure needs to handle the increasing volume of goods entering by sea. Therefore, port logistics needs to be incorporated with the supply chain to contribute with a consistent and efficient goods flow throughout the port.

Intermodal goods transportation, in the perspective of port logistics, faces many challenges for an efficient goods flow. To identify mitigation potential of existing barriers in intermodal goods transportation a clear perspective of transitions where socio-technical systems are described as a configuration of elements, need to be understood. The elements comprise technology, policy, infrastructure, consumer practices, cultural meaning and scientific knowledge where the change within these systems refer to socio-technical transitions (Geels, 2012). Referring to the different socio-technical systems this thesis will focus on the technology element where potential digital technologies will be researched for the mitigation potential of existing barriers.

7.3 Digital technologies

The maritime industry has changed due to the push of digitalization making way for modern digital applications, opening up for new opportunities beyond the traditional limits of the conservative industry (Heilig, Lalla-Ruiz, & Voß, 2017). "Technological changes in ships and ports and the increased volume of goods transported through ports have increased the importance of coordination at the interface of ports" and their consequent land segment (Heaver, 2011, p. 155). Digital technology is becoming more and more prevalent on the global market and it is disrupting nearly all existing industries (DHL, 2016). Different technologies can help improve the transport industry, such as enabling the information flow between the different intermodal transport modes to reduce paperwork and consequently manpower.

Information Systems (IS) has not only become a useful resource for different industrial processes, but also a tool for different actors to gain competitive advantage. Furthermore, arrival of Information Technology (IT) has similarly as IS changed the way the supply chain is operated in industries and how it is used for competition purposes. When Internet along with other related technologies spread around the world, consumption of products changed drastically, which led to changes in the logistics and supply chain structures (Alshawi, 2001). Rise of the Internet consequently led to rise of digitalization, which has transformed the maritime industry and improved the productivity, efficiency and sustainability in the logistics sector. Development of digital technologies, such as smart ports, i.e. utilizes IT to allow improved planning and management within and between ports (Heilig et al., 2017). According

to Fruth and Teuteberg (2017), container traffic has grown globally by an annual average of 10 percent since 1990 and there have been a continuous increase in the ship sizes, which give rise to new challenges in the logistics. Due to the increase in customer demand and higher competition, maritime logistics (including its role in intermodal goods transportation) gain great benefit from the appearing digital technologies. There are, however, some obstacles that come with the adoption of digitalization, such as data abuse and cyber-crime (Fruth & Teuteberg, 2017).

In order to gain as much benefit from the digital technologies as possible, it is crucial to adapt the intra- and inter- organizational activities to the innovation and make sure that organizations can coordinate and collaborate with one another (Heilig et al., 2017). Through the literature review and interviews with stakeholders related to the logistics sector, certain digital technologies were identified as most appropriate to mitigate the intermodal barriers with further investigation using a policy Delphi method. These digital technologies, which could feasibly help mitigate identified barriers in intermodal goods transportation, are presented below and they include: IoT, big data, cloud logistics, blockchain technology, digital identifiers, sensor- and -automation technology.

7.3.1 Internet of Things (IoT)

IoT has the capacity to connect different systems, which include a range of sensors for monitoring and register large amounts of data, and thus help in increasing efficiency in data driven logistics (Kubác, 2016). Nowadays, logistics providers have a possibility to work with objects that can communicate, receive, process and store information on their own (DHL, 2016). Furthermore, supply chain management (SCM) benefits greatly from IoT services by gaining support in integrating information and material flows, but in order to set up such operations there are a need for good communication amongst different actors involved in the SCM (Papert & Pflaum, 2017).

As stated in the industrial report by DHL (2016), there is a prediction that by year 2020 more than 50 billion objects will be connected to the Internet. Such estimations give great promise and opportunity to the logistics sector, since currently there are only a few IoT projects that had a considerable influence. Reasons for the low interest considers the question of security, lack of standardized processes in the logistics industry and the consumer market, which raise the demand for innovative solutions, which have a common foundation in connectivity and security (DHL, 2016; Pacheco & Hariri, 2018). Sensors and devices, every object with a digital identity, make up IoT, which is connected to the data network using a platform for communication of these devices (Tu, Lim, & Yang, 2018). These sensors have the ability to measure and communicate internal and external conditions, and some of the typical networks used are Wi-Fi, Radio Frequency Identification (RFID), near-field communication (NFC) and global positioning system (GPS) (Kubác, 2016). Some of the innovative IoT solutions such as RFID and sensor tags have intelligent features, which allow, identification, localization, communication and sensing that will help optimize the SCM for instance in transports using real-time tracking and "a global infrastructure of networked physical objects (Papert & Pflaum, 2017; Tu et al., 2018, p. 65).

Currently, logistics providers work with large amounts of data where information of shipments' start and end point, size, weight content and location are available in the global delivery network. With IoT, market fragmentation can be avoided and instead connect the supply chain data from different logistics providers and create a whole new level of communication (Kubác, 2016). Moreover, IoT can contribute to creating connected warehouses or terminals, which with

individual tagging will raise transparency and improve the localization of assets. This tagging will allow real-time visibility of the item, which will transmit its current order, content and location including providing information of the inventory status (DHL, 2016). Intermodal transportation can benefit from IoT as it will be able to connect the different interfaces in the supply chain and help in the decision making and monitoring of different processes whilst improving their efficiency (Chuang et al., 2017).

There are some other opportunities that IoT has to offer and include in the intermodal transportation system. The application of IoT can, e.g. increase transparency, traceability and reliability in the logistics sector and due to automated decision making it will enable higher operational efficiency and contribute to reducing costs. Real-time monitoring, which is possible with the use of IoT has the potential to improve quality of service and reduce risk of theft and damage to the goods. Some key challenges, however, are also present with adaption of IoT. Some of these challenges are, fragmentation within the logistics operations, which needs a further development of IoT, standard and security issues, which increase with the use of IoT (DHL, 2016).

7.3.2 Big data

Digitalization allows for massive amount of data to be transferred throughout the supply chain, which integrates logistics into a new level. Big data has the ability to optimize capacity utilization, improve customer experience, reduce risk and give rise to new business models (DHL, 2016). The new data sources, i.e. big data, generates immense quantity of unstructured data which are greater than a usual database software can manage (Ben Ayed, Ben Halima, & Alimi, 2015). It is used to register, store, manage and analyze data and thus allows real-time monitoring of products in the supply chain and forecasting of future situations (Kubác, 2016). Analysis of big data allows logistics providers to follow the development of the processes. Currently, there is huge competition amongst different service providers in logistics. The global market continuously changes, which leads to transportation issues due to lack of estimation of the future and insufficient information for predictions of transport capacity, storage areas etc. (Y. Wang, Chang, Feng, & Wu, 2017). Big Data can be described by four characteristics listed in *Table 4* below.

Table 4: Characteristics of big data (Kubác, 2016, p. 11)

Volume	The quantity of data that is generated
Variety	The next aspect of big data is its variety. Data comes from different sources and is being created by machines as well as people
Velocity	The term 'velocity' in the context refers to the speed of generation of data or how fast the data is generated and processed to meet the demands
Veracity	The quality of the data being captured can vary greatly. Accuracy of analysis depends on the veracity of the source data

In the transport industry big data plays an important part in working with large volumes of information and by organizing it (DHL, 2016). True value of big data is the information it stores and the tools it contains to extract the information, which is needed and then finally the results, which come from analyzing the data. Useful information resulting from analysis can be certain patterns, derived meaning, decision indicators, maintenance cycles, market trends and overall general knowledge, allowing a more informed interpretation of the environment (Kubác, 2016; G. Wang, Gunasekaran, Ngai, & Papadopoulos, 2016). Having all of this information available helps to obtain full use of the available capacity and optimize different systems. As this

technology moves forward, it will become necessary for the logistics sector to have the skills, such as social, images, video, to manage structured and unstructured data (DHL, 2016).

Transparency and quality of service management are very important factors in the logistics industry, and they can be improved with the utilization of big data. Information sharing can help the performance of the organization to be more transparent and also contribute to its development and improvement (Y. Wang et al., 2017). Big data can improve the operational efficiency by using the data to enhance the use of resources, process quality and performance. It can also help make the decision-making process more transparent and time efficient by including "demand planning, procurement, production, inventory and logistics" (G. Wang et al., 2016, p. 99). Another very important competitive advantage this technology presents is improvement of customer experience. With utilization of big data the aim is to increase customer loyalty and optimize customer service (Kubác, 2016). The effective outcome of the process can be achieved by transporting a combination of data, such as shipment information, weather, traffic, which will subsequently contribute to adjustment of real-time scheduling and forecast of estimated time of arrival (ETA) (DHL, 2016). In intermodal transportation, big data can be useful since there is a demand from the customers to for instance, know their order status. Furthermore, logistics providers benefit greatly from use of big data as it will allow for faster and better communication between the different modal interfaces and allow them to make more informed and faster decisions about traffic and transportation routes (Y. Wang et al., 2017). Big data offers various opportunities, which could be beneficial for the logistics sector in general as well as for the intermodal sector. Enhanced operational efficiency, visibility and control over supply chain is possible with use of big data. Additionally, this technology can improve real-time assessments and adaptation to demand and variations in capacity, as well as give rise to new business models through data-based services. There are, however, certain privacy issues that rise with collection of data and consequently causes challenges with transparency of data and its accessibility (DHL, 2016).

7.3.3 Cloud logistics

Presently the logistics sector suffers from inefficient and error-prone processes, which is mainly a cause of disruptions and lack of interconnectivity at the interfaces between different actors in the supply chain. Integrating a mediator at these interfaces can thus help eliminate such disruptions and cloud logistics has the potential for such integration. In the maritime supply chain, cloud technology is being used to avoid these unproductive processes (Haasis, Landwehr, Kille, & Obsadny, 2015). Moreover, cloud logistics is useful for dynamic and complex environments as it allows for new business model opportunities based on "Logistics-as-a-Service" (LaaS) (DHL, 2016). It has the capacity to improve business activity and productivity and increase efficiency while decreasing costs (Kubác, 2016). Cloud services can be activated and deactivated on request, which enables a higher performance in service and management without the traditional setup and maintenance expenses of having a private IT infrastructure (DHL, 2016; W. Li, Zhong, Wang, & Cao, 2013; Tipping & Kauschke, 2016).

In the past few years, cloud logistics has started to become more popular among logistics providers due to it allowing a fast, effective and flexible access to IT services, "a pool of virtualized resources across the internet" (DHL, 2016; W. Li et al., 2013, p. 1696). Cloud computing models have the potential to improve and scale up existing analytical solutions and contribute to creating new ones (Kubác, 2016; Tang, Dai, Liu, & Chen, 2016). Many companies are already using this technology to acquire access to local logistics IT specialists, who in turn gain advantage from having better access to global markets if their service is run in the cloud

system. Meanwhile, some of the uncertainties with cloud technology are based on data security and development costs, the main focus in the future will be on cloud security and its performance in large scale and real-time operations (DHL, 2016; Tipping & Kauschke, 2016). Intermodal transportation can acquire several opportunities from cloud logistics such as flexible business models as well as affordable customized and personalized logistics services. Hence, some challenges with cloud logistics are that there are data transmission and security issues as well as integration of cloud services into the existing systems that are difficult to change (DHL, 2016).

7.3.4 Blockchain technology

Blockchain technology, mostly known from its Bitcoin cryptocurrency application, is currently growing in the sector of logistics and SCM (Francisco & Swanson, 2018). The blockchain technology is a distributed database system that archives a variety of transactions along with other information and organizes all the data (Z. Li et al., 2018). Blockchain in the recent years has been developed for different kinds of applications one of which is 'smart contracts', where computer protocols are joint with user interfaces creating transactions following programmable rules (Risius & Spohrer, 2017). These contracts are very useful since it eliminates the need for involving lawyers and banks and allow forming contracts with cryptography without e.g. a notary (Nofer, Gomber, Hinz, & Schiereck, 2017). With its various possible applications great interest has developed in the logistics industry as there is a consumer demand for transparent operations, where blockchain can deliver the ability to process transactions openly reducing frauds (Tipping & Kauschke, 2016). There is a wide range of possibilities with blockchain, whether it is checking for the legality of a process or whether a particular item is authentic, all that information would be available to the customers and suppliers (Francisco & Swanson, 2018).

Blockchain offers a tradeoff between transparency and privacy as a system that is available for anyone to see the information. On the other hand, a completely private system allows no such transparency. A system can however be both transparent while at the same time give a guarantee of privacy with the use of cryptography with full anonymity (Wüst & Gervais, 2017). Besides increased transparency, blockchain can help make a number of processes, including payments and various paperwork, more efficient. Payments can be done faster while being completely transparent and a variety of information that might be required for a particular process will be available, which could be beneficial for the intermodal transportation processes (Francisco & Swanson, 2018). Blockchain is still at an early stage of development in the logistics industry and many aspects of its application in the supply chain are still under investigation and there are still too few users to adopt this application as of today. Blockchain technology can be beneficial for intermodal goods transportation due to its developed applications, such as 'smart contracts'. This application can contribute to quick and transparent transactions and signing of documents, while reducing the paper work and thus the time of some logistics processes.

7.3.5 Digital identifiers

In the 1990s, automatic identification and positioning technologies started being introduced to port operations and IT/IS continued to be used for automatic processes and visibility of port operations until late 1990s. With time, interest for more digital technologies continued growing to simplify trade and shipping management amongst carriers, shippers and forwarders, which consequently led to further development of different digital identification technologies (Heilig et al., 2017). In the logistics sector there are some new types of digital identifiers, such as digital

watermarking (DW), disposable smart labels and low-cost biometrics, which are used to control the supply chain, asset, stock, inventory management and end-to-end security (DHL, 2016). Growing usage of various digital identification technologies presents possibilities for greater connectivity in the supply chain and enables total transparency and ability to track goods.

Competition in the market puts strain on the logistics companies to cut their expenses, increase efficiency and supply chain flexibility (Rogers, Hakam, Hartmann, & Gebhard, 2015). Invisible barcodes, NFC and Quick Response (QR) codes are now used for making 'smart-tagging' possible and biometric devices are applied to have better precision in identification of items (DHL, 2016). Another automatic identification technology that helps improve efficiency and quality of the logistics' processes is the RFID (Rogers et al., 2015). RFID technology is becoming more and more important in the industrial sector, especially in shipping and container business (Hakam & Solvang, 2012). The RFID system is made up of two components: the reader and the RFID tag, which communicate with each other through radio frequency. Each tag that is marked with an individual electronic code can bound to an object which can then be identified. The way the RFID works is that the tag transmits data to the reader, which then converts the radio waves into another form of data. The data collected from the tags comes through the communications interface and is stored in the database for later processing. Some of the main outstanding advantages of the RFID identification system are no-contact, high degree of automation, reliability and durability, recognition speed, adaptation and ability for multi-tag identification (Kubác, 2016).

The intermodal sector gains a lot of opportunities from digital identifiers, which expand the gathering, storing and providing of information. Digital identifiers also give rise to better transparency and traceability of intermodal transportation processes, hence increasing product safety through integrity control. However, some issues arise due to lack of international standards and privacy policies, which delay an expanded utilization of this application throughout the logistics sector (DHL, 2016).

7.3.6 Sensor technology

Wireless sensor network (WSN) is one of the technologies that has been contributing to the facilitation and development of IoT (Xu et al., 2017). The original sensor devices made it possible to read the information at the end of the goods transport, which meant that damaged goods were only noticed at the final destination. The new generation of sensors offers much more advantages, such as autonomous configuration, on the road sensor access and autonomous assessing and decision making (Jedermann, Behrens, Westphal, & Lang, 2006). Original sensor technologies such as smartphones, tablets and game consoles can be applied in many new ways in the logistics business. Many expensive sensors can be replaced by new low-cost sensors and catalyze development of new applications for monitoring and controlling the logistical processes (DHL, 2016). WSN mainly focuses on micro sensors, integrated data attainment, processing of data, and communication and control (Xu et al., 2017).

There is a broad variety of low-cost sensors, which are already available and used in consumer electronics. Some of these sensors are accelerometers, gyroscopes, temperature and humidity sensors, which are said to be developed further into customer-to-industrial applications in the future (DHL, 2016). Currently, the aim is to have sensors that could measure a quality index from inside packed transported goods. These sensors offer security in communication and reduced use of energy for monitoring the different environmental parameters (Jedermann et al., 2006). Smartphones and tablets are being used for logistics' processes and they have been

successful in various applications, such as barcode scanning, image documentation of freight and signature capturing on delivery. As the NFC compatible smartphones become more of a trend it will give rise to new logistical applications, e.g. identifying items wirelessly with RFID transponders and electronic scanning with smartphones, which will decrease the demand for expensive traditional scanning systems (DHL, 2016).

Sensor technology is a very useful application for the intermodal transportation sector, as it allows real-time monitoring and controlling of logistics' processes, while also saving costs in comparison to the traditional scanner systems. The problem with this device is mainly due to the fact that they tend to lack robustness and durability, which is necessary for everyday use in the logistics sector. Security is also an issue as these cloud-based applications may not be reliable and meet all the customer demands (DHL, 2016).

7.3.7 Automation technology

Arrival of automation in port logistics has brought big changes to the logistics processes and operations (Okorie, 2016). Industrial automation includes the following systems and elements: mechanic, hydraulic, pneumatic, electric, electronic and computerized, which are applied for controlling equipment and processes (Martín-Soberón, Monfort, Sapiña, Monterde, & Calduch, 2014). Besides a variety of great advantages, the increased use of automation technology has caused for a decreased need for manpower, which can lead to legal issues and changes in the traditional rules of the port (Okorie, 2016). The logistics industry is presented with a fast-growing spectrum of automated solutions with potential of performing processes with zero-defect and increase productivity (DHL, 2016).

With arrival of e-commerce the demand for much faster and efficient operations have increased as each individual order needs to be processed continuously. In the past few years, automation technologies have evolved and become faster, more accurate and flexible while being affordable (DHL, 2016; Tipping & Kauschke, 2016). An automated port, a great example is the fully automated terminal established in the Port of Rotterdam in 1993, which is a port that uses a variety of technologies, such as automated gantry systems, automated guided vehicles (AGVs) and automated stacking cranes (ASCs). For instance, automated container terminals have automation processes in the yard and dock-yard interchanges, as well as in the gates and quay cranes. Today, automation is adapted in ports, but to a different degree depending on the port. Automation is present in equipment handling as well as in the operational processes for ports and terminal operators (Okorie, 2016). Using automation technology decreases human involvement, which in turn results in higher control of the processes, standardization of performance and service levels, elimination of uncertainty in response times and reduction in costs for operations and human errors (Martín-Soberón et al., 2014).

Automation technology brings a lot benefits to the intermodal sector as it increases activity and elasticity of the logistics operations and helps improve efficiency while decreasing costs and the occurrence of mistakes. The challenges that rise with use of automation are regulatory, ethical and legal issues (DHL, 2016).

8

Methodology

In the methodology part, the methodology and methods of 'Phase 2' are described beginning with constituting the research design followed by an exploratory study to finalize with data collection methods. The data analysis approach will also be described to increase validity of the data collection methods.

8.1 Research design

In deciding upon which methodology to use in a master thesis it is important to choose an appropriate research design. A quantitative, qualitative or mixed research design can be used where the difference between them are based on what type of data that is used. In quantitative research numerical data (numbers) is collected by any data collection technique or data analysis procedure, e.g. questionnaires, graphs, statistics etc. (Saunders, Lewis, & Thornhill, 2016). In qualitative research non-numerical data is collected through procedures such as interviews observations, focus groups or direct participation. However, these two research designs are more than often combined into a mixed design or triangulation since "quantitative and qualitative research may be viewed as two ends of a continuum, which in practice are often mixed" (Saunders et al., 2016, p. 165). In this thesis a qualitative research design was used relating to the data collection methods that contributed to the results.

When choosing the research design, it is imperative to include the critical part of research ethics. According to Booth, Colomb, and Williams (2008), it is essential to consider ethics of civil communication as research is contemplated to reflect social activity where creation of trust, avoiding biases when collecting and reporting data etc. are constituted. The network of social activity connects those who will use or benefit, even suffer, from the use of this research, but it also connects to others' research by using it as theory in a vast network. At the university, the Board at Chalmers (2016) highlight the importance in conducting research based on:

- Democracy and respect for everyone's equal value
- Human rights and freedom
- Quality, openness, participation, respect and diversity
- Firm scientific foundation
- Academic freedom and responsibility to ensure integrity and objectivity
- Sustainable, long-term approach in our decisions and strategies
- Morally and intellectually independency of political, religious, ideological and economic power bases

The ones that were affected or a subject of this thesis was referred to as ‘they’, ‘them’, ‘their’ or a related pseudonym if needed to safeguard their integrity related to gender-neutrality and anonymity (Wiles, 2013). To value each interviewees’ privacy was of great importance as it created an inclusive environment and a safe place to give unobstructed opinions.

8.2 Exploratory studies

Research can be designed to fulfil different purposes, according to Saunders et al. (2016) an approach of exploratory, explanatory, descriptive or evaluative purpose, or a combination of these can be used. The research question often sets the purpose of the research, meaning that in what way the research question is put the purpose or nature of it is easily defined. Important to keep in mind is that the research project or question may change over time, and consequently also the purpose of the research.

In this thesis an exploratory study was conducted related to the nature of the research project and in the way the research question was put. Exploratory studies are valuable to use when there are open questions on a topic of interest that need to be discovered furtherly. A research question in this type of study usually begins with a ‘what’ or ‘how’ to investigate a problem or issue that most probably has an uncertain nature and an unsure result. A number of methods including literature search; expert interviews; in-depth individual interviews are used when conducting an exploratory study (Saunders et al., 2016). Related to the broad perspective and exploratory nature, the interviews tend to be relatively unstructured, which contribute to a flexible and adaptable research, not too affected by change. For an exploratory research to be conducted successfully the researcher needs to be open to changes as the research process develops. Normally, an exploratory study will have a broad perception in the beginning, thus as the research progresses the focus will become narrower.

8.3 Data collection methods

In a research the data collection can be, as described above, both quantitative or qualitative. Relating to this thesis, a qualitative approach was used to collect data, both secondary and primary, in the form of systematic literature review, semi-structured interviews, Delphi method and a dialogue workshop conducted in the Delphi study. The research questions decided upon, with the theory as a foundation, was explored by the different data collection methods.

8.3.1 Literature review a systematic approach

To answer a research question, according to Saunders et al. (2016), researchers needs to undertake various sources of data to furtherly analyze them even though the initial purpose of the collected data would have been other. The data, known as secondary data, include both published summaries and raw data. Even though the data had another purpose, the collection provides additional knowledge and interpretations that can deliver insight from another perspective. Secondary data includes both quantitative and qualitative data and in this thesis a document secondary data, qualitative, was used, as well as primary data gained from semi-structured interviews and the policy Delphi steps. Document data includes online sources, physical written material and even non-text material such as video recordings or images and is normally used in research that also collects primary data.

The objective of this research was to find existing barriers to intermodal goods transportation and possible applicable digital technologies that could have mitigation potential. Therefore, a systematic literature search was conducted by using online databases Chalmers University of Technology subscribes to, i.e. Summon and Google scholar. The search terms were selected as intermodal transportation, intermodal goods transportation, intermodal barriers and port logistics where they were combined with and/or to have a more accurate list of publications.

8.3.1.1 Systematic literature review

The systematic review of literature is a process where literature is reviewed by having a structured approach in finding data, evaluate its contribution to structurally generate findings and furtherly come to a conclusion in what the literature contributes with, is known, and what it lacks, not known. According to Denyer and Tranfield (2009); (Saunders et al., 2016) the systematic approach can be listed in five stages, and the process completed in this research can be seen in *Figure 18*:

1. Formulating the research question(s)
2. Finding relevant data in literature to generate a list of potential data retrieved from online databases searches
3. Evaluate the data gained for literature research to create a list of relevant data related to the research question(s). The list can be made by determining headings for different columns in an excel sheet. A list can help with phasing out literature that is not relevant to the research
4. Analyze the data to create a list of key points extracted from the literature findings that are of value to the research
5. Report all the results of the systematic approach in the excel sheet

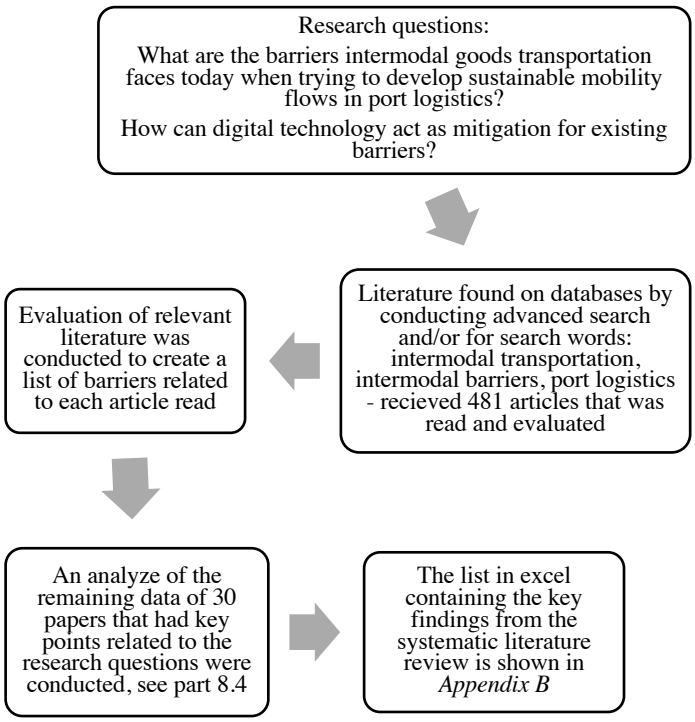

Figure 18: Flow chart of systematic literature review

The systematic literature review is very subjective when it comes to making decisions regarding inclusion or exclusion of papers, therefore both researchers conducted the systematic review (Gimenez & Tachizawa, 2012). The process of the systematic approach started with the researchers deciding on research questions and afterwards some key words that was to be used in the literature search. The '*' sign was used at the end of some key words to include more search results since, according to Gimenez and Tachizawa (2012, p. 532), "many papers use slightly different key words for the same concept". To encompass a broad perspective to gain papers related to the research questions, the researchers selected three classes of key words:

1. Words related to intermodal goods transportation: "intermodal transport*", "intermodal goods transport*" and "transport supply chain"
2. Words related to barriers: "intermodal barrier*"
3. Words related to ports: "port logistics" and "port supply chain*"

The literature search was based on all possible combinations of the above search words, which constituted in a lot of papers, approximately 100 000 hits. To narrow down the width of the search results, the researchers decided to only include papers with titles that had relevance to the research questions, including papers from well-known databases, publishers and journals such as Summon, Google Scholar, Rutledge, Springer Link, Emerald, Inderscience, ProQuest, ScienceDirect and Taylor & Francis. When the literature was narrowed down, the researchers started to put emphasis on papers that had either an intermodal goods transport, port or barrier focus, which resulted in 481 papers. To continue reducing the amount of literature the attention when reading the abstracts was based on one criteria, which had to be fulfilled to be regarded: does the paper analyze or describe any barrier to intermodal goods transportation? From the criteria, the amount of papers was furtherly reduced to about 70 and these were read to see whether they had any contribution to the research questions. Lastly, the researchers had only 30 papers, which were analyzed by extracting the barriers identified, their explicit explanation, all in an excel file (see *Appendix B*) and a subsequent thematic analysis as described in part 8.4. *Figure 18* summarizes this systematic process.

8.3.2 Semi-structured interviews

Interviews, i.e. primary data, can be formalized and structured in different ways depending on the research participant, where some sections of the interview can have transitions related to the formality and structure used (Saunders et al., 2016). For example, standardized questions, unstructured and informal conversations, but also a mix of structured and unstructured parts, etc. can be used. In exploratory studies this type of interview, semi-structured, can be useful as it will provide important background information for the research topic. The data gained during semi-structured interviews can be captured by audio-recording or note taking.

In this thesis, semi-structured interviews were used to explore two purposes: (1) to identify barriers in intermodal goods transportation, and (2) to investigate if a digital technology can be utilized as a possible solution to mitigate existing barriers. The purpose with having semi-structured interviews was to combine the outputs with the systematic literature review, which was consequently used in the Delphi study to receive input from stakeholders to reach consensus. Therefore, by using a semi-structured outline the interviews were kept open to give a broad perspective of answers. The interviews started with a short description of the research and the interviewees had the opportunity to freely comment on the subject. An interview guide was created to prepare exploratory questions needed to answer the research questions including the build-up of real understanding. As stated by Wright (2017, p. 52) "the interview guide

should capture the argument the innovator is making" where argument equals innovation, as both includes inference. Thus, resulting in a good foundation for the interview, as arguments can be both analyzed and criticized. The foundation starts with the argument 'If P then Q' meaning that the questions asked can probe for the specific research and either result in valid arguments or just logical fallacy. The exploratory questions asked with probes:

- What do you see are the barriers of intermodal goods transportation today?
  - *Probe:* Can you specify barriers to rail, road and sea in the port logistics perspective?
- The capacity for intermodality exists in Gothenburg port, but are there any ways to utilize it more sufficiently and efficiently?
  - *Probe:* Can you specify any practical or theoretical potential solutions?
- Do you know any digital technology developments that can help mitigate mentioned barriers?
  - *Probe:* What do you see can be the hindrances/benefits with implementing potential digital technology?
  - *Probe:* What should a digital technology contribute with to intermodal goods transportation?

Table 5: Background of interviewees

Interviewee no.	Type of Business/Organization	Position
A	Research institute	Researcher
B	Cooperation platform for transportation	Manager
C	Maritime research, innovation and development	CEO
D	Port facility	Manager
E	Academia	Researcher
F	Freight forwarder	Manager
G	Logistics provider	Manager
H	Cooperation platform for transportation	Manager
I	Rail service provider	CEO
J	Port and integrated inland service provider	Manager
K	Logistics provider	Manager

During the interviews all questions were not explored, the agenda with having exploratory questions was to invite to further discussions on the subject, keeping the scope of answers open. Eleven face-to-face interviews were conducted at varying lengths, between 30 minutes and two hours. The ones interviewed were carefully selected stakeholders related to the topic of the thesis, professionals and academic researchers working with intermodality in Gothenburg, see *Table 5* above. Throughout the interviews the information gathered was documented in writing.

8.3.3 Delphi method

The Delphi method was originally developed to focus on trends of science and technology to understand where it impacts society the most. The method is especially useful when the problem at hand has no need for advanced or precise analysis, rather it is an advantage to use a more subjective approach to gain a collective result (Critcher & Gladstone, 1998). In the process of

dealing with complex problems the technique of pooled intelligences, i.e. a group of pre-determined experienced individuals, is used to acquire expert opinions (Franklin & Hart, 2007).

There are three types of Delphi methods; classical, decision-making and policy Delphi, where in this thesis a policy approach was used. A policy Delphi creates the foundation for future solutions as the actors, experts or key stakeholders involved possess expert insight in the complex problems, where a collective decision is more reliable than ones from individuals. When selecting actors to be involved in the process, both formal and informal can be selected to give a range of opinions regarding the issues (Rayens & Hahn, 2000). The method was founded on the idea that the decisions decided upon by a collective expert group gives a more objective opinion than an individual (Delbecq, Van de Ven, & Gustafson, 1976). Policy Delphi has objectives that underlies the outcome of an acceptable option as a solution of an issue, where the objective is to ensure that all of the options are considered to estimate impacts and consequences of them. The important features of the policy Delphi are according to Delbecq et al. (1976); (Franklin & Hart, 2007): (1) to create a group of experts related to the topic, (2) gather information about the topic at hand by questionnaires, and (3) use and summarize the data collected to get feedback from the expert group. According to Rayens and Hahn (2000, p. 315), "the policy Delphi method is a useful tool for systematically building consensus among decisions makers" especially when the topic is not well-defined or the issues are complex.

8.3.3.1 First round of Delphi

In 'Phase 1' part 3.4.2 the concept including the importance of dialogues is described, which was used in this thesis in trying to gain a more collective approach to the Delphi method. The dialogue conducted was based on the research questions including the findings from the semi-structured interviews. According to Isaacs (1999), dialogues are imperative for refining and sharing of knowledge to increase collaboration between individuals and to create trust. In preparing the dialogue workshop it was important to understand how imperative it is to facilitate discussions on issues related to the thesis and include participants from the triple helix; academia, business and society. In part 3.4.2.1, about the fishbowl set-up in 'Phase 1', a method of conducting dialogues is described. According to Arivananthan (2015), the fishbowl method increases the engagement from participants in dialogue workshops to spontaneous share information on issues at hand. The only difference in the set-up of this dialogue workshop was that all people involved was in the fishbowl and none were a passive participant. During dialogues it is also important that the group discussing keeps it within the topic decided upon and that the facilitator does not lead the group towards certain opinions (Saunders et al., 2016).

In the dialogue workshop conducted, a facilitator, one of the researchers, briefly presented the thesis and explained the various digital technologies that were perceived to have mitigation potential during the semi-structured interviews. Important to highlight was that all participants in the dialogue were previously interviewed, which simplified the start-up of the dialogue. As everyone had enough background information, more energy could be assigned to the dialogue rather than to present all barriers profoundly. After the brief explanation, the facilitator clarified how the dialogue would start with them receiving one digital technology, which they would evaluate if it had any potential to mitigate the presented barriers in front of intermodal goods transportation. When the dialogue started, each digital technology was evaluated for each presented thematic grouped barrier. In total, the dialogue lasted for three hours included breaks. The facilitator steered the dialogue within the workshop to gain as centered and valuable results as possible for the next round of Delphi, meanwhile the second researcher simultaneously transcribed the whole session, analyzed according to part 8.4.

8.3.3.2 Second round of Delphi

To reach consensus in the Delphi method a data collection form, i.e. a questionnaire, was handed out to sixteen stakeholders who participated in the semi-structured interviews, the ones participating in the dialogue workshop and to those who were contacted but could not make it to either an interview or the dialogue. Handing out questions in this round of the Delphi study are a tool to collect data, which was done after the dialogue workshop to get knowledge of the stakeholders' opinions of the result from the dialogue. According to Franklin and Hart (2007, p. 239), it is imperative that the questionnaire reflects the "key elements of the research topic". Therefore, the questions were created from the data obtained by both literature and the dialogue workshop, consequently, to gain validity and reach consensus, i.e. the level of agreement between participating stakeholders with expertise knowledge (Von der Gracht, 2012). The Delphi data collection form, i.e. questionnaire, was designed by analyzing the collected data and making statements. The statements specified that digital technologies can mitigate specific barriers (thematic combined barriers) and with the rating of agree, disagree or not sure to receive a feasible result. In addition to the rating of the statements, a compulsory why question to understand whether the participants' opinion was agreeable or not was given. An example of a statement is "I believe…can mitigate the barrier…in front of intermodal transportation" where first a technology was stated and secondly the barrier, which can be mitigated, coming from the analysis of the results of the dialogue workshop, including the mandatory why question.

There are many ways to distribute a questionnaire and in this thesis a Word document questionnaire, using the developer tab, was used. The respondents received the questionnaire via email, they downloaded the document, answered it and sent it back to the researchers. The answers from this round were analyzed by the use of Average Percent of Majority Opinions (APMO) formula, see part 8.4.

8.3.4 Quality issues

When conducting the interviews to gain more insight in the research topic it is important to ensure data quality. Issues that relate to quality when conducting semi-structured interviews are reliability, biases, cultural differences, credibility and generalizability (Saunders et al., 2016). To overcome these issues during interviews, preparedness by giving and gaining more knowledge of the research is imperative, as well as to bridge biases. Furthermore, the questions asked need to be well-formulated not to cause any confusion for the interviewee and by providing the collected data for overview, trust can be attained resulting in credibility achievement. The generalizability of the qualitative research can be gained by testing existing theory, which was conducted in this thesis and can demonstrate that the results of data collection have a broader theoretical significance. As always it is important to accept and understand cultural differences by reflecting upon them in the preparation of the interviews. Cultural reflexivity is imperative for proper interactions with the participants to gain their acceptance.

In logistics the methods of collecting data are developing towards increased use of case studies and qualitative interviews. In this thesis, logistics was the general foundation and therefore, quality should reflect the whole research process. According to Halldórsson and Aastrup (2003, p. 326) trustworthiness is a "traditional way of thinking about quality within logistics" as it corresponds to a more realistic way of considering the idea of quality. The personal presumptions are seen as the realism in logistics where trustworthiness provides a more evaluative approach to research quality. To better understand where efforts should be

concentrated in the logistical system, the combined qualities of trustworthiness are explained. The qualities are, credibility, transferability, dependability, and confirmability, see *Table 6*, and they were related to the quality of data collection in the research process.

Table 6: Dimensions of trustworthiness: credibility, transferability, dependability and confirmability (Halldórsson & Aastrup, 2003, pp. 327-328)

Credibility	Credibility is established based on that there are several objectives. The respondent will have their objective with a perception of their own reality and the degree of match between the respondents' answers and what the researcher represents constructs credibility. Interpreting the realities that the respondent gives shows that they have a central role in falsifying or correcting the picture or reality that the researcher has concluded.
Transferability	To the extent that the research can make general claims of the world, the conventional term is external validity that is reflected in the generalizability of a question. There are constraints e.g. time and space that hinders generalization of findings
Dependability	"Stability of data over time", also termed reliability and it is a precondition for validity. It is achieved when replication of the similar study with same instruments, receives about the same results. Dependability is achieved by documenting the logic of process and method decisions outlined in a dependability audit
Confirmability	The findings represent the results of the inquiry and not the researcher's biases. Conclusions, interpretations and recommendations are to be traced back to their sources, achieved by an external actor to assert the results of the study

In this thesis the four qualities were achieved, or partly, by conducting systematic literature review, semi-structured interviews and a policy Delphi with its two rounds of data collection. Credibility was achieved as various opinions in regard to different views about the same reality were given by the participants and consequently changed the researchers' perception, by correcting or making the researchers rethink a particular reality. In addition, the literature gave the researchers their perception of reality which was consequently challenged by the participants of the interviews. By using an interview guide in the interviews, transferability was achieved as the questions need to have generalizability, which was gained by having open questions. The dependability and confirmability, however, were only partly achieved. Dependability, also termed reliability, was moderately achieved by conducting the interviews and the two rounds of policy Delphi since the latter reaches consensus, i.e. collective agreement. Nevertheless, confirmability was also partly achieved by having references and quotation, since then the data is trackable to its source of origin. It was hard to fully achieve the qualities of dependability and confirmability, as a dependability audit and having an external actor to assert on the results require time which were not accounted for in this thesis.

8.4 Data analysis

The qualitative data gained from the systematic literature review and semi-structured interviews was analyzed using thematic analysis. It is a systematic approach, which according to Saunders et al. (2016, p. 579) is "a foundational method for qualitative analysis". In this type of analysis the researchers collect data from different data sets (such as interviews and literature), generally large ones, in where they try to identify themes or patterns that can be further analyzed. Normally the researcher will code their own themes and the thematic grouping of data results in "rich descriptions, explanation and theorizing" (Saunders et al., 2016, p. 579). The coding is used to find data with similar meaning and the outcome of the process is to make a large amount

of data available for further analysis by narrowing down the scope of the data set. However, a code consists of a single word or a short phrase and to continue the analysis, Saunders et al. (2016) suggest that the researchers ask themselves questions regarding the importance, reoccurrence and trends of the codes. The process of analyzing the codes are not unproblematic and to furtherly understand the data set, questions regarding themes coherence and whether any codes need revision needs to be considered. The codes that have been identified from the data sets will be gathered into themes or thematic groups of codes. In this thesis both the systematic literature review and interviews were analyzed by using thematic analysis since the large amount of data gained from review and transcribing had better function being grouped in themes for further use in the Delphi method. The thematic codes were directly related to all barriers received from the literature review and interviews, and they were later on assembled into thematic groups. The results from the analysis can be observed in part 9.1 and 9.2.

For a policy Delphi the process of conducting analysis is subjective since it condenses, refines and develops questions by utilizing previous data that are subjected to the knowledge and perceptions of the researchers (Franklin & Hart, 2007). Therefore, it was important for the researchers when analyzing the semi-structured interviews and dialogue workshop to systematically concise the essence of the participants' response and comments to develop the subsequent Delphi data collection form. As one of the major objectives with the use of policy Delphi is to reach consensus, i.e. a collective agreement, for issues regarded, a proper analysis method was used (Islam & Zunder, 2014). The consensus analysis does not necessarily have to reach full agreement and in this research, the APMO formula for cut off rate was used. In this formula the "majority refers to a greater than 50 percent agreement or disagreement with the statements" in the questionnaire (Islam & Zunder, 2014, p. 399). Consequently, to calculate the APMO rate, see *Figure 19*, only the majority of disagreements and agreements are used and divided with total opinions expressed. To be able to calculate the consensus rate the researchers assembled how many that agreed and disagreed, the not sure value was left out since it does not tend towards either disagreement or agreement. In part 9.3 the results of the Delphi analysis can be observed.

$$\text{APMO} = \frac{\text{majority agreements} + \text{majority disagreements}}{\text{total opinions expressed}} \times 100\%$$

Figure 19: APMO formula (Von der Gracht, 2012, p. 1530)

Continuously throughout this thesis, systematic combining, an abductive approach, was used to utilize 'matching', one of the cornerstones of the research process in systematic combining (Dubois & Gadde, 2014). Matching is the process where theory and framework are used in an interplay with the research activities. According to Dubois and Gadde (2014, p. 1279), "matching is about going back and forth between framework, data sources and analysis" contemplating the continuous movement between an empirical and model world, or theory and reality (Dubois & Gadde, 2002). In the continuous process of this research, the issues concerned, and analysis conducted was restructured consecutively when it collided with the empirical world, or as in this thesis the desired future. The direction and redirection, i.e. restructuring, were conducted to increase the scope of information gained from different data collection methods as well as from different sources of data. Consequently, the restructuring with direction and redirection are important to achieve matching. The abductive approach with the systematic combining focus, was used as the research foremost focused on identifying the barriers by interviews, but also by a systematic literature review including the interplay in-between them. Continuously, throughout the research process existing theory was used, gathered from literature, to analyze the significance of identified barriers.

9

Results

9.1 Systematic literature review

The results from the systematic literature review can be found in *Appendix B*, part 13.2. The conducted review was done according to the five stages of a systematic approach, see part 8.3.1.1. Various and vast data was collected and sorted out to find those that would be most suitable for this thesis. The consensus of all articles and reports reviewed was that the barriers to intermodal transportation seen from a port perspective are price and cost for transport, flexibility, time, communication and a higher demand of goods including reliability of the transport. To analyze all data gained from the systematic review, the barriers were thematically coded into five main thematic groups of price and cost, reliability, flexibility, communication and time. In *Table 7* the five thematic groups with their underlying key barriers, i.e. thematic codes, and a concise explanation are presented, for a comprehensive description see part 9.1.2.

Table 7: Thematic groups of barriers from literature

Thematic group	Key barriers	Explanation
Cost and Price for transport	Price, cost, price sensitivity, higher demand for goods, increased goods flow, congestion, environment, low willingness to pay for "green solutions", awareness and increased risk for damage	Due to increased demand of goods, bigger ships, bigger ports and additional movements of goods between different transport modes, costs are increasing hence no willingness by customers to pay for green solutions
Reliability of transport	Capacity, quality of transport, goods delivered at an agreed time, last-mile delivery, bottlenecks, increased goods flow, and transport buyers not interested in change	Modal shift is facing limited possibilities due to unreliable quality of transport with the challenges of bottlenecks, lack of capacity and last-mile delivery
Flexibility of transport	Bottlenecks, congestion, technical incompatibility, railway connectivity, limited rail infrastructure, flexibility, mindset, policy, conservative industry and reliability	Moving goods from one transport to another is an issue that affects the flexibility and challenges, such as connectivity issues and congestion problems
Communication	Communication, cooperation between actors, competition between actors and different transportation modes, awareness, planning, policies, lack of information, independent networks, IT, business models and conservative industry	Lack of communication are resulting from various barriers, such as planning where both allocation of capacity and policy-changes are inefficient, moreover the competition on the market puts pressure on collaboration, which inhibits good communication

Time for transport	Transit time, transport time, planning and transport infrastructure, limited availability of appropriate management and labor	Decision makers are willing to accept risk of loss or damage to goods if transit time is faster, hence time is an imperative factor when deciding modal choice

9.1.1 Thematically grouped barriers from literature

Price and cost for transport: According to Elbert and Seikowsky (2017), rail/road transport has a more sensitive price elasticity in comparison to road transport. Furthermore, the cost of intermodal rail/road transport decreases with longer distances compared to road transport, which is a fact that is supported by Behrends and Flodén (2012) and Roso (2013). Moreover, this is discussed by Reis et al. (2013) who states that intermodal transport costs is lower per kilometer, and conversely that road transport has lower costs due to no transshipment points or maintenance of railway tracks. In addition, Behrends (2015) discusses that intermodal transport costs increase due to additional movements of a container during change of transport, which is also highlighted by Monios and Bergqvist (2017). They state that prices for intermodal transport are increased due to extra handling, including pre- and post-haulage.

Heaver (2011) mentions increased goods flow, which affects the costs due to the fact that expansion of transport capacity is lagging behind the increasing volumes. Additionally, Rushton et al. (2017) discuss the issue of cost and the challenge in finding the balance between costs and customer service, with the continuously increasing demand for transport services. Walker, Di Sisto, and McBain (2008) claim, however, that there is a tendency of consumers to choose the options at the lowest price, which is a consequence due to the lack of willingness to pay more for a sustainable option. Likewise, Elbert and Seikowsky (2017) discuss that consumers have a low willingness to pay for "green solutions".

Reliability of transport: For goods to be delivered within an agreed time frame, some actors are willing to pay more, which is stated by Elbert and Seikowsky (2017). Behrends and Flodén (2012) discuss the issue of limited possibilities for a modal shift due to the quality of transport being unreliable. Meanwhile, Roso (2013) takes up the question of bottlenecks, which are due to road congestion and inadequate railway connections from the seaports perspective. This can in turn hinder an efficient goods flow and thus cause delays and decrease the reliability of the transport system. Bottlenecks are further discussed by Rodrigue and Notteboom (2009) who bring up the issue of goods being caught in ports because shippers and logistics service providers use terminals for temporary storage of the goods as it is cheap. Thus, causing delays and put strain on the capacity in the supply chain. Heaver (2011) points out that capacity of ships, trains and trucks varies, and as ships are increasing in size, these differences grow. Due to the fact of these growing gaps, terminal operations are faced with increased pressure including in the interfaces between different transport modes and this consequently effects the reliability of transport services.

Bontekoning and Priemus (2004) bring up the fact of organization, management and implementation of innovation can contribute to improvement of reliability of the intermodal transport system, which is not very simple because of the logistics industry being conservative when it comes to implementing change, as stated by Monios and Bergqvist (2017).

Flexibility of transport: Behrends (2015) takes up railway connectivity as an issue to flexibility of transports, since rail companies put more effort in the nodes where there is most goods flow, which leads to a concentrated rail network. Furthermore, Behrends (2015) discusses the problem with mindset, and that some actors within the supply chain do not have high confidence in intermodal services because of a decline in transport quality and reliability. Railway infrastructure is said to be limited and requires further development to eliminate restrictions to the flexibility of rail/road transport, which is mentioned by Woxenius (2007), Elbert and Seikowsky (2017) and Tsamboulas, Vrenken, and Lekka (2007).

There is a growing demand for JIT which outs pressure on logistics service providers, which puts rail/road transport one step behind as it is less flexible in comparison to road transportation. Currently, road transport has the greater competitive advantage in comparison to intermodal rail/road transport and that is discussed by Eng-Larsson and Kohn (2012), Elbert and Seikowsky (2017), Reis et al. (2013) and Bergqvist and Monios (2016). Policy is another issue intermodal transportation is facing, there have been changes and incentives implemented towards the road transport, but there need to be more done towards rail and other intermodal transports. This issue is discussed by Elbert and Seikowsky (2017), Behrends and Flodén (2012), Tsamboulas et al. (2007), Reis et al. (2013) and Walker et al. (2008), who argue that many companies are redundant to changing their operations towards more sustainable ones and that the issue with intermodality is that it has not been incorporated in the planning process for the existing infrastructure of today.

Communication: Planning issues cause problems with allocation of capacity to jobs and scheduling in terminals, as stated by Tsamboulas et al. (2007). Furthermore, Reis et al. (2013) take up the issue of planning time being too long for policies and that there is a need to push for modal shift. Monios and Bergqvist (2017) bring up cooperation between actors and discuss that horizontal collaboration is not efficient enough, which requires vertical collaboration between shippers, rail operators and 3PLs. Moreover, Bergqvist and Monios (2016) support this statement and continue to deliberate on the fact that trust, knowledge sharing, and decision synchronization are required for sufficient collaboration to increase utilization of intermodal transportation.

Heaver (2011) brings up a discussion about how inadequate information exchange between actors might be due to competition and their unwillingness to share valuable information. The competition issue is also highlighted by Wilmsmeier et al. (2011), who supports the argument that there is competition between actors in different intermodal sectors. In addition, Bärthel and Woxenius (2004) add another angle to the competition perspective, where they say that since there is a competition between intermodal transportation and road transportation, there need to be good understanding and cooperation between involved players in the intermodal sector. Furthermore, another communication issue is lack of information, which is elaborated by Y. Wang et al. (2017). They discuss the various problems caused by lack of information with logistics providers being unable to make predictions, which results in their inability to adapt the transport capacity and storage area.

Bontekoning and Priemus (2004) state that many operations still use separate networks, which means that transport between rail and maritime terminals requires extra management operations and waiting time. This is further supported by Evert (1994), who discusses the need for better utilization of information technologies to reduce costs and have better communication with customers.

Time for transport: According to Bontekoning and Priemus (2004), transit time increases for many transport models in the intermodal chain. Measures to reduce transport time in the rail transport need to be implemented, such as shorter processing time, delay control and establishment of more transport relationships.

A fact is that transit times are longer when shifting to intermodal transportation, which is supported by Eng-Larsson and Kohn (2012). It is important to improve the intermodal transit time since time of delivery is one of the key barriers that affect the choice of transport and the transportation route, as stated by Winebrake et al. (2008). Moreover, Behrends and Flodén (2012) discuss the reason for increased transit time in intermodal transportation, which is due to the many choices of transport modes and Behrends (2015) further states that it is also due to additional operations and goods handing needed in the interfaces of modal transport.

9.2 Semi-structured interviews

The results from the semi-structured interviews conducted with stakeholders from business and academia are presented in *Appendix C*, part 13.3. All interviews resulted in many barriers with equal amount of explanations to what the barriers reflects upon when it comes to intermodal transportation. The interviews were conducted using the interview guide with questions and probes, see part 8.3.2. All barriers that were mentioned in the various interviews are all displayed in *Appendix A*, part 13.1, where they are in a descending order starting with the ones mentioned the most.

The barriers that showed most interest, had the highest frequency, was capacity, price of transport and conservative industry. The combined consensus of these barriers was that a more unsustainable transport mode i.e. trucks, are more flexible, cheaper and faster while rail, which is a preferred choice by logistics providers due to a more environmental sustainable solution, do not have sufficient connectivity, incur high costs and prices including underutilized capacity due to old-fashioned industry not making way for digitalization.

All results that we gathered from the interviews were analyzed and thematically grouped into barriers with a wider scope. Each barrier, i.e. key barrier or thematic code, that were thematically grouped had a similar definition with those they were grouped with, this to make it easier with constructing the dialogue workshop in the continuous Delphi approach. In *Table 8* all five thematic grouped barriers are represented with their underlying key barriers of definition including a brief explanation. An important note is that some of the barriers are repeated in the different thematic groups depending on their applicability on several areas. Those that are repeated are reliability and conservative industry in the three thematic groups of flexibility, capacity, and communication and business models. The reason for repetition is that the barriers have such broad application that they impact different thematic groups.

Table 8: Thematic groups of barriers from interviews

Thematic group	Key barriers	Explanation
Cost and Price for transport	Price, cost, environment and awareness	The cost and price of transport is too low for trucks which disables the use of rail that is a more greener solution but not sought after by society since poor awareness

Capacity of transport	Capacity, maintenance, lack of incentives, reliability, last-mile delivery and transport buyers not interested in change	The capacity for all intermodal transport exists, but is not utilized where incentives for maintenance and start-up of new services are absent including the difficulties in reliability of customers and slot times where last-mile delivery is one of the issues with change of transport mode
Flexibility of transport	Bottlenecks, railway connectivity, flexibility, simplicity, technology adaptation, economic risks, mindset, legal aspects, conservative industry, complexity of long-term policies, reliability and administration	Congested infrastructure, insufficient connections and an old-fashioned industry, i.e. poor flexibility, makes it difficult to adapt both mentally and physically
Communication and Business models	Communication, planning, customs, manual processes, policies, systems do not cooperate, business models and conservative industry	Transportation is an old-fashioned industry, manual processes and outdated business models, where communication between actors are poor and the need for planning and coherence with different legislations is needed for cooperation
Time for transport	Transit time, transport time, planning and bookings	Time concerning transport, delivery and transit are not equal important, without sufficient planning and bookings, time becomes a constraint for efficient goods flow

9.2.1 Thematically grouped barriers from interviews

In this section interviewees coded with letter at *Table 5* will be referred to as stakeholders.

Cost and Price for transport: The most common statement from the participants in the interviews was that trucks are cheaper than rail and that it needs to change as rail is a more sustainable option. The truck industry is an unhealthy market and *Stakeholder D* and *K* stated that the working conditions for truck drivers are bad and that more effort to highlight green transports are needed, but as always it depends on the price. Regarding the shipping option in intermodal goods transportation, *Stakeholder C* discussed that there are more costs incurred for shipping, consequently making rail a more competitive modal choice. Hence, *Stakeholder E* contemplates that if goods are transported on longer distances, both sea and rail will be more competitive choices than road. Nevertheless, *Stakeholder D* declared that larger volumes or longer distances, i.e. 300 km or more, are needed to outcompete road transports.

Poor societal awareness was stated by *Stakeholder A* to underpin the consumer behavior that increases the environmental impact from transports, since an order from far East to Sweden normally goes by air freight depending on the time efficiency. Furtherly, the environment was also highlighted by *Stakeholder I* who discussed that if a customer does not have an end-consumer contact, they will not consider the environment when choosing type of intermodal transport. In addition, *Stakeholder F* and *G* who acts as logistics providers mentioned the imperativeness of price when choosing type of transport.

Capacity of transport: According to *Stakeholder C* rail has been highlighted or prioritized over other intermodal transports such as shipping i.e. making no incentives to utilize the capacity of the shipping segment. Hence, rail infrastructure is old and in need of development. *Stakeholder D* stated that heavy investments are needed and that the poor rail system is a downside of deregulating the market after state monopoly since many of today's actors are small consequently making them more interested in profit than in development. None has the incentives to maintain a vial railroad. *Stakeholder A* emphasized that transport buyers are not interested in change and are not interested enough in the environment and contemplated that "being environmentally sustainable must be easy".

Many participants also discussed the issues with reliability concerning the capacity since starting a rail service is both time consuming and expensive, but not the main issue as having reliable, i.e. committed, customers is difficult. Consequently, the rail company takes all the risk in starting a new service and according to *Stakeholder F* there has been cancellations of rail services which decreases the capacity. Furtherly, reliability of the rail transport itself was highlighted by *Stakeholder C* and *E* as important for especially society since efficient and sufficient transportation is a basic demand and to downgrade public transport to make way for goods transport is not easy. The capacity in Gothenburg port logistics is discussed by *Stakeholder I* to be theoretical since the capacity exists but at the wrong time, i.e. day time as the opening times has been limited. Therefore, terminals and inland ports with their own capacity can support rail in becoming more efficient as stated by *Stakeholder J* the volume and schedule of the railway is known making plan and execute easier.

Flexibility of transport: *Stakeholder D* stated that rail and sea are inflexible mode of transportation and that bottlenecks are created due to that terminals move too slow, rather than having too much goods to handle. For the amount of goods coming into the port Stakeholder *H* and *J* stated that goods owners either does not get the memo that their cargo has arrived, or they intentionally use the port as an intermediate storage area, creating bottlenecks in the port logistics. Concerning the rail infrastructure around 50 percent of the goods that moves out of the port are carried on rail, hence *Stakeholder F* and *J* discussed the lack of railway connectivity in Sweden as being a flexibility issue for transportation. The connectivity in-between ports, disregarding the size, needs to be reliable, but there is no sufficient railway network to connect smaller ports hence the need for another type of transport. Rail is built on scale-benefits contemplating scheduled departures/arrivals and bookings are needed. According to *Stakeholder E* if a potential booking is missed, then the delivery of the goods will be delayed since the process of making new bookings are time consuming. In addition to rail bottlenecks, road transport is easily delayed due to congestion in the traffic stated by *Stakeholder D*. The overarching concern for flexibility is if there is willingness to change among the actors in the industry which was discussed by *Stakeholder A*.

Communication and Business models: Communication have been declared by *Stakeholder G*, *H* and *I* to be imperative for efficient and sufficient transportation. The information flow and sharing has to be integrated into the whole supply chain, this with sufficient information will facilitate transport as good planning will contribute to good business. It is imperative that the right type of information is shared at the right time including importance to highlight what information customer wants and needs. Hence, Stakeholder J and K highlighted that there are no current or a lack of IT solutions that can cooperate. There is also a slowdown in the implementation of IT based systems due to cybersecurity. Nevertheless, moving from one transport system to another, i.e. changing business model, is difficult and *Stakeholder I* and *B*

discussed that first it takes a long time to adapt to one and secondly there are not enough policies to give incentives for choosing sustainable transport.

Time for transport: Related to time for transport, *Stakeholder A* mentioned that the imperativeness of time depends on which mode of transport that is used, but for end-customers time always matters. Moreover, in shipping, the longer sea transport affected by various circumstance, such as weather conditions, makes transport time less reliable. Therefore, according to *Stakeholder D*, *E* and *F,* transport time is not the critical factor, instead reliability of the transport becomes more important, i.e. honesty towards customers with giving transparency about the anticipated transit time. However, this does not apply when the goods reach ports and have a subsequent carriage, then delivery time becomes imperative. Further, *Stakeholder F* stated that the irregularity of sea transports may impact transit time, since delays due to direct calls or feeder traffic can hinder an efficient goods flow.

9.2.2 Digital technologies

During the interviews, almost all interviewees mentioned digital technology as a solution or mitigation for some of the barriers including providing some ongoing projects related to IT and automation. All those digital technologies can be seen in part 7.3 and to make the process for the Delphi approach easier to conduct, the technologies were grouped into five areas: (1) IoT and big data, (2) cloud logistics, (3) blockchain technology, (4) sensor technology and digital identifiers, and (5) automation technology. The digitalization mentioned throughout the interviews with the various stakeholders has a concise analysis below.

Digitalization is needed to make communication more efficient, this by facilitating coherence between information flow and correlation between different IT systems work. Cooperation between different systems will most probably, and as a result from more automation technology, decrease the turnaround time of goods in port including time wasted conducting manual processes e.g. administration and paper handling. According to *Stakeholder H* the digital technology of "cloud logistics is an easy and efficient way to make information available, as there are no expensive investments in new IT infrastructure" since existing can be used. In addition, other intermodal transport providers and actors within the supply chain, such as *Stakeholder A*, *F, J* and *K*, also stated that they see the potential in having a joint system or a platform of digitalization. The platform should work throughout the whole supply chain, making everyone in the chain to efficiently forward the goods when it arrives in ports. Nevertheless, *Stakeholder D, G* and *I* mentioned that a lot of documentation is made manually i.e. old-fashioned industry, which contemplates the need of digitalization to make the information flow more effective and available, hence increasing performance.

Digital technologies have many areas of applicability, e.g. with sensors and RFID, hence the problems are lack of incentives from society and those organizations working in the transport industry, such as rail companies, truck companies and shipping companies. According to *Stakeholder G*, an issue for companies that work with a lot of small packages is that customers are not willing to invest money in having all their individual packages tagged with and RFID tag. The challenge is that normally a change, which is not needed or sought after, does not either implicate any incentives to furtherly make any, even if existing measures for digitalization are in place. The question is 'why change anything that already works as it is?' which was mentioned by *Stakeholder A, B* and *G*. The environment that is supposed to be a driver for change is not highlighted enough by logistical customers or organizations, as accordingly to *Stakeholder A* "being environmentally sustainable must be easy". *Stakeholder G* highlighted

that at the moment green solutions are costly, where renewable fuels and other measures for decreasing the emissions and reduce pollution require investments and consequently a higher price for customers. Probably, the incentives for utilizing more sustainable options for transportation will emerge when development and usage of environmentally sustainable options has evolved and increased in number.

The digital infrastructure was highlighted by *Stakeholder B, H* and *J* as being more difficult to implement than physical infrastructure, this as a responsible actor for implementing an efficient and sufficient IT system is problematic. With the use of digital technologies and a growing amount of goods in the global trade, ordering and booking in online systems become more apparent. According to *Stakeholder G*, e-commerce is constantly growing making companies vulnerable against cyber-attacks, which makes it imperative to invest in cyber security. By using digital resources, performance is increased as there consequently will be sufficient information of goods whereabout and amount in terminals. Usually the goods' owners or those providing the logistical services have no information of when to pick-up goods which causes disruption in port terminals, since a lot of goods are caught and as a consequence, waiting for further transport. According to *Stakeholder D* and *J*, digital technologies could be used for efficient goods handling, resulting in a system with direct cooperation among forwarders and logistical companies for fast handling times, increasing the flow of goods through the port instead of having it in warehouses and occupying space from the terminal. Hence, the real-time positioning, both when the goods move and stand still, is important especially for customers, which is stated by *Stakeholder E, D, F* and *K*.

Automation in ports was also highlighted in the interviews as a potential digitalization of port systems to make goods flow more efficient, especially by *Stakeholder C* and *J*. *Stakeholder J* and *K* mentioned that trucks will, generally, come when they ought to come. There is no schedule like for rail on when they come, which implies a challenge to port terminals to be open and have manpower including the risk of congestion. Therefore, automation of gates was highlighted as an ongoing project to increase efficiency and reduce congestion by extending the opening hours of the port without the need of extra personnel. Nevertheless, further implementation of automation technology applies to the port operations where it was highlighted by *Stakeholder J* that, e.g. Port of Rotterdam has a fully automated container port up and running. Hence, the application of an automated port in Gothenburg were seen as very distant in the future, thus some functions of automation were highlighted to have applicability in easing pressure on personnel and to increase the goods flow.

9.3 Delphi method

The results from data collection via policy Delphi method, first and second round, are described below. In the first round a dialogue workshop was conducted with three professionals and it was conducted to gain valuable results to reach some answers for the thesis's research questions. The second round contained sending out a questionnaire to different stakeholders within academia and business, which related to this research, to reach consensus from the whole process of data collection and to gain understanding that the results, which emerged during the first round actually had some mitigating potential. To analyze the findings from both rounds of Delphi the benchmark article by Islam and Zunder (2014) was used.

9.3.1 First round of Delphi

The participants of the first round of Delphi represented the industry from a port, freight forwarder and researcher perspective. They contributed with a lot of information to gain results for the research questions regarding mitigation potential of digitalization for existing barriers. To organize the first round, i.e. the dialogue workshop, an analysis of the systematic literature review and semi-structured interviews was conducted. The results of the analysis of qualitative data emerged as five thematic grouped barriers and five grouped digital technologies.

In the dialogue one of the researchers acted as the facilitator of the workshop. The facilitator started with giving a brief presentation of the thesis and explaining the different barriers that had emerged from the semi-structured interviews and systematic literature review, including a brief explanation of the digital technologies that were to be considered in the dialogue. The workshop was continued by instructing the participants in picking one digital technology, in which they had to evaluate the potential in it to mitigate the presented barriers in front of intermodal transportation. Every participant was encouraged to contribute, and the dialogue was conducted with a port logistics perspective in mind. It took a total of three hours to conduct the dialogue workshop, including breaks. Simultaneously as the workshop continued, it was transcribed by the second researcher. The results were highly relevant and are reflected upon in the viewpoint of each thematic grouped barrier.

The only technology that all the participants reached a fully agreement on was for blockchain technology. Blockchain is used when there is lack of trust because it has full transparency and there is no possibility to change anything that has been uploaded to the platform, or blockchain. According to the participants, it is not a viable way of mitigating any barriers and will not result in a more efficient goods flow. Their opinion was that most organizations try to implement new 'fancy' technologies, which has emerged on the market to be first, not because it can be usable. Nevertheless, it is how the business world works and furtherly the opinion was shared that the technology as it is formatted today does not fit the purpose of mitigating intermodal barriers.

9.3.1.1 Price and cost for transport

There are various potential digital technologies that can mitigate the price and cost for transport barrier. IoT is seen as a technology that might not serve its purpose to the full potential and do not have, or very little, impact on mitigation potential. Therefore, big data and cloud logistics are mentioned as technologies which collects and process data that is more promising including more impact on reducing price and cost to benefit the environment and make society more aware. The participants discussed that collecting a lot of data is good, but an interface is needed since otherwise the amount of data gathered will be overwhelming and consequently it will not make sense. The ability to draw data that is of good quality and sort data, which is needed should be carried out by either a user or in the future by possible Artificial Intelligence (AI).

Data can also be used for route optimization, the idle mile for rail and road, which reduces the cost for transports. Big data could continuously serve the purpose for locating modes of transport to load goods on the return trip to the port, without having the major challenge with empty containers not being sufficiently or efficiently utilized. According to the participants there is a lot of insecurity in having inland depots, therefore the rail will not cooperate with road to make the best route. A virtual depot with the use of data can be a solution, but also networking and interface between different actors are imperative to use big data for creation of reduced transport price and increased flexibility. Highlighted in the dialogue was that you in addition to collect a lot of data, need to be able to send the same amount.

For cloud logistics it was discussed that it is a prerequisite for all other technologies to be used, as if you do not have data you cannot share it. There need to be a willingness to share data via cloud logistics in society, to understand how to connect data or transform it to something else. It is systems of systems, where all systems can be connected to each other via the cloud, the only challenge with it is how to interpret the different coding languages. Here, Ericson has a semantic web solution, which translates different coding languages so that different systems can cooperate in the cloud, including that the cloud understand what data is to be distributed or shared. For example, a terminal operator is not interested in what is in the container, only the characteristics of the container, whereas the customs want to know the contents, i.e. different stakeholders want different information or data, which cloud logistics can help with. All different applications described can reduce the barrier in the extent that stakeholders, e.g. avoid unnecessary operations, have different sources to trace data, make route optimization including making transports more environmentally friendly.

Applying sensor technology or digital identifiers to cargo has both its pros and cons, where trust issues especially in Sweden are not a concern for the organization. Therefore, technologies are more easily implemented and consequently more efficient processes, which reduce the costs. The participants meant that by applying modern technologies into an organization new data will open new doors, hence increasing trust. The use of various sensors or identifiers will make the system of goods transport more efficient and thus reducing cost. For high-value goods, e.g. RFID tags are used to track, but traceability and proof of delivery are parameters that are hard to receive since the system as it is now works, and sensors and identifiers are fairly expensive. In the dialogue, the 'linkability' of goods were mentioned as a solution for digitally make use of manual data or data that already exists, but not utilized. In addition, also to link the goods with one digital identifier or sensor to a specific ship, train or truck. Consequently, the 'linkability' of goods can make the transport less expensive.

A huge potential and enabler in saving costs for transports were according to participants, automation technology and its self-driving potential. Today, there are a lot of legal concerns of having, e.g. self-driving trucks, but in the near future they will save the industry a lot of money. In a port, automation also have massive potential for mitigation due to its labor-intensive operations. It was mentioned that most ports are concerned how they should improve their businesses, especially smaller ports, by expansion or change in physical infrastructure, such as deepening of fairways. No port mentioned how they could make their operations more efficient. Implementing automated infrastructure in ports can reduce costs due to less manpower needed and moreover increase reliability as there are no employees who will go to strike. Heavily investments will be needed to automate a port, but the cons of changing the business for the future must be added to the cost of implementation. The future changes in the industry will make automation a prerequisite for having a functioning and effective port with low costs. Participants stated that smaller ports have more time to adapt to increased automated port operations.

9.3.1.2 Capacity of transport

Big data has the potential to mitigate this barrier, however it all depends on how the information is handled. Knowing the information about the freight movement in the transport chain for instance, gives a possibility to adapt and build new services. Today, service providers are very optimistic, and they do not base any decision on data rather they make own predictions that goods volume will increase in certain areas, hence making investments. With the use of big

data, i.e. sufficient information, they would not make pooling arrangements or investments, rather make smart decisions based on tangible data. IoT could contribute to maintaining the infrastructure of rail through better connectivity and decreasing manual processes for maintenance, which would increase reliability of the railway transportation. Instead use of digital technologies and data to have sufficient information on when maintenance is needed. If IoT and big data applications are combined, they can enable sharing of accurate data, which will contribute to planning of railroad maintenance and optimization of routing of containers. Improved connectivity and information sharing between different actors will also eliminate unnecessary operations and expenses, such as transportation of empty containers, hence increase the capacity. Nevertheless, everyone in the supply chain wants to compete to gain the most market share and customers.

When the participants discussed cloud logistics related to the capacity barrier they reflected upon that for it to have a mitigation effect, there needs to be a dynamic sharing between cloud logistics and big data. Furtherly, other technologies such as sensors and digital identifiers can help avoid traffic congestion by real-time traffic monitoring. The participants mentioned cognitive sensors that can be used through combination of traffic prediction and statistical data, which will allow the container terminals (i.e. port terminals) to have information on when there will be congestion and adapt their operations accordingly. In addition, by evening out the traffic, hence decrease congestion, the environment is positively impacted.

Automation can help increase capacity and consequently save a lot of money by having, e.g. one pilot in a control center overviewing and managing several ships' operations for instance in coastal shipping. Pilots are a major cost for ships entering Swedish ports and automated pilots would increase efficiency and capacity. Handling a container ship with about 20 000 TEUs is heavy labor work, and a lot of time and money would be saved if it was managed by automation instead of manpower. Automation of port operations would increase safety for labor and consequently make faster operations as opening times for ports can be around the clock, this as automated technologies do not have legal resting hours. Nevertheless, automation technology such as automated gates can also extend the operational opening hours to around the clock, which subsequently can increase the amount of work done. Additionally, planning mistakes will be eliminated, which will also contribute to more capacity being handled and saved costs.

9.3.1.3 Flexibility of transport

IoT and big data can contribute to increasing information available for the shippers and intermediate terminals, so that they are aware of what is happening to goods in the transshipment chain as well as information about the port's capacity and inventory. Big data can, however, help predict and estimate different congestion and bottlenecks while also increasing transparency and reliability for customers. Utilization of this data will allow to predict certain unexpected situations such as strikes and help in avoiding traffic through predictive analysis and re-routing, thus making freight transportation more efficient and flexible. Predictive analysis and historical statistical data can help in making estimations about specific goods and predict possible problems that might occur, thus adapt the operations and perhaps re-route the transportation. Therefore, predictive logistics are according to the participants imperative for the industry to utilize efficiently to make transport flexible.

The transport industry is very slow and has very little appetite for futuristic thinking, hence big shippers are becoming more and more active in their choice of transport. Backwards thinking has always been the way of logic in logistics industry, innovation has not been the foundation

rather the need has been the starting point of production, but the trend is shifting. Predictive logistics, i.e. use of data, can make organizations use historical data to predict what flow and what product to produce within a certain time span. Distribution of data can be easier and faster if the foundation for communication or translation have been established for cloud logistics. The shared data in the cloud and exchange of information between systems will increase transparency, which in turn will increase reliability of transport, which is mostly important for port congestion and port operations. Congestion have been one of the major challenges, according to the participants, for organizations relating to stocks, as delivery has been hard to foresee and delivery continuously delayed. Cloud logistics is the technology that can be used to reduce the stock and hence increase flexibility. In addition, honesty towards customers is highlighted as imperative when it comes to reliability. Predictive analysis is imperative for cloud logistics, however, the first connection needs to be established in order to make use of data available.

The technologies, sensor and digital identifiers, can help with mitigation by tracking and monitoring, which will enable well-informed and faster decision making. Possibilities for smarter route choices, i.e. route optimization, can also increase with an ability to predict the location of the goods at a certain time, which is essential especially for truck drivers so that they, e.g. do not end up in a queue. Flexibility will also increase since automated systems will have the characteristics of thinking for itself and the potential of self-learning, possible AI.

9.3.1.4 Communication and Business models

Big data is correct data where organizations seek to collect data that are directed as correct towards their business. Since there is a lot of competition on the market, the participants highlighted that two organizations within the same field of operation will probably not communicate their data or information in-between. For example, two rail companies will not share, but maybe a shipping and rail company will. Consequently, all organizations related to intermodal transportation have their own set of data, which is rather small data collections. Therefore, it is important to internally integrate the organizations horizontally to facilitate sharing of data. The main barrier is that the industry is not getting any closer to a big pool of data, even if some organizations share their data there are no specifications, which is needed to make decisions. There are some shippers that want to share big data to make their transports more efficient, resulting in that the proprietary view of data is slowly changing to a more sharing of data. Business models of organizations will also have to be modified since the demand for transports transform, which encourages change for future societal needs.

With physical infrastructure it is easier to point out an owner, but for abstract infrastructure, such as cloud logistics, it is harder to pin-point a responsible actor. The participants highlighted that there has to be a supplier of the technology, someone that builds it, as clouds connect to each other to form bigger clouds and someone needs to construct that connecting cloud. Ericson has a solution which is a semantic web, but when organization decides to use cloud logistics it will implicate changed business models. A question is whether organizations are willing to invest in a cloud and hence their business. Transportation is a conservative industry and the implementation of new modern technologies can be reluctant as the current system, according to the participants, works fine. Sensor technologies or digital identifiers have a very modern application and organizations want to utilize them, but as in part 9.3.1.1, maybe there is no need to have each consignment marked with an identifier or sensor rather one for the whole transport mode e.g. a ship or a train and linking the goods, i.e. ‘linkability’.

By applying automated processes to intermodal goods transportation and port logistics, communication and business models will be modified. Therefore, as society is rapidly changing, with alterations in demand and supply, a thorough investigation of automation technologies is needed. Manual processes and the old-fashioned industry will embark on a journey of transition to cope with increased goods flow to keep up with trends.

9.3.1.5 Time of transport

When the participants reflected upon the barrier of time, it was more or less incorporated in the previous barrier discussions. Time is a very abstract barrier that has the potential of being mitigated by all of the technologies mentioned in this thesis, maybe not to a full potential but medium, i.e. partly. Big data is highlighted to be used for re-routing and maintenance of goods and infrastructure where time for transport can be reduced. Planning is also relevant concerning use of collected data since seasonality impact travel time for ships on certain routes and its predictive logistics can be used to increase transport efficiency and hence reduce time. As cloud logistics is said to be a prerequisite for IoT and big data, the possibilities of using clouds for exchange of information to conduct route optimization for shorter travel time is important. Nevertheless, transit time is not the imperative factor that is discussed today rather the reliability of the transport since shipping is a very unpredictive transport mode and therefore transport time of the sea transport has an accepted delay margin. Since forces of nature are very unpredictive, customers are more focused on reliability of the transport and logistic providers need to indicate the reality and be honest.

Using sensors or digital identifiers to mitigate time was highlighted for the on-time delivery where real-time information of goods whereabouts can increase efficiency hence reduce time. Automation technology can reduce time by making planning easier as e.g. automated gates can keep the port open around the clock leaving port operations to be carried out at times that are most suitable for transport providers such as rail, road and sea since all processes are automated requiring little or no personnel.

Table 9: Summary table of results for Delphi round one

	Price & cost for transport	**Capacity of transport**	**Flexibility of transport**	**Communication & Business models**	**Time of transport**
IoT & Big data	IoT – little or no impact, but big data have high mitigation potential for route optimization	Medium mitigation potential, but more knowledge is needed	Uncertain level of mitigation potential for near future	IoT not mentioned to have potential, but big data has medium mitigation potential since the level of competition between organizations decreases the sharing	Medium mitigation potential, as a consequence of better maintenance and possible re-routing time can be reduced for transport

Cloud logistics	Medium mitigation potential as it is a prerequisite for all other technologies to exist but there has to be a willingness to share data	There is mitigation potential, but need cooperation with big data to increase capacity	High mitigation potential where sharing of predictive logistics can decrease congestion and increase flexibility	Medium mitigation potential as it is a conservative industry and willingness to change business needs to be accounted for	Medium mitigation potential as where route optimization can result in shorter travel time
Blockchain technology	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Sensor technology & digital identifiers	High mitigation potential especially with e.g. linkability of goods to a bigger entity e.g. a ship which reduces the costs	High mitigation potential by using cognitive sensors to reduce congestion and make operations more effective	Medium mitigation potential where tracking and monitoring can enable faster decision making	Medium mitigation potential, linkability of goods for traceability (information exchange)	Medium mitigation potential, real-time information by using sensors can optimize time
Automation technology	Massive mitigation potential due to various autonomous operations and less reliance on labor costs	High mitigation potential where e.g. one pilot can manage several ships going in and out of ports by automated activities	High mitigation potential resulting from automated systems with self-thinking and potential of self-learning AI	Medium mitigation potential, as organizations will have to adapt to new trends in automation the business models will change	Medium mitigation potential due to automated processes where better planning can result in time-efficiency

In *Table 9* the low, medium and high mitigation potential refers to at what level the technology has potential to mitigate each group of barriers. A high mitigation potential technology has the ability to fully apply its features to mitigate, medium mitigation can partly remove the barriers, and low mitigation potential indicates that either it has very little application or none. The results from the dialogue workshop contributed with many different perspectives among the participants, hence they did not reach any formalized consensus in all thematic grouped barriers and applicable digital technologies. Therefore, it was imperative to continue with constructing a Delphi data collection form, i.e. a questionnaire, in where more stakeholders were addressed in order to increase reliability of the mitigation potential of digitalization and to reach further consensus.

9.3.2 Second round of Delphi

In the second round of Delphi the data collection form, see *Appendix D*, was developed by using the analysis of the first round of collected data where thirteen participants gave their valuable input, i.e. qualitative data, to whether any digital technologies had mitigation potential to our thematic grouped barriers. One of participants only answered the two first statements, which resulted in that thirteen people answered statement 1 and 2, as where in statement 3 to 7 only twelve people answered.

The results from the analysis of the first round created seven statements of whether digital technologies can mitigate barriers in front of intermodal goods transportation. Theoretically the statements were created following the methodology in related literature, but only one round of questionnaires instead of two, as the first round consisted of a dialogue workshop with expert focus, which underpinned the foundation for the statements (Islam & Zunder, 2014). The statements were, accordingly, developed from the first round of Delphi analysis. The participants in the questionnaire had the opportunity to reflect on the statements and choose whether they agreed, disagreed or were not sure about the mitigation potential. Furtherly, the questionnaire had the compulsory, qualitative, comment for participants to answer of why they had their particular opinion regarding the statements made.

Table 10: Consensus rate for policy Delphi round two

Statement	Number of agreements	Number of disagreements	Not sure	Consensus rate (percentage)	Consensus achieved
1	4	3	6	57	Divided opinions
2	12	1	0	92	Yes
3	11	0	1	100	Yes
4	10	0	2	100	Yes
5	7	4	1	64	No
6	9	0	3	100	Yes
7	10	1	1	91	Yes

In *Table 10* the results from the distributed questionnaires are visualized. The number stated in the first column in the table refers to its respective statement, as seen in *Appendix D*. Consensus was received when calculating the majority of agreements and the majority of disagreements, contemplating a consensus rate of 50 percent or more. Those statements that received a consensus rate less than 50 percent, were considered to not have reached a collective agreement or disagreement, i.e. consensus. In *Table 11* all data needed to calculate the APMO cut off rate are stated.

Table 11: Data for calculating APMO cut off rate

Total number of opinions	86
Majority of agreements	63
Majority of disagreements	9
APMO cut off rate (%)	84

Given the cut off rate of 84 percent the researchers can conclude that among the participants, the expert stakeholders, consensus was reached for statements 2, 3, 4, 6 and 7. In statement 1 and 5, where consensus was not reached, the expected outcome was not to achieve understanding whether the digital technologies could mitigate or not. Rather it was to gain insight in whether the statements made during the dialogue workshop regarding blockchain and IoT was correct or not. Therefore, the overall consensus regarding the digital technologies can be regarded as achieved, i.e. collective agreement that the digital technologies can mitigate existing barriers in front of intermodal goods transportation. To elaborate on the consensus rate and why the participants chose to agree or not on the statements, an analysis regarding the participants' opinions was conducted.

Statement 1: In this statement the participants were asked if blockchain had any potential in mitigating the existing barriers. The answers were very spread, which conclude that the opinions were divided. There was no majority on who agreed, disagreed or were not sure, therefore the researchers concluded, with respect to the cut off rate, that consensus was not reached. The participants had several comments about a possible or not possible potential for blockchain, where opinions ranged from that there currently are no practical applications for the technology to that it might work for some operations in the transport industry. Moreover, it was mentioned that blockchain should primarily be used in cases where there is an issue of trust between the parties, thus blockchain is not a technology (or approach) supporting the existing barriers identified. In addition, blockchain was mentioned as not being the main technology for mitigating the barriers, as it is always the investments that incur problems as none wants to take the risks. However, it was also mentioned that blockchain has the potential of being part of a solution, therefore more research should be conducted as it is too early to say whether it could or not, mitigate existing barriers. Lastly, it was mentioned that it can help synchronize at the links and ease up administration, but it is not a silver bullet.

Statement 2: In this statement the participants were asked if any of the digital technologies, except blockchain and IoT, can mitigate the barrier of cost and price for transport. The answers were very unanimously among the participants where all except one agreed, which resulted in that consensus of this statement was reached. There were many opinions stated by the participants and the one who disagreed mentioned that all technologies can help make the system more efficient, but it does not necessarily make the decision whether it is possible to start the transport or not. Furthermore, it was stated that the more insight organizations have of the transport, the better solutions. Automation was mentioned several times as having a big effect to reduce cost and price. Smaller terminals would have less time-dependent costs in terms of personnel, including the help to coordinate flows to make up for the amount of goods allowing intermodality and also to allow transport/handling at odd hours. In addition, self-driving vehicles can have an impact, but it is stated that probably it will reduce cost for trucking more than the cost of rail transports, contemplating that the added benefits for intermodality are less certain than the overall cost reduction.

Moreover, it was mentioned that through optimization of available transport modes, whether it is trucks, trains or barges/ships, the cost per transported unit can be lowered. The use of big data is practical for the purpose, which can be done on a small scale (intra-company) or a larger scale, but then there should exist a platform for data-sharing outside the single enterprise. Furthermore, availability of information was stated by a participant to have the potential to make the transport chain more efficient, which can decrease costs and administration of work. Additionally, when accessing a larger amount of digitized data with an interface able to sort

and interpret data, large savings can be made when arranging and executing transport operations. This by increasing larger transparency in the actual planning and handling of cargo. Lastly, one participant stated that the intermodal transport system is a couple of decades behind when it comes to use and adoption of these digital technologies. However, it is not just to implement the new technology, probably the human factor in adopting and using the new technology might be a larger barrier.

Statement 3: In this statement the participants were asked to decide whether they believe that all of the digital technologies, except blockchain, can mitigate the barrier of capacity of transport. The drawn conclusion from the results shows that consensus was reached among the participants. It was highlighted from the opinions given by the participants that technologies can mitigate the capacity barrier primarily due to better data, but also with the increased potential for decision making to support better resource utilization, such as filling grade and time utilization. Moreover, better planning can impact capacity, but it is an uncertainty as it would perhaps impact reliability more. In addition, one participant stated that transparency and knowledge in intermodal transport systems will make the planning process more efficient, which can result in more capacity. Furthermore, if there is a good technology, planning of rail can be more efficient, which could result in a better way to maximize capacity. With the utilization of digital technologies, it was highlighted that there is an added benefit of being able to more easily and correctly evaluate possible new rail routes/loops, including similar alternative transport solutions. Important to add, was that this is more the case of big data where overall transportation data is shared, than for single-company big data usage. Lastly, the more insight available of the transport the better solutions.

Statement 4: In this statement the participants were asked whether they believe any of the digital technologies, except IoT and blockchain, can mitigate the flexibility of transport barrier. The opinions among the participants were collective and consensus was reached for this statement. The opinions given stated that there are certainly potential for these digital technologies in being able to better predict congestion and other infrastructure issues, especially by the use of both sensors and big data. However, for rail transportation in particular there are not a lot of alternate routes which can be chosen if the primary route is congested, therefore to translate the information gained from, e.g. sensors and big data, do not have a very practical use. Furthermore, as larger quantities of data from different sources is becoming available for parties in a supply chain, there will consequently be a higher degree of transparency especially related to alternative transport routes. In addition, with more and better information, planning will be improved giving quick answers on, e.g. container movements in terminals and available spots. Lastly, it was mentioned that much of the rigidness of time plans, services etc., can be relieved using digital technologies, both at the supplier and transport buyer side.

Statement 5: This statement asked whether there is any uncertainty in IoT's mitigation potential towards the flexibility of transport barrier. The participants had various opinions regarding agreeing or disagreeing, resulting in that collective agreement or disagreement was not reached, i.e. no consensus. The reason for differing opinions was highlighted by the participants to emerge from the uncertainty of the technology and that there is a lack of knowledge amongst the transport companies. In addition, it was stated that IoT is still in the very early stages of development, but it might have potential to replace and/or complement sensor technology in the future. Thus, it is not yet clear how useful or widely used IoT will be. Nevertheless, some participants mentioned that IoT do have potential as it will provide possibilities for better planning and operations, resulting in flexibility. However, it depends on the willingness of sharing and on the system level in which the goods are transported. Lastly, a participant

declared that there are not many consignments at the level of unit load, maybe 70 per train, but IoT can help controlling the flows on the level of item/parcel/pallet inside the unit loads, which contemplates that there is potential for IoT as a mitigation technology.

Statement 6: In this statement the participants were asked if they believe that any of the digital technologies, except IoT and blockchain, can mitigate the communication and business model barrier. Some of the participants were not sure of the mitigation potential, but the majority agreed which resulted in achieved consensus. Many of the opinions emphasized that business models need to change, but it is not as easy as it may look. The traditional elements of the logistics industry will not necessarily become more susceptible to change because the conditions for change are made clearer, even if it would be preferred. However, when the benefits in the form of cost savings or increased reliability become too big to ignore, then changes would be more apparent but not necessarily in the earlier stages. In addition, it was mentioned that there might be untested business models and sometimes it can be good that someone from the outside try to drastically change a business, but often new business models fail to regard all aspects of the problem. This is particularly evident if big players with huge investments are not onboard. Furthermore, business models can, as mentioned by a participant, remove certain work processes by easier access to data, ultimately lowering the overall cost for transport, including other applications of smart business models. Additionally, logistics is not only about connecting stakeholders and to optimize flows.

By some participants communication was seen to be partly overcome by using technologies for the integration of systems into the supply chain, i.e. improving communication between different parts in the logistics chain. The systemized communication could help reduce administrative burdens of re-typing information, by consequently using original information sent from the source of data, i.e. shippers' unaltered data, throughout the chain of communication to the final receiver. Lastly, information gained from technologies will enable better planning and new business models, but it depends on how the information is used.

Statement 7: In this statement the participants were asked to decide whether they believe that all of the digital technologies, except blockchain, can mitigate the barrier time of transport. Consensus was reached, and the participants' opinions varied a little stating both that digital technologies have benefits in affecting time, but that there also exists limitations. One participant declared that technology could speed up terminals, but that they are constrained by other factors such as time tables, hence time being fixed. Moreover, transport operators are aware of the arrival and departure time of e.g. rail, and the flexibility will only be available when building a new transportation line, contemplating schedules to be fixed. Additionally, a participant stated that the potential for reducing time is limited, but the primarily reduction would be in introducing new services as a result of mapping cargo flows, which identifies where a service need is not currently being met, i.e. creating a new rail route or similar. However, there are further benefits with the technologies, such as the opportunities of having better information available for proactive decision making. This by gaining better knowledge of alternative routes and streamlining in terminal operations, large time gains can be achieved. In addition, time would be decreased as planning processes could be improved and more efficient, resulting in that actors could gain more awareness about what happens in the transport chain, i.e. transparency. Finally, one participant declared that this is one of the main areas for technology improvement. Planning better and combining flows for higher frequency and shorter time at nodes, rather than faster transport, will help by allowing larger and slower modes, in the sense of total transport time.

10

Discussion

The purpose of this research was to identify barriers that intermodal goods transportation faces today and if any digital technologies can have mitigation potential in order to develop a sustainable mobility flow through port logistics. After conducting the systematic literature review and interviews with stakeholders many barriers in front of intermodal goods transportation was identified. Some of the results from the literature and interviews differed, whilst some of the barriers were overlapping. In the Delphi study, consensus among stakeholders was found regarding digital technologies that could implicate mitigation for identified barriers. It is important to highlight that from what the researchers have found, no existing research has the same perspective or broad application of identifying digital technologies that can potentially mitigate barriers of intermodal goods transportation. Therefore, the research conducted could contribute with a new insight into the problematics with applying digitalization to an industry that is often referred to as conservative.

In the following, findings from the thesis are discussed and firstly, the complexity of current barriers facing the intermodal goods transportation and the supply chain of port logistics are discussed. The discussion will further be continued to reveal mitigation potential of digitalization, which is the relation between the barriers and digital technologies. This is followed by an examination of the methods used for data collection to disclose the imperativeness of conducting efficient and sufficient research. Finally, the implications of this research are discussed in relation to further research.

10.1 Barriers against intermodal transportation

With respect to the first research question it was revealed by this research that intermodal transportation faces various barriers. After analyzing the results from the literature and interviews it came to the researchers' attention that the barriers found are quite similar, contemplating that the differences tend to be communicated in a varying style, i.e. wording. The barriers that were most often discussed in literature and interviews are viewed as the greatest issues in intermodal goods transportation.

In this research, it appears that cost and price of transport are key factors that affect the modal choice, which puts extra pressure on intermodal transportation. The price and cost issues as discussed by Behrends (2015) and Bergqvist and Monios (2016) seem to have emerged from additional movements at the interfaces of the different transport modes, as well as by the extra handling of goods in port terminals, such as repacking, customs handling and registration. In addition, Heaver (2011) stated that increased movements in terminals could be impacted by the retained ownership between the ocean carrier, warehouses and port terminals, since the goods consequently will be owned by various actors. Furthermore, intermodal rail/road transport suffers due to competition with road transport, which is highlighted in numerous papers, such

as in the ones by Bärthel and Woxenius (2004), Woxenius (2007), Bontekoning and Priemus (2004), Winebrake et al. (2008) and Woxenius, Persson, and Davidsson (2013). It was indicated in literature that rail transport only gains competitive advantage in cost over road transport when it comes to transporting large volumes over short distances or over long distances. This research gives further support to this perspective by providing that rail in fact becomes a much better option for transport when it comes to either larger volumes or longer distances, which additionally appears to be a common opinion among rail and port operators as well as freight forwarders. In comparison, rail transports' higher start-up cost makes it an unfavorable option when transporting small volumes over short distances. On the contrary, making road transport, which has lower start-up cost, the most affordable choice on the market. From the empirical evidence the issue of road transport being cheaper than rail was found to be highly undesirable since road is seen as one of the more unsustainable modal choices. Moreover, the research also indicated that due to the cost differences and the uncertainties for rail companies to gain reliable customers with a constant goods volume, rail is seen to be in great competition with road transport. In addition, it was found that compared to sea transport, rail transport has a superior competitive advantage as sea is incurred with extra shipping costs.

Road transport is not the most sustainable mode of transportation, yet according to the research findings customers appear to be reluctant to pay extra for green solutions, which is further supported by Elbert and Seikowsky (2017). This indicates that sustainable options need to decrease in price to become the most preferred modal choices, as being environmentally sustainable must be easy. A similar finding discovered through this research was that road transport is both bad for the environment and has negative effects on the working conditions, i.e. no fair working conditions, which leads to a great need for green transportation. However, as mentioned in both literature and from the empirical evidence, the modal choice always depends on the price. One interesting finding was about costs, suggesting that a cost-efficient way should be found, such as establishing a way to find the required information with use of a digital application, such as sensors. The problem is that these types of sensors already exist, and they are available especially for the rail transportation, however, the organizations do not want to pay extra to improve a system which in their opinion works fine. Furthermore, higher costs for intermodal transportation appear to result from some unnecessary operations that could be eliminated by the use of digitalization. After having analyzed all results, the research indicated that one of the options for making rail transport a favorable choice, is perhaps by decreasing its cost and managing the logistics in such a way that majority of routes are only over longer distances, thus making road less desirable. Besides the price and cost, capacity appears to have a lot of influence on the performance of intermodal goods transportation.

Capacity was in general discussed as a barrier, however, rail capacity has received extra attention in literature and during interviews, as majority of capacity issues are generated from the challenges of creating an efficient and sustainable land transport network. From Woxenius et al. (2013) and Behrends (2015) railway connectivity, linking of ports, is seen as insufficient, hence an issue as the rail infrastructure is not sufficiently expanded, which forces rural areas to depend on road transport, which is not regarded as a sustainable option. The challenge of having an insufficient rail capacity, theoretically and practically, was stated in the empirical findings to emerge from having capacity available at the wrong time. There is a need to increase capacity both related to infrastructure and time, which can be achieved through increased investments. Furthermore, it was found by the research that rail infrastructure is not maintained sufficiently due to former state owned system, which when transitioned to the current private owned system led to lack of incentives to maintain a well-functioning rail system. Moreover, an important point revealed by this research was that slow handling time puts strain on the rail capacity, an

example of which is the Swedish Transport Administration's system, which seems to have a very old-fashioned and manual approach to scheduling as well as responding to customers. It was also indicated by Behrends (2015) that rail service providers put more effort in offering a sufficient rail network where most volumes are being transported, which results in a concentrated network which raises difficulties in utilizing the intermodal rail/road transport.

It is interesting to note that in regard to the practical insufficiency of the rail capacity and its infrastructure, there are no side tracks for longer trains to utilize as waiting area leading to no capacity for increased rail utilization. Furthermore, this research revealed an interesting point, which is not mentioned in literature, that it is difficult to demote public rail transport in favor for increased capacity for goods transportation, which is yet another issue. However, the findings from the current research further reveals that in Sweden the national transport administration has started to prioritize goods transportation over public, thus only during night time since it is when these transports take place. Nevertheless, it seems that the capacity in ports is also an issue where the goods flow is hindered by bottlenecks, which is supported by Rodrigue and Notteboom (2009) and Woxenius and Bergqvist (2008). These bottlenecks seem from this research to be caused due to the fact that shippers and logistics providers use terminals and warehouses for temporary storage, i.e. intermediate storage function, as it is cheap, which leads to delays and capacity constraint in the supply chain. In addition, it was indicated by Woxenius and Bergqvist (2008) that the higher demand for goods and bigger ships entering the ports make the subsequent land transport paralyzed to the fact that a lot of goods need to be handled. On the contrary to literature, this research found that bottlenecks depend on terminals' handling time being too slow, rather than having too much goods to handle. Furthermore, through the empirical research it was stated that the large volume of goods is an issue for trucks due to the road infrastructure and related congestion, including the smaller volume the trucks can transport compared to rail and sea. This is a different perspective in comparison to literature, as it suggests rail transport being at a competitive advantage in handling large volume of goods unlike road transport. This result may be explained by the fact that rail infrastructure has boomed over the past 15 years, resulting in that a majority of the goods leave Gothenburg port on rail.

Congestion in ports is similarly caused by insufficient information flow, leading to land transport carriers and ports not having the proper information of the arrival of the goods. Tsamboulas et al. (2007) highlights that planning in regard to allocation of manpower and scheduling of work in port terminals is a major problem, which seems to be connected to poor communication and cooperation between actors in the supply chain. In addition, congestion tends to be a result from lack of communication, where different actors in port logistics do not have sufficient information on when road transports will arrive in the port, hence causing port terminals not to have sufficient manpower at the correct time. This is supported by Roso (2013) who highlights that from a seaport perspective, road congestion and insufficient railway connections hinder an efficient goods flow. The empirical research further supports this perspective by providing that there is a need for a better information flow throughout the supply chain between different actors, such as suppliers or factory operators. Moreover, the research suggests that if an enhanced information exchange is established, intermodal transportation will become more transparent, consequently ensure a more updated and developed system.

Nevertheless, information sharing tends to be inadequate between actors in the transport supply chain, which due to market share competition leads to withholding of information, hence hindering cooperation. Evert (1994) supports the communication barrier and pin-points that information systems needs to be utilized even more for enhanced collaboration to reduce costs

and handling time of goods in ports. Even though it is crucial to improve and develop cooperation between actors, cyber security is another aspect, which was indicated by the empirical evidence in this research to cause difficulties for creating a joint platform or network for communication. Further, this research revealed that in order to improve communication, the current system needs to go back to basics while gaining an efficient information flow and providing the right type of information at the right time, along with the information required by the customer. However, it is indicated that communication must be established between all modes of transportation and in the whole supply chain of transport to gain an enhanced goods flow. Delays or early arrivals of goods by ships will impact the intermodal transportation, especially rail since the goods have to move quickly in and out of the railway yard. After conducting this research, it became even more clear that there is a need for an 'easy system', which can reduce work related to flow of information. Additionally, when it comes to the question of communication issues, this research contributed to providing that there is definitely a need for improvement in the current communication situation in intermodal transportation.

Last, but not least, time is imperative for customers, especially concerning the delivery of goods. According to Behrends and Flodén (2012) and Eng-Larsson and Kohn (2012), one of the greatest factors affecting transit time is the shifting between transport modes in the intermodal chain, which leads to extra operations for movement and increased waiting time. In addition, during the empirical research another interesting point was discovered, it regarded the fact that transit time is greatly affected by the waiting time that trucks faces outside the port to get serviced, which in turn increases their turnaround time. Furthermore, Elbert and Seikowsky (2017) highlights that decision makers are willing to accept the risks of loss or damage if transit time is faster, but important to emphasize is that shorter transit time only gives value to the customer.

Nowadays, it appears that the time for transport from shipper to receiver is not necessarily optimal due to time variations between the various transport modes, e.g. sea transport tends to take longer time and is affected by external circumstances, such as severe weather conditions. Consequently, this can lead to inability to meet the promised deadlines of delivery, therefore honesty about possible delays are crucial for logistics providers to disclose to their customers. On the contrary to the literature, an interesting finding during this research was that time is less of a barrier for shipping due to the longer distances the goods are transported. However, as the literature also mentions, this empirical research found that it is indeed important to be transparent and honest about the possible delays that may occur to consequently, increase reliability of the transport. Reliability was found to be in close relation to the transit time since transportation is seen as reliable if it delivers at the promised time or if the logistics providers are honest about the possible delays. An important point revealed by this research was that when it comes to reliability, there is no commitment from the customers, leading to rail companies having to take on all the risks. An example of this was provided during this research, when a shipping company turned out to be both a reliable and unreliable client to a freight forwarder depending on the inconsistent goods volume being transported.

Nonetheless, in regard to the first research question it was revealed from these findings that there are numerous barriers in front of intermodal transportation, such as cost, price, bottlenecks, congestion, lack of capacity, time constraints, and reliability issues. Therefore, to facilitate optimization of routes for faster transits, increase capacity for rail, reduce costs and enable communication, digitalization can be a useful mediator.

10.2 Digital technologies as mitigation

It appears from the research conducted that digitalization has gained more and more potential influence on intermodal goods transportation. With its various applications, digital technology can help make logistics processes more efficient, eliminate unnecessary operations and reduce transit time while reducing cost. Some of the digital technologies, however, did not seem to have significant impact on the identified barriers, which are blockchain technology and IoT. After the empirical research, it appeared that blockchain technology has very little or no impact at all because it seems not to have the right mitigation characteristics or a suitable platform for the current intermodal challenges. Moreover, it was indicated that transport companies merely considered blockchain due to its popularity on the market and not for its potential impact. Unlike the findings of this research, the literature has a different perspective on the blockchain technology. Risius and Spohrer (2017) discuss that blockchain technology has been developed for an application called 'smart contracts', which can be very useful for quick and transparent payments, and contract signing reducing the unnecessary paper work and time. The final results gained from the second round of Delphi indicated that there was no consensus on whether blockchain technology had any potential in mitigating the existing barriers as the results from the empirical research varied, i.e. divided opinions amongst the participants.

Furthermore, IoT was suggested to have some mitigation potential, but it had an uncertain applicability since the technology is in the very early stages of its development. In the literature it is stated by Chuang et al. (2017) that IoT can be beneficial for intermodal transportation since it will be able to connect the different interfaces in the supply chain and help in the decision making and monitoring of different processes. In addition, according to DHL (2016) application of IoT can help the intermodal transport system by increasing transparency, traceability and reliability in the logistics sector. On the contrary to the literature, the empirical results of this research were dissimilar. It was discovered that IoT has little or no impact on majority of the barriers or an uncertain level of mitigation due to its unknown future applications and absence of a sufficient communication platform, where IoT could be implemented. Moreover, an important point revealed by this research was that even if there is mitigation potential, a lot more knowledge of the technology and its characteristics is needed along with a communication platform in order for it to work. Furthermore, in the second round of Delphi, the researchers found that there is an uncertainty about IoT mainly due to lack of knowledge amongst the transport companies and that it is in an early stage of development, thus all the future benefits are yet not known.

However, big data which is in close relation to IoT was suggested by the empirical evidence to have a more useful application for reducing costs, increasing capacity and flexibility. G. Wang et al. (2016) brought up that big data can improve operational efficiency, help decision making process becoming more transparent and enhancing time efficiency. Benefits of big data for intermodal transportation were also mentioned by Y. Wang et al. (2017) who stated that big data can be useful since there is a demand from the customers to know their order status. In addition, big data will allow faster and better communication between the different intermodal interfaces. Further, the research corroborates the findings given by literature by providing that big data can help analyze, handle, collect and process information gathered, which was expected, however, an interface for the collected information is imperative as otherwise the amount of data would be overwhelming. Moreover, it was found that possible implementation of big data could be combined with cloud logistics, which indicates a possible effect if the communication platform could be stronger between the involved actors. Without solid collaboration or clear responsibilities for the implementation of digital technologies, no process

of the supply chain could be efficient or sufficient enough to support a feasible goods flow. Furthermore, this research discovered that predictive logistics could be a solution for most of the barriers by using historical data to foresee certain circumstances, such as strikes, real-time traffic and weather conditions. Additionally, the application of big data has a surprising potential to affect when it comes to increasing capacity, since that large amount of data could be the foundation to build new transport services. The final results reflect the empirical findings that big data can indeed be practical and useful for intermodal transportation, but there should exist a platform for data sharing and that there are issues in communication due to opposition between competitors. Thus, until there is a mutual desire to share information, big data might not reach its full potential.

The potential for sensors and digital identifiers to mitigate barriers is indicated by the research to be high. In literature, such as by Kubác (2016) and DHL (2016), it has been mentioned that main opportunities for intermodal transportation gained from these technologies are expansion of gathering, storing and providing of information. It has also been stated that digital identifiers give rise to better transparency and traceability of intermodal transport processes, while sensor technology allows real-time monitoring and controlling of logistics' processes. This research has found that various sensors, such as RFID and cognitive sensors, already have opportunities for implementation but it seems that actors within the intermodal sector lack incentives. On the market, many sensors and identifiers are available including some systems, which are already in place. However, the empirical evidence indicates that some of these systems are not yet utilized, such as the RFID scanners on the railway, which the Swedish Transport Administration has put up for rail companies to utilize. Moreover, they do not seem to have sufficient incentives to pay for the attachment of individual RFID tags on the rail wagons or containers. Further, through the empirical evidence, it was stated that applying this type of technology, many barriers could be mitigated, hence the industry seems to need changes in policies to gain incentives for their application. During the research, however, it was indicated that 'linkability' of goods could be utilized to keep costs low while having the opportunity to trace these goods as they are connected with one sensor or identifier throughout the whole shipment, instead of having individual tags for traceability, thus reducing costs. The results of this research confirm that sensor technology and digital identifiers have high mitigation potential by reducing congestion, making operations more effective and allowing better traceability of goods. In addition, an important fact revealed by this research was that these technologies can help with smarter route choices, such as route optimization, which could have great effect on the flexibility of transport and transit time.

Automation technology is one of the innovations in this research which is already being utilized around the world and continuous to grow, develop and gain further potential. Martín-Soberón et al. (2014) mention that utilization of automation decreases human involvement, which results in higher control of the processes, standardization of performance and reduction in costs for operations and human errors. The empirical findings of this research indicated that many automations seem to have mitigation potential, but for some, such as self-driving, the regulations and policies have been an obstacle for increased implementation. Nevertheless, it is also indicated that these regulations and policies can be overcome, and that self-driving will induce many savings, such as less reliance on labor costs, for organizations within the transport industry. Moreover, automation was discovered to apply additional benefits to intermodality and port logistics, in excess of decreased labor costs, such as having the possibility to have a port open around the clock enabling more operations, resulting in efficient goods flow, and further by reducing the risks of strikes and work-related accidents. Furthermore, this research revealed that investments are needed to rebuild port infrastructure to apply the automation that

is indicated to make port operations more efficient. Thus, actors in the supply chain seem to have no or very little incentives to make investments since the immediate costs are immense, and why change a system that already works sufficiently. Unfortunately, the empirical findings also indicated that the potential development is not seen due to the fact that investors tend to concentrate on the downfall of the start-up costs and consequently oversee the future benefits of this technology. Moreover, it is likely that the human factor is more of a barrier than the old-fashioned industry itself, indicating that the adoption and usage of the technology by actors might have more impact on why there are lack of incentives. The results of this research indicated that automation technology has massive mitigation potential and that it appears to be the most promising technology, as long as organizations are willing to adapt to new trends in automation and change current business models.

In addition to the digital technologies mentioned in this research, the findings further contributed with the indication that customers of transport and shipping companies have a need for an integrated solution from the initial purchase of the product to its delivery at point of destination. Today, there are few actors that work with providing a complete integrated transport solution for goods, i.e. chain of sustainable transportation, but with digital technologies, an integrated approach could probably be established. For freight forwarders it is imperative to stay ahead of competition and be relevant to their business, where the company needs to offer something that no one else can, i.e. digitalization beyond digitalization. However, after conducting this empirical research, it appears that there are always issues with digital technologies and their applicability to each process, as no current joint system for cooperation exists to have a transparent supply chain. Therefore, many freight forwarders see the necessity in changing their business to facilitate the future needs of the society.

Finally, this research set out with the aim of mapping the barriers in front of intermodal transportation and the potential of different digital technologies to mitigate existing barriers identified. Consequently, in regard to both research questions it was revealed that there are various intermodal transportation barriers and that they tend to be dependent on one another. Furthermore, this research contributed to discover the possible mitigation potential of the studied technologies, which are also interconnected with one another when it comes to their implementation.

10.3 Implications for theory, practice and policy

The researchers of this master thesis have only solved a part of the challenge in identifying mitigation potential of digitalization to existing barriers within intermodal goods transportation from a port logistics perspective. The researchers took a holistic approach in identifying the challenge, therefore a more in-depth approach could be useful to be able to see the full potential of the innovative implementations. For future studies it is suggested that theory, or the agencies funding research, needs to put more focus on research of digitalization to further understand its application as an approach to mitigation of barriers against intermodal transportation. Furthermore, implications for theory should be to include all modes of intermodal transportation in research since interconnectivity in port logistics is important for the efficiency of goods flow. This to further include the sea transport in research regarding sustainable options for intermodal transportation, as this research has found a lot of literature mostly considering the modal choices of rail and road. Moreover, prioritization need to be emphasized on sustainable transports in port logistics' interfaces to cope with the increased demand of goods to decrease the impact on the environment.

The implications for practitioners, i.e. transport industry, are to take action, as in both literature and interviews it was positively highlighted that digitalization is an approach that can be used to encourage intermodal operators to develop and implement new ways to increase their respective service utilization to the highest potential. The intermodal transport sector consists of rail, road and sea where implications for each transport mode varies. In this research the rail transport has been underpinned to have more theoretical capacity than practical, which implies that policy-makers need to change their transport network design in order to facilitate efficient operations. This since today's manual processes and long handling times for scheduling are not sustainable, hence with digitalization a more sufficient network could be created. Moreover, the decision-making processes for policies would be faster, facilitating the choice of more sustainable transport.

For all intermodal transport modes implications for future research would be to consider the underpinnings of the industry, since it is a very conservative industry many processes seem to be hindered, lagging behind or even being under-developed. Therefore, it is imperative that practitioners understand the importance in creating an efficient and effective goods flow throughout port logistics by applying the digital technologies that this research has recognized. However, another implication for practitioners is that actors, especially freight forwarders, within the intermodal sector should caress the idea of reliability of service times, since for transport it is imperative and customers value reliability of deliverance more than an anticipated, and faulty, delivery time. Moreover, implications for practitioners would be to focus on the transport supply chain, choosing another perspective than port logistics to include more actors, which might have valuable input in future research of intermodal transportation.

Nevertheless, all evident barriers implicate that theory and practitioners, as well as policy-makers, have a lot of challenges to overcome to efficiently create sustainable intermodal transportation. Business models need to change, communication have to be simplified to enhance collaboration, capacity and flexibility need to be improved to increase connectivity in the interfaces, and consequently costs plus price for intermodal transportation have to decrease to ensure that green transport solutions become a priority choice. This is facilitated by the implementation and future development of digitalization, which was indicated in this research to be an imperative implication. Probably, the transport industry will have a trial and error period where new digital solutions will emerge, be implemented and developed to significantly challenge the existing barriers in front of intermodal transportation.

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Conclusion

The challenges induced by the growing global trade, its subsequent increased goods flow and a constant development in trade patterns have put a lot of pressure on the transport industry. Consequently, congestion in major hubs, i.e. ports, around the world is a fact, which causes major consequences for actors within the supply chain. There is a demand for change and therefore, this research draws the attention to intermodal goods transportation with a port logistics perspective and highlights that implementation of digitalization can have mitigation potential for existing barriers. However, the path to a successful implementation is faced with various obstacles. First of all, there are a lot of barriers confronting the industry, which hinder an efficient flow of goods. It was discovered that barriers such as price and cost, capacity, flexibility, communication and business models, and time have major impact on intermodal goods transportation. Furthermore, the research identified that to overcome these barriers, digital technologies are imperative, hence possible implementation relies on incentives from the industry to make investments. According to the stakeholders participating in the research, digitalization, such as automation, big data, sensors and cloud logistics, can have major mitigation potential. However, IoT had uncertain function in the near future and blockchain was realized to have no application at all. Besides that, the possible digital applications can result in enhancements, such as increased communication and exchange of information between actors, reduced costs, trackability of goods throughout the whole transport and route optimization. Consequently, more emphasis needs to be put on making organizations within the transport industry aware of the importance in creating efficient goods flow throughout port logistics, i.e. choosing sustainable choices of intermodal transportation. Furthermore, the supply chain of port logistics should facilitate close collaboration between actors to create joint incentives and make investments in the transport system to facilitate mitigation of barriers with digitalization. Finally, it is important to emphasize that consensus was reached among participating stakeholders in regard to the mitigation potential of mentioned digitalization for existing barriers.

11.1 Limitations and future research

The limitations according to the researchers were not overly restrictive due to the fact that the area chosen focuses on intermodal goods transportation, which in itself is a quite broad subject. Therefore, public transportation has been left out of this particular research, hence goods transportation has many different modal choices and those decided to relate to this thesis are road, rail and sea. To choose three of the applicable intermodal choices was a decision made based on that air transport does not directly relate to port logistics, which is the main perspective of this thesis. In addition, the overall aim of this research is based on sustainable development hence air freight is excluded due to it having the most negative impact, which was also stated by stakeholders during the interviews. However, air freight can be an idea for further research to evaluate the need for faster transport among actors in the logistics supply chain.

In regard to the 'Climate strategy 2030', this research has had a limitation to a regional perspective, which might have been challenging at times since a lot of literature is generic and not specifically concentrated on Gothenburg port logistics. However, the generalizability of the references made it easy to apply all relevant information to reach a comprehensive result. The gained regional perspective was achieved through conducted interviews and subsequently a Delphi study. Furthermore, the number of participating stakeholders were limited to managers or researchers that had a direct connection to the city of Gothenburg, which might have affected the outcome. However, as the overall limitation was to Gothenburg port logistics further studies can be conducted by expanding the research beyond the regional limits to include national or European perspectives, and also to include stakeholders at different levels within organizations.

Digitalization is another broad subject which had to be restricted within this research to acquire comprehensible results and to conduct thorough interviews. Thus, the digital technologies that were chosen for the evaluation of their mitigation potential were initially limited to the digital technologies mentioned in the DHL and PWC reports, which indicates logistical improvements in transportation. However, in recent logistics literature these digital technologies, mentioned in the two reports, are getting more prominence, which are further described in papers, such as those by Strandhagen et al. (2017), G. Wang et al. (2016), (Xu et al., 2017) or Martín-Soberón et al. (2014). This limitation was also implemented because the majority of these technologies was highlighted in the interviews. Nevertheless, there are many applicable digital technologies that can act as a tool to mitigate barriers, hence further studies can continue discover and evaluate further mitigation potential of digitalization.

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Appendices

13.1 Appendix A

Barrier	Times mentioned
Price for transport	10
Capacity	10
Conservative industry	8
Flexibility	5
Mindset	5
Communication	5
Planning	4
Bottlenecks	4
Cost for transport	3
Railway connectivity	3
Administration	3
Customs	3
Systems do not cooperate	2
Time	2
Transit time	2
Business models	2
Lack of incentives	2
Maintenance	2
Sensitivity to external conditions	2
Transport time	1
Awareness	1
Transport buyers not interested in change	1
Policies	1
Last-mile delivery	1
Manual processes	1
Complexity of long-term policies	1
Legal aspects	1
Simplicity	1
Environment	1
Bookings	1
Technology adaptation	1
Economic risks	1

13.2 Appendix B

Literature	Barrier	Explanation
Woxenius, J. (2007) Intermodal freight transport network designs and their implication for transhipment technologies		
	Geography	
	Supply of infrastructure	They are all included as preconditions by the transport network design - no demand, no process design. There are in this article 6 different designs: direct link, corridor, hub-and-spoke, connected hubs, static routes, and dynamic routes, where dynamic is the most efficient since it utilizes actual demand
	Competition between different transportation modes	
	Character of transport demand	
	Viability of consolidation	"an active effort to more efficiently utilize transportation resources" - parameters affecting: consignment size, transport distance, transport time demand, product characteristics and availability of other goods along the route
	Reliability of transport	
	Infrastructure	Policy makers need to make decision in improving infrastructure so that for rail, the goods can move during day time
	Technical incompatibility	Moving goods from one transport to another can be an issue both domestically and internationally, a focus on exchanged resources, i.e. unit loads
	Funding	A less strict line between private and public funding

Sommar, R., & Woxenius, J. (2007) Time perspectives on intermodal transport of consolidated cargo		
	Consolidated cargo	Time! A strong prerequisite for using intermodal transportation
	Increased fuel prices	Congestion and more impact on the environment make shippers use intermodal freight transportation, where transport time and punctuality are the most vital parameters. This is why intermodality has not yet been more utilized (rail/road perspective)
	Higher demand of goods	
	Reliability of transport	
	Awareness/Consciousness	Environmental impact of different transports
	Time	For transport, punctuality and frequency
Bergqvist, R. & Woxenius, J. (2008) Hinterland transport by rail - a success for maritime containers but still a challenge for semi-trailers		
	Business model	"maximizing revenue by filling ships and then "fixing" the hinterland operations simply does not work anymore" (p. 1)
	Increased lead time and costs	Due to increased demand, bigger ships and bigger ports, where the hinterland does not catch the fast-evolving bottlenecks
Behrends, S. (2015) The modal shift potential of intermodal line-trains from a hauler's perspective: drivers and barriers in the mode choice process		
	Small volumes over short distances	Restricts the competitiveness of rail compared to road especially from the small volumes and short distances (less than 500 km)
	Price for transport	Due to the additional movements, a container needs to be put on a train, which causes additional costs and more time

	Railway connectivity	Rail companies have put more effort in those nodes where more goods are handled and carried between. Only provide services where the conditions are favorable, resulting in a concentrated rail network, making people living in peripheral regions rely on road transport
	Transport time	
	Mindset	An experienced decline in transport quality and reliability on intermodal services in recent years, therefore no high confidence on this type of service
	Business model	An alternative business model is needed in order to utilize the modal shift potential of rail
Elbert, R. & Seikowsky, L. (2017) The influences of behavioral biases, barriers and facilitators on the willingness of forwarders' decision makers to modal shift from unimodal road freight transport to intermodal road-rail freight transport		
	Price and cost of transportation	A decisive factor for the modal choice decision making. Shippers seeking the least cost paths for freight transportation. Price elasticity is more sensitive for rail/road transport than for road transport. Cost of intermodal rail/road transport decreases with a longer distance rather than for road transport. Fuel prices are also highlighted as it has more impact in road transport than rail. Economies of scale for rail as more goods can be carried over longer distances than road
	Transit time	Decision makers are willing to accept risks of loss or damage to goods if transit time is faster, thus shorter transit time often only give additional value to the customer
	Flexibility	An increasing popularity since there is an increased demand of logistics concepts like JIT and JIS (Just in Sequence). Rail/road transport is less flexible than road since the first is rail-bound

	Reliability	Some actors might be willing to pay more for transport if the service provider can ensure reliability of the transport; goods delivered within an agreed time frame
	Limited rail infrastructure	Absence of rail infrastructure in rural areas restricts the flexibility of rail/road transport
	Business models	
	Policies	Need incentives, political objectives to change the means of transport. Already done for road transport, but needs more to move towards rail and intermodal transportation
	Lack of standardization	Varying track gauges, transshipment technologies and loading units
	Complex coordination	Due to cooperation, revenue sharing and risk sharing
	Low willingness to pay for "green solutions" or environmentalism	
Behrends, S. & Flodén, J. (2012) The effect of transshipment costs on the performance of intermodal line-trains		
	Cost for transport	Rail only compete with all road transport when large volumes are transported over long distances. However, most freight flows are transported over shorter distances and/or are too small to facilitate a full train
	Reliability	Limited possibilities to consider a modal shift since the quality of transport is not reliable
	Policies	Policies aiming for incremental improvements in the rail system including charging policies on road transport have limited effect since there are no good option to road transport
	Transit time	Increases as due to many transport modes in the intermodal chain. The conventional methods used to move goods between the different transports need to change to decrease time
	Terminal concepts	To change the way a terminal work with its tools and techniques for moving goods is hard. There is an uncertainty among actors about the costs and benefits of implementing an alternative terminal concept

Eng-Larsson, F. & Kohn, C. (2012) Modal shift for greener logistics - the shipper's perspective		
	Transit time	Longer transit times when shifting to intermodal transportation solutions e.g. rail/road
	Delivery time	Lower precision
	Flexibility	Lowered related to the time perspective with schedules
	Damage to goods	Increased risk of damage to goods when moving it in-between different transport modes
Tsamboulas, D., Vrenken, H. & Lekka, A-M. (2007) Assessment of a transport policy potential for intermodal mode shift on a European scale		
	Terminals	There are not a sufficient number of terminals that can be used for intermodal transport
	Planning	Problems with allocation of capacity to jobs and scheduling of jobs in terminals
	Infrastructure	Unifying of intermodal transport infrastructure in Europe
	Digital technology	Developing a more user-friendly software supporting intermodal transport operations and services
	Cost and price of transport	
	Policies	There are limited approaches and no efficient policy that can be utilized to push for a modal shift – no effectiveness in making policies
Reis, V., Meier, J.F., Pace, G. & Palacin, R. (2013) Rail and multi-modal transport		
	Cost for transport	Truck transport are an almost linear cost, but for combined transport the cost is lower per km e.g. truck-rail-truck usage. Road transport has lower costs due to no transshipment points or maintenance of railway tracks, but for shorter distances
	Flexibility	Road transport is much more flexible than rail

	Legal	Different regulation in different countries, intermodality has not been part of the planning processes of existing infrastructure
	Planning	Planning times are too long in the political processes
Roso, V. (2013) Sustainable intermodal transport via dry port – importance of directional development		
	Bottlenecks	In the landside transportation from a seaport perspective where road congestion and inadequate railway connections hinder an efficient goods flow – in turn cause delays and raised cost for transport
	Cost for transport	Depends on volumes and distance
Bergqvist, R. & Monios, J. (2017) Intermodal freight transport and logistics		
	Transit time	
	Flexibility	Rail compared to road carriage
	Last-mile delivery	The role of the transport delivering the goods the last mile, to the retailer/customer
	Starting a rail service	It is very hard and complicated to start a new rail service. Therefore, hard for new rail companies to enter the market, which hinder intermodal growth
	Cost for transport	Rail has a very high fixed cost
	Cooperation between actors	Horizontal collaboration is not efficient anymore, vertical collaboration between shippers, rail operators and 3PLs are needed to gain higher quality and increased market share
	Conservative industry	High inertia when it comes to changing an existing logistics structure
Bergqvist, R. & Monios, J. (2016) The last mile, inbound logistics and intermodal high capacity transport – the case of Jula in Sweden		
	Cost for transport	Extra handling costs, and pre- and post-haulage costs that comes with using intermodal transportation, but also the increased cost for only the rail haul

	Reliability	Needs to be improved
	Transit time	Distance and speed
	Flexibility	Road vs. Rail
	Cooperation between actors	Trust, knowledge sharing, process integration and decision synchronization needs to be done for sufficient collaboration to increase intermodal transportation and hence lowering costs. Cooperation is also needed to achieve economies of scale
	Last-mile delivery	Distribution and pick-ups from shippers, intermodal terminals, are not coordinated, and road congestion is a problem including fuel prices. Normally is 25-40 percent of the total cost of intermodal transport, the last-mile delivery
Bergqvist, R., Falkemark, G. & Woxenius, J. (2010) Establishing intermodal terminals		
	Large-scale terminals	The terminals today are very big and intermodal transportation has problems competing for large flows over medium distances (200-500 km). There is a need for more small-scale terminals to make intermodal transport system an attractive alternative to single-mode road transport
Rodrigue, J.P. & Notteboom, T. (2009) The terminalization of supply chains: reassessing the role of terminals in port/hinterland logistical relationships		
	Bottlenecks	Goods are caught in ports since shippers and logistics service providers use terminals for temporary storage for their goods as it is cheap making terminals the main source of delay and capacity constraint in the supply chain – operational issues (storage space, port call frequency and gate access)
Heaver, T.D. (2011) Coordination in Multi-Actor Logistics Operations: Challenges at the Port Interface		
	Responsibility along the supply chain	The responsibility of the goods when ownership changes at port interface. Even with retained ownership, responsibilities

		changes between shipping lines, rail companies, warehouses, port terminals etc.
	Capacity	The capacity of ships, trains and trucks are somewhat different, and the discrepancies are widening since ships are becoming larger. Inevitable results are the increased pressure on terminal operations including the interface between different transport modes. In addition, also different practices among organizations, especially of working hours
	Communication	Inadequate information exchange between actors, coordinated logistics is dependent on visibility along the chain. This might be a result from the history when commercially valuable information was not shared, but today cooperation is very important so there is an inadequacy of communication and sharing
	Increased goods flow	Expansion of capacity has lagged, and the volumes have increased. Port terminals have put effort in intensively use land areas for container handling, but it has affected other resources for actors in the logistics chain
	Society	Increased road traffic has resulted in congestion, raised noise and emissions which can build up conflicts with society
Wilmsmeier, G., Monios, J., & Lambert, B. (2011) The directional development of intermodal freight corridors in relation to inland terminals		
	Cost	Criterion for choice of hinterland transport, the modal choice
	Competition	Competition between actors in overlapping segments
	Distance from ports	With the advent of inland terminals, inland ports and dry ports, hinterlands are now extended even further inland, adding to the complexity of the analysis of port economics and logistics activities

Bärthel, F. & Woxenius, J. (2004) Developing intermodal transport for small flows over short distances		
	Competition	There is a competition between intermodal transportation and road transport. The competition requires systems approach, good understanding of the competitive situation and cooperation between involved players
Wang, Y., Feng, L., Chang, H., & Wu, M. (2017) Research on the impact of Big Data on logistics		
	Lack of information	There is highly competitive and rapidly changing market environment, many problems are due to logistics providers lacking prediction of future market through data analysis, and they blind to increase transport capacity and storage area when they only see the immediate business growth. There will be a large number of surplus capacity and vacant warehouses when the market shrinks and the business volume declines, which will lead to the loss of logistics enterprises
Papert, M. & Pflaum, A. (2017) Development of an Ecosystem Model for the Realization of Internet of Things (IoT) Services in Supply Chain Management		
	Communication	Connectivity amongst different companies - too implement digital technologies, such as IoT, companies need to have free exchange of information at the interfaces in order to make it work
Rushton, A., Croucher, P., & Baker, P. (2017) The Handbook of Logistics and Distribution Management		
	Cost	It is a challenge to find the balance between the costs and customer service with continuously increasing demand for transportation services in today's industry
	Forecasting	With changing environment and varying demand, it is difficult to make certain predictions in the inventory and costs

	Transport infrastructure	Limited transport infrastructure is an issue for the complex flows of the goods transportation. Many companies use outsourcing as a solution
	Environment	Due to growing awareness and increasing pressure from the global environmental policies. Due to the demand for greener logistics there has been noticeable
	Congestion	Road congestion has brought a lot of challenges to logistical aspects such as just in time (JIT) and quick response systems
	Limited availability of appropriate management and labor	With all the increasing demands for goods transportation to be efficient and sustainable it is an issue for many managers to adapt to continuously growing and changing technologies, demands and policies
Bontekoning, Y. M. & Priemus, H. (2004) Breakthrough innovations in intermodal freight transport		
	Competition	Intermodal transport is in cost competition with road transport as it is currently remaining to be the main modal choice in the freight transportation. Road transport sector is dominated by many small companies which are not disrupted by long journey times and they are very flexible and cost competitive
	Efficiency	From the maritime perspective, centralized services could help in improving the efficiency of the processes. This can be implemented with reduced amount of calls, reduced waiting time at the terminals and reduced handling time
	Capacity	There are a few issues in the train system. Many parts of rail network and shared by passenger and cargo trains resulting in reduced capacity of the rail transport due to passenger trains being prioritized and cargo trains having a slower travelling speed
	Reliability	Organization, management and implementation of innovation systems can contribute to improving reliability of the intermodal transportation systems
	Transport time	Measures to reduce transport time in the rail transport such as shorter processing time, delay control, establish more

		transport relationships and higher frequency of services need to be implemented
	Independent networks	Many operations still use separate networks which means that transport between rail and maritime terminals requires extra handling operations and waiting time
	Lack of standardization	Because of long technical operations it is an issue for implementing automation of container transfer in railway
	Distribution of costs and benefits among the actors	The unequal distribution between rising costs at the transport centers and decreased costs between the centers is a great obstacle for implementing innovations
Blümel, E., Boevé, W., Recagno, V., & SchilkShip, G. (2008) Port and Supply Chain Security Concepts Interlinking Maritime with Hinterland Transport Chains		
	Transport security	It is important to manage security legislations together with technical requirements in the maritime and intermodal hinterland transportation. Maritime sectors have adopted security regulations whereas rail and road transportation systems have still not fully implemented all the regulations which results in a demand for innovative security strategies which include maritime and hinterland transport in one system
Evert, E. (1994) Knocking down intermodal barriers		
	Capacity	There is underutilized capacity in the railroad, feeder and short lines
	Capacity – terminal and operations	Terminals have a high cost and with establishment of many intermodal terminals operational efficiency will decrease as the costs will rise
	Information systems	There is a need for better utilization of information technologies to reduce costs and handling time in order to have better communication with the customers and different handling points about the updates on the freight transport

Walker, H., Di Sisto, L., & McBain, D. (2008) Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors		
	Cost	Consumers tend to choose the lowest price options which is a hinder for a more sustainable option which costs more
	Lack of legitimacy	Many companies are redundant to changing their operations towards a more innovative and sustainable ones
	Poor supplier commitment	Companies tend to not want to exchange information to avoid losing their competitive advantage
Johnson, H., & Styhre, L. (2015) Increased energy efficiency in short sea shipping through decreased time in port		
	Efficiency	Important to improve energy efficiency to avoid increase in carbon dioxide emissions. There appears to be an energy efficiency gap, gap between what is done and what is economically optimal
	Waiting time in port	Increased efficiency and elimination of unnecessary operations can reduce the waiting time
	Communication	Communication between ship operators, ship agents and crew are not well organized at times
	Turnaround time	
Lind, M., Brödje, A., Haraldson, S., Hägg, M., & Watson, R. (2015) Digitalisation for sustainable sea transports		
	Cost	Besides transportation costs, extra costs occur for the waiting time outside the port
	Distances	Longer distances sailed than necessary, a need for voyage optimization tool
	Environment	Environmental issues caused by inefficient transportation; a cargo ship travelling at high speed and in the end have to wait outside the port for hours to get serviced

Taylor, J. C. (1993) Remove barriers to intermodal		
	Efficiency	Need for utilization of most efficient mode at each stage of movement to decrease congestion, pollution, etc.
	Cost	Freight sector is mainly focused about the need for the intermodal transportation costs to be low that can deliver smaller and more frequent shipments in a reliable manner
	Competitiveness	
	Regulations	Regulations related to the intermodal parties' rights and obligations
Winebrake, J. J., Corbett, J. J., Falzarano, A., Hawker, J. S., Korfmacher, K., Ketha, S., & Zilora, S. (2008) Assessing Energy, Environmental, and Economic Tradeoffs in Intermodal Freight Transportation		
	Transportation distance	These barriers affect the choice of transportation and the route. There is a significant trade-off between them
	Time of delivery	
	Costs	
	Competition	Competition with road transport. Trucks hold a competitive advantage with time of delivery
Woxenius, J. (2012) Directness as a key performance indicator for freight transport chains		
	Infrastructure	These barriers are the reasons for not choosing the shortest path
	Traffic	
	Cost	
	Consolidated goods	
	Regulations	Effects travel distance, adds subsidies to services and certain restrictions for transportation
Woxenius, J., Persson, J. & Davidsson, P. (2013) Utilising more of the loading space in intermodal line trains – measures and decision support		

	Railway connectivity	Insufficient
	Loading space utilization	This highly underlines the profitability if intermodal transportation
	Competition	Intermodal transportation is in strong competition with all-road transport which leads to companies not being able to leave many empty wagons in the train
	Information sharing	Needs to be improved in order to be able to assess measures that need to be taken for improvement in the intermodal system. This means actors need to be involved, such as transport buyers, freight forwarders, road haulers, terminal operators and rail operators
	Capacity (rail)	Rail transport capacity needs to be adapted to the current demand including frequency of departures and number of wagons in the trains

13.3 Appendix C

No.	Stakeholder	Type of Business /Organization	Perspective	Barrier	Explanation
A	Researcher	Research institute	General		
				Flexibility	Willingness for change; a system that works why change it? Most probably a risk is inevitable
				Transport time	Depending on transportation mode, time is imperative for end-customer
				Price for transport	Truck transports are cheaper than rail, make rail (a sustainable option) more competitive
				Sensitivity to external conditions	e.g. weather
				Maintenance	Especially for rail infrastructure, expensive repairs due to poor maintenance in the past
				Transport buyers not interested in change	Not interested enough in the environment, "being environmentally sustainable must be easy"
				Awareness	Society awareness about environmental impact that transportation has, buying from far East and transport it by air freight due to time efficiency needs to stop - no awareness
				Administration and Paper handling	Refers to the huge amount of papers that are used in the industry as well as legislations
B	Manager	Cooperation platform for transportation	General		
				Conservative industry	

				Lack of incentives	Why make changes, when things work sufficiently or satisfactory?
				Business models	Business models are sensible for organizations, it takes long time to utilize them to full extent and there is a need for a functional one for efficient use and development
				Policies	Not enough to give incentives to organizations in implementing new technologies for sustainability
				Last-mile delivery	Goods flow consolidated
				Inflexible city planning	Freight transportation is not highlighted when building or changing infrastructure
				Manual processes	Makes digital incentives disappear as no one utilizes them
				Systems do not cooperate	
				Complexity of long-term policies	Hard to know what the future desire
				Administration	Communication
C	CEO	Maritime research, innovation and development	General		
				Lack of incentives	There are no incentives to go by any other mode than rail, rail capacity has increased due to more goods being transported on rail - if it is possible to cope with expansion in rail why not also in shipping?
				Price for transport	There is a cost difference due to other costs that are incurred for shipping, making rail more competitive than ships
				Maintenance	Heavy trains due to goods transport; poor maintenance in the past
				Capacity	Increase capacity on rail by making investments so that the railway can cope with heavier loads
				Reliability	Society needs to rely on efficient and sufficient transportation system, no one wants to have increased travel time due to goods transportation on rail during day-time

				Conservative industry	
				Legal aspects	Different for different transport modes
D	Manager	Port facility	Port logistics		
				Price for transport	The price for truck transport is too cheap, including that it is an unhealthy market with no fair working conditions for drivers. More green transports are needed, but it always depends on the price. When the distance is about 300 km or more the other modes become cheaper than truck including if there is a big volume of goods for shorter distances, and also about 20 containers (TEUs) or more needs to be transported to make it cheaper than truck
				Flexibility	The other intermodal modes of transportation, except from truck, are inflexible (rail and sea)
				Mindset	Who to call in order to get a container on rail instead of truck, the need of simplicity and also lazy people. 3PLs need to be better in knowing and providing all modes of transportation including rail in a more cooperative manner - solutions should be integrated. Everyone has their minds set in that everything is difficult to accomplish or start up - most people want simplicity. Most people are more focused on where the product or service is produced, not how it makes it to the retailer. Rail is not reliable - common mindset in society. Goods transport by rail is more reliable than public transport and truck. About 98 percent on-time deliveries by rail to port.
				Bottlenecks	At the moment it depends on terminals moving too slow, rather than having too much goods to handle. For trucks it is an issue concerning road infrastructure and related congestion including the lesser volume trucks can carry compared to rail and sea. Rail infrastructure has bloomed over the past 15 years and today about 50 percent of the goods from port leaves on rail.
				Time	For container trade it is not a critical factor, but for semi-trailers it is more critical since the goods coming into the port has travelled less time, from Northern Europe only, and delivery expectancy is faster.
				Customs	There are duties/taxes to get goods out from the port which entitles a lot of paper work for every goods entering the port to various destinations in

					the hinterland. A more hands-on solution to increase goods flow would be to implement duty-free zones and move customs handling to an integrated port which collaborates with the receiving port.
				Capacity	Rail infrastructure is old and in need of development, investments need to be made. The poor rail system is a downside of de-regulating the market after state monopoly as many of the today's small actors utilizing the rail are more interested in profit than investing in development - none has the incentives to maintain a vial railroad.
				Conservative industry	Especially shipping, where more and bigger ships are being built creating a competitive market where shipping companies builds even bigger than their competitor, but soon it will come to an end. The competitiveness of having the biggest ship will come to a point where they are too big to handle in ports.
E	Researcher	Academia	General - more rail		
				Time	Less of a barrier to shipping contemplating the longer distances the goods move, this is related to transit time.
				Price for transport	Rail has lower running costs, but the startup costs are higher due to more lifts than for example truck where it is the opposite: lower start up, but higher running costs. Can be managed by going longer distances with high volume cargo, as then both rail and sea will be more competitive than truck.
				Flexibility	When carrying goods on road, the transport will accommodate every demand of your choice. Rail is built on scale benefits; there are scheduled departure and arrival, including a booking which is needed to get a time slot. If this procedure is missed, then the delivery will be delayed.
				Simplicity	Transport buyers want everything to be as easy as possible, things have to be easy - people are lazy. The simplicity depends on the structure of the demand and system of transport: saving-planning-comparing. There is always motivation in what people do, and sometimes it is laziness.
				Capacity	Rail infrastructure is not sufficient enough, no side tracks for longer trains to wait, equals to that there are no capacity for increased rail utilization. Not easy to downgrade public transport to make way for goods transport - prioritization.

				Bottlenecks	Created as there are a lot of goods moving out of the port on rail.
F	Manager	Freight forwarder	Freight forwarder		
				Railway connectivity	Need of reliable connection to and between ports. In smaller ports there are not sufficient railway network to use rail as an option of transportation.
				Transit time	Transit time is not really relevant when it comes to cost, maybe for the inland transport segment when the transport moves further north and cost for container rent increases if its overdue or delayed - because when transit time is more than agreed, costs increases. If a transport mode has a transport time of more than two days, it will be exempted (related to domestic transports within Sweden). This as the overall transit time increases for the shipment of goods. In Uppsala/Gävle a line is drawn whether transit time will incur too much costs or not to get the container back to port of origin in Sweden. The irregularity of sea transports impacts the transit time, delays due to direct calls or feeder traffic can hinder an efficient flow.
				Price for transport	Price is key when choosing type of transport.
				Customs	Not on the forefront of digitalization, still uses fax.
				Capacity	A lot of capacity in port of Gothenburg, they could increase work to utilize it more efficiently. Cancellations of rail services has also been an issue, today no one wants to start up a service as it is both time consuming and expensive. It is really easy to get interested customers for a new rail service, but hard to get them committed.
G	Manager	Logistics provider	Freight forwarder		
				Communication	There is a need for information from someone in the supply chain e.g. supplier, factory etc. If there is sufficient info e.g. shipment info, transport will be facilitated with importance to communication. Some customers have scheduled pick-ups which do not require any booking information, there communication is important.
				Planning	Good planning results in a successful business. Transit time will not matter as much if sufficient planning is done e.g. spare part hubs can be

					located for e.g. Volvo, in Europe to minimize long-distance flight which is environmentally unsustainable.
				Environment	More education is needed to the society, some customers are willing to pay for green transport solutions but not so many. It is not easy for transport companies to lower the price for green solutions as demand is created by more customer using it, not easy but an ongoing process. It is also important to involve subcontractors into the organizational goals for greener solutions. The reason for companies not choosing environmental options can relate to poor knowledge and a non-committed top management.
				Mindset	The constantly growing e-commerce business offers free deliveries and free returns, increasing the number of packages in rotation. No awareness amongst society that there are unnecessary movements of goods due to the huge amount.
				Price for transport	Is of outmost importance.
				Bookings	The transport companies located domestically do not know where the goods are when it is shipped from Asia, not until it is being handled in the port a booking kicks in and they get an order to pick-up delivered goods in the port.
H	Manager	Cooperation platform for transportation	General - more rail and road		
				Systems do not cooperate	
				Communication	Go back to basics, gain an efficient information flow and providing the right type of information at the right time including what information is needed or asked for from customers
				Cost	Find a cost-efficient way to find the information needed e.g. the technology of sensors that the Swedish Transport Administration has put up along the railway system and which is not utilized since organizations does not want to pay for something that works fine.
				Administration	Related to information and planning - with proper information handling

				Conservative industry	Inefficient work in the port leads to increased costs - information disappears and the problems/issues need to be solved in the port.
				Bottlenecks	Planning is the key, today probably many cargo owners does not get their cargo directly when it arrives in the port as they most probably see the port as an intermediate storage function as they cannot handle it on their own - too much goods in the hubs. The need of sufficient information flow is imperative.
				Planning	The port needs to know the amount of goods that will come into the harbor to plan for employee schedules etc. Information sharing, i.e. communication, is imperative for planning. Without sufficient information the movements will stop sooner or later. Could be automated by using event regulated techniques e.g. that info will be sent to the transport company in the exact time when the goods are moved from the arrived ship so that the intermediate storage will be shorter. Information should be available before the goods to be able to PLAN.
				Mindset	Everyone believes that everything should move fast, that a ship takes about 40 days before it arrives in Port of Gothenburg society do not mind, but the delivery time from port to home should be conducted within the hour. People need to understand better to be able to have a sustainable approach to transport of goods.
				Sensitivity to external conditions	The climate makes it difficult to have sustainable transport in the form of electrical road vehicles. Winter conditions with cold temperatures, snow etc. reduces the chances of using e.g. induction to reduce usage of fossil fuels.
I	CEO	Rail service provider	Rail		
				Business models	Moving from one system to another is difficult, to convince people to change from truck to a rail-truck solution is hard as customers rely on their existing business models - all depends on the PRICE. Also, the need of huge volumes of goods to be competitive.
				Price for transport	End of discussion with customers if the price for transport is not lower than existing or intended transport e.g. rail/road transports are much faster and less pricy. If the customer does not have an end consumer contact, they will not consider the environment when choosing type of intermodal transport.

	Capacity	Long-term planning is not suitable for today's business structure related to logistics. No clue in how many customers will use rail to transport goods in the forthcoming year, the only tool that rail providers have when planning for rail capacity is the history from previous years. From a historical perspective this has changed towards the worse - before there were ad-hoc times which meant that if there were slots left on a train they could be booked/scheduled and used the next day. Today, even if slots are available the booking procedure takes five days until the left-over goods can be transported resulting in creation of bottlenecks - slower processes at the Swedish Transport Administration nowadays. An additional problem relates that in Gothenburg the capacity of goods handling cannot be increased since the open times for rail is shortened to only day time.
	Mindset	If a new rail service is being started, the need of reliable customers or one are imperative. Volume based contracts are very risky for the customer and also the rail company, but the customer seldom wants to take any risk.
	Bottlenecks	Huge bottleneck problems outside the terminal areas where the rail arrives. The problems are in the rail yard where the trains arrive including 'Hamnbanan' (today only one single track) which reduces the possibilities for waiting areas during the night e.g. Vänerexpressen arrives at night but there is no place for a 640 meters long train. The railway yard has also problems with opening times, today it is only open day time and no weekends including that it is tremendous work with changing a system within short time.
	Theoretical capacity	Gothenburg has a reputation of having a lot of capacity, thus it is only theoretical since the capacity exists but at the wrong time - during the day. Rail companies cannot have their trains in Gothenburg during day since they do not have any goods to pick up including that there is misalignment in working hours in Gothenburg because it is complicated to be sure what time schedules rail services have.
	Planning	Need coherence between rail services with an operational focus to make an efficient goods flow. Optimize all terminals in port logistics, not only one to make efficient operations. Planning internally and in-between terminals.
	Communication	Between all modes of transportation, in the whole supply chain of transport to gain an enhanced goods flow. Delays or early arrival of goods

					by ships will impact the intermodal transportation, especially rail since it has to move quickly in and out of railway yard. There is a need for an easy system that can be used to reduce work relating to information flow.
				Conservative industry	Not keen on changing systems, especially in shipping since it is old-fashioned and have not kept the pace of evolution within the transport segment. In rail there are a lot of manual processes still, and no solutions yet.
J	Manager	Port and integrated inland service provider	Terminal operator/Rail		
				Flexibility	Main barrier to modal shift, road to rail, as on rail there are standard volumes/bulk volumes, no digital implementations to ease the shift, schedules are planned one year ahead based on history, hard to predict the future need
				Cost for transport	Save money by using rail since rail comes at a scheduled arrival where they have slot times, but trucks can come and go as they want often resulting that they come all at the same time increasing costs for more personnel to handle them
				Price for transport	Road is cheaper for shorter distances than rail, but for longer distances rail is cheaper, start-up cost vs. running cost
				Conservative industry	The work conducted is in an old-fashioned way, goods are caught up in the terminals as customers don't know that the goods is in the port until much later, there should be some sort of interface so when goods are unloaded from a vessel the customer get that info, so they can order pick-up or that the terminal just can put it on a train to its destination
				Communication	Lack of IT solutions to cooperate, not only because different transport actors are competitors, but also due to cybersecurity – there is a slowdown in implementation for IT based systems
				Capacity	A lot exists, but more is needed on rail. Terminals and inland ports have more of its own capacity to use to support rail as they can be more efficient as the volume and schedule of the railway is known. Easier to plan and execute. In Gothenburg port there are limited capacity for trucks as the space is limited – if everyone works as they do today the queue

				with trucks will become longer and longer. During day-time trains leave Gothenburg not fully loaded, but during night the trains are fully utilized – APM aims to increase the utilization of the rail more during day-time
			Mindset	Business regarding e.g. rail can be used around the clock, but society has their restrictions as rail has some noise when the rail ports are nearby habitat areas
			Railway connectivity	As containers are rented and costs money when the rent period ends, all cargo above Gävle/Borlänge costs more as the container starts to incur more money. Therefore, a move towards going back to conventional rail (using wagons/bulk instead of standardized containers) for forest products as they normally come from the north of Sweden
			Reliability	Goods transportation has been prioritized by the Swedish Transport Administration over passenger transport, mostly because goods are moved during night – a game changer for goods transportation. Before the weather could have major impact on the reliability for goods transport, but not nowadays. It is trickier to find customers that are reliable to continue having a rail service
			Customs/Paper handling	Rules and policies at customs do not make it easier for goods flow through the port since the customs need to be able to access the goods at any time, when needed. Therefore, a cooperation by having customs handling in an inland rail port is difficult
K	Manager	Logistics provider	Road and rail	
			Capacity	There is capacity and space, but rail companies/services don't utilize it due to the long time it takes for the Swedish Transport Administration to reply about available slots (they are behind on digitalization)
			Flexibility	Difficult to enter changes into the traffic schedule, thus trucks are needed instead
			Technology adaptation	New systems, takes time to phase into it and adapt
			Economic risk	There are more rail services provided, but there is an economic risk as to make rail an option that is worth using you need volume to fill up the train. Rail is therefore used on lines where there is a known goods volume

	Reliability	There is no commitment from customers, a rail company takes on all the risk. An example, Maersk was both a reliable and unreliable client who had goods volume, but which was dependent on other customers to deliver goods to them which lead to a variation in goods volume
	Planning	A need to plan ahead as everything needs advance scheduling
	Transport time	Waiting for trucks (their turnaround time) outside the port to get serviced is about six hours
	Price for transport	Competition in price, trucks don't want to drive for too little money, bad working conditions for drivers and big issues with "supply" of trucks during holidays since many drivers are on vacation. Price for rail and truck are almost the same for one container, but time wise the truck wins and accordingly trucks should become a greater cost
	Communication	Information flow – all information needs to be written down manually which is very time consuming and unnecessary. IT systems cannot cooperate with each other. In a rail/road company an IT system can be used sufficiently, but without the connection to an IT system in the port the notion of when goods are arrived in the port will not reach the company for pick-up. A lot of orders and emails, digitalization would make communication and information flow much more efficient
	Railway connectivity	Old tracks and lack of digitalization. The Swedish Transport Administration has an issue concerning their handling times, but people think that the space/slots on the tracks are the issue. Though, it is the time between when the Swedish Transport Administration is receiving the application and actually giving the answer

13.4 Appendix D

Digital mitigation potential of existing intermodal barriers

The below seven statements are asked to receive consensus of what digital technologies can be applied to mitigate the barriers in front of intermodal transportation. The digital technologies that are considered in this questionnaire are IoT and big data, cloud logistics, blockchain technology, sensor technology and digital identifiers, and automation technology. You can find a short description of the listed barriers and digital technologies at the end of this document.

When you answer the statements below there are three options whether you agree, disagree or are not sure about the statements given. There is also a compulsory question 'Why?' you think that the barrier can be/cannot be mitigated by the technologies mentioned or which technologies that you consider have mitigation potential. Your answers are highly appreciated and imperative for our results to reach consensus in the possibilities of increased efficiency in goods flow in Gothenburg port logistics for intermodal transportation.

Thank you very much for your participation!

1. I believe that blockchain technology can **NOT** mitigate the barriers (price and cost, capacity of transport, flexibility of transport, communication and business models and time of transport) in front of intermodal goods transportation

   ☐Agree ☐Disagree ☐Not sure Why? (compulsory) Click or tap here to enter text.

2. I believe that technologies such as: (cloud logistics, big data, sensor technology and digital identifiers and automation technology) can mitigate the barrier price and cost for transport in front of intermodal goods transportation

   ☐Agree ☐Disagree ☐Not sure Why? (compulsory) Click or tap here to enter text.

3. I believe that technologies such as: (IoT and big data, cloud logistics, sensor technology and digital identifiers and automation technology) can mitigate the barrier capacity of transport in front of intermodal goods transportation

   ☐Agree ☐Disagree ☐Not sure Why? (compulsory) Click or tap here to enter text.

4. I believe that technologies such as: (big data, cloud logistics, sensor technology and digital identifiers and automation technology) can mitigate the barrier flexibility of transport in front of intermodal goods transportation

   ☐Agree ☐Disagree ☐Not sure Why? (compulsory) Click or tap here to enter text.

5. I believe that there is an **uncertainty** about the mitigation potential of IoT against the barrier flexibility of transport in front of intermodal goods transportation

   ☐Agree ☐Disagree ☐Not sure Why? (compulsory) Click or tap here to enter text.

6. I believe that technologies such as: (big data, cloud logistics, sensor technology and digital identifiers and automation technology) can mitigate the barrier communication and business models in front of intermodal goods transportation

   ☐Agree ☐Disagree ☐Not sure Why? (compulsory) Click or tap here to enter text.

7. I believe that technologies such as: (IoT and big data, cloud logistics, sensor technology and digital identifiers and automation technology) can mitigate the barrier time of transport in front of intermodal goods transportation

   ☐Agree ☐Disagree ☐Not sure Why? (compulsory) Click or tap here to enter text.