CHALMERS
UNIVERSITY OF TECHNOLOGY

Drivers and barriers for truck appointment systems at container terminals

A business model perspective

Master's thesis in the program Quality and Operations Management

REBECCA ERICSSON
PHILIP SVENSSON

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF SERVICE MANAGEMENT AND LOGISTICS

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2022
www.chalmers.se
Report No. E2022:081

REPORT NO. E2022:081

Drivers and barriers for truck appointment systems at container terminals

A business model perspective

REBECCA ERICSSON
PHILIP SVENSSON

Department of Technology Management and Economics
Division of Service Management and Logistics
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2022

Drivers and barriers for truck appointment systems at container terminals
A business model perspective
REBECCA ERICSSON
PHILIP SVENSSON

Technical report no E2022:081
Department of Technology Management and
Economics
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone + 46 (0)31-772 1000

Gothenburg, Sweden 2022

Drivers and barriers for truck appointment systems at container terminals
A business model perspective

REBECCA ERICSSON
PHILIP SVENSSON

Department of Technology Management & Economics
Chalmers University of Technology

SUMMARY
An increasing demand for global freight transportation by sea as well as increasing competition within the sector require that container terminals re-evaluate their current operations. Inefficient container transactions between a terminal operator and trucking companies negatively impacts the two actors as well as social and environmental performance. The truck appointment system has been forwarded by several academic researchers as an alternative solution to capacity expansion; Rather than stressing limitations in capacity the system facilitates the efficiency of container transactions. Although the system was conceived already in the early 2000s and is associated with multiple benefits in academic literature, it has only been implemented in a few container terminals. This indicates a misalignment between the drivers and barriers forwarded in literature and those perceived in practice as well as a lack of know-how among terminal operators on how to realize the system's benefits in practice.

This master thesis report aims to address the drivers and barriers of different truck appointment systems seeking to facilitate the service of container transactions and hence terminal competitiveness. A qualitative research strategy has been deployed in the study. Concurrent to a literature review, semi-structured interviews have been conducted in the frames of a multiple-case design.

The contributions of this study include: a framework compiling, categorizing, and clarifying the different TAS components and options; compilations and clarifications of different drivers and barriers; a compilation and clarification of the relations between overlying drivers and barriers and truck appointment system components and options; identification and clarification of positive and negative relations between different overlying drivers and barriers and hence the necessity to consider the constraints and objectives of both terminal operators and trucking companies when designing and operating a truck appointment system; and an analytical business model framework based on TASs considering the constraints and objectives of both terminal operators and trucking companies. These contributions are meant to increase terminal operators' know-how regarding the truck appointment system and how to reinforce the drivers respectively mitigate the barriers of the system through the related design as well as their business model.

Keywords: terminal appointment system, truck appointment system, gate appointment system, business model

Acknowledgement

This thesis was conducted as a part of the master's program Quality and Operations Management at Chalmers University during the Spring 2022. The project was conducted in a collaboration with the research institute SSPA as a part of the research project DREAMIT 2.0 that focus on effective access management in seaport terminals.

We would like to give our first gratitude to our supervisor, Gunnar Stefansson, Associate Professor at the Division of Service Management and Logistics at Chalmers University who has guided and supported us throughout the research process.

Secondly, we want to thank SSPA and the participants of DREAMIT 2.0. A special thanks to our co- supervisors Per Wide, Sara Rogerson, and Vendela Santén for giving us the possibility and the trust in the project and all valuable insights that you have contributed with during the project.

Lastly, we would like to thank all the interviewees that took their time to participate, contributing with valuable knowledge needed to realise the project.

Thank you all for making the thesis possible!

Rebecca Ericsson & Philip Svensson
Gothenburg, June 2022

Table of figures

List of Tables

GLOSSARY

Dwell time	The time a container is waiting within the container terminal before being picked up by the next transport carrier.
External trucking company	Is an independent external trucking company performing container movements to and from the container terminal.
No-show	When a truck driver misses or skips a booked appointment at the terminal.
Truck transaction time	The time a truck spends within the outer entry gate and exit gates
Truck turnaround time	The time a truck spends within the outer entry gate and exit gates (truck transaction time) as well as outside the outer entry gate.

ACRONYMS

BAS	Block appointment system
DAS	Dynamic appointment system
IAS	Individual appointment system
STAS	Static appointment system
TAS	Truck appointment system
TC	Trucking company
TO	Terminal operator
TTT	Truck turnaround time

1 Introduction

In this chapter the aim of the study is motivated and outlined. The introduction is presented as following: In section 1.1 the background to the situation at container terminals are described. Then in section 1.2, the problem areas related to truck appointment systems are described. based on the problem areas the aim and research questions are presented in section 1.3 followed by the delimitations in section 1.4. Lastly, the disposition of the upcoming chapters of the study are presented in section 1.5.

1.1 Background

The transportation of goods is essential for today's global economies to operate (European Commission, 2011; Rodrigue et al., 2006); The transportation sector accounts for a significant amount of jobs and provides governments with tax revenue that enable economic development (Giuliano & O'Brian, 2007). While globalization on the one hand has significantly increased the demand for global logistics (Jacobsson et al., 2017; Namboothiri & Erera, 2008), traffic on the other hand needs to be shifted from road to train or sea, to be able to reach the EU goal of reducing emissions of greenhouse gases (European Commission, 2011). Ocean shipping is also gaining attention because of its high returns to scale (Giuliano & O'Brian, 2007). The increasing importance of transportation by sea for global trade has not only implied an increased market share for ports with capacity for large ships or those situated nearby or with great transport connections to an attractive consumer market but has also opened for increased competition between ports (Giuliano & O'Brien, 2007; Van der Horst & De Langen, 2008). Container terminals, handling perhaps the most important cargo flow of many ports, are especially prone to such competition (Van der Horst & De Langen, 2008).

The increasing demand and competition put pressure on terminal operators (TOs) to partially allow for a greater throughput, partially provide improved services (Baccelli & Morino, 2020; Jacobsson et al., 2017; Namboothiri & Erera, 2008). To increase throughput, TOs target greater sizes of container vessels which leads to higher traffic loads at container terminals' gate entries or container storage blocks, challenging the terminal operation's productivity and sustainability (Chen et al., 2013b; Covic, 2017; Phan and Kim, 2015; Van der Horst & De Langen, 2008). As the role of container terminals has developed from a drop-off and pick-up point to a service hub, their role in the information network has become more important (Baccelli & Morino, 2020). However, some challenges arise with such information sharing (Marchet et al., 2012; Perego, et al., 2011); The intermodal node of the seaport is complex as different actors with different transportation modes interact (Bisogno et al., 2015).

When seeking to enable flexibility for the trucking companies (TCs), some container terminals allow trucks to arrive at any time throughout the terminals opening hours (unscheduled access) (Namboothiri & Erera, 2008). Limited opening hours combined with unscheduled access to the terminal, results in peak and off-peak hours (Covic, 2017; Juang & Liu, 2003; Namboothiri & Erera, 2008; Van der Horst & De Langen, 2008). While peak hours imply that terminal capacity is fully utilized, off-peak hours imply some level of overcapacity (Covic, 2017; Huynh & Walton, 2008; Namboothiri & Erera, 2008). The prevalence of off-peak hours implies that there are periods when the terminal resources are under-utilized resulting in a waste of resources. At the same time, when the terminal's capacity is fully utilized, it gives rise to queues and congestion (Covic, 2017; Phan & Kim, 2015). As a result, TCs experience longer truck turnaround times (TTT) which reduce the number of requests that can be performed without increasing the fleet size meanwhile local air pollutions become condensed, ultimately causing increasing health and environmental related problems (Chen et al., 2013b; Covic, 2017; European Commission, n.d.; Huynh & Walton, 2008; Namboothiri & Erera, 2008; Phan & Kim, 2015; Torkjazi, 2020).

Keeping the TTT at its minimum is an important element to ensuring a high throughput as a functioning landside operation is key to attract large vessels (Van der Horst & De Langen, 2008). When improving the efficiency of landside operation, also the business of stakeholders up-stream in the supply chain is facilitated; on-time delivery at the end-customer's location is ensured when the TO facilitates the operations of TCs (Torkjazi, 2020). Moreover, successful positioning in the shippers', forwarding agents' and shipping lines' mind, not only increase terminals' competitiveness against other container terminals, but also the competitiveness against other means of transportation and hence entire transportation chains (Kotler et al., 2017; Van der Horst & De Langen, 2008). Although the scope of this master thesis does not include an analysis of the potential effects of improved landside operations on a supply chain level, the benefits of intermodal shipping, is a well-researched topic in academia (see for example Frémont, 2013).

Limitations regarding terminal capacity and more specifically, the gate- and yard area, equipment (for example internal trucks and cranes), and personnel (Covic, 2017), imply that the landside operations must be planned and organized to not undermine attempts to increase the competitiveness and sustainability (Van der Horst & De Langen, 2008). The increased demand for terminal transactions in combination with an unchanged terminal capacity means that peak hours grow in duration, hence causing more idling trucks to wait and to wait longer. Increasing stacking heights of containers is yet another issue deriving from an increased demand for storing in a limited yard area (Kemme, 2013), amplifying the problems with long TTT and fluctuations in capacity utilization. Stacking multiple containers on top of each other ultimately prolongates the TTT and decreases capacity utilization as then the number of redundant crane lifts (shuffle moves) increases during retrieval operations (Covic, 2017).

Researchers in the field have primarily targeted the problem of congestion in container terminals using two different approaches, gate capacity expansion and management of truck arrivals (Chen et al., 2013b). According to Guan and Liu (2009) the former approach has two primary downsides, the first being that the possibilities to expand land and resources might be limited and the second one being that expanding gate capacity without streamlining or expanding yard capacity simply moves the congestion to the inside of the gate entries. In the latter approach the truck arrival rate is managed through economic incentives, operational methods, or both, to limit the number of arrivals throughout the day or to minimize the occurrence of high truck arrival rates (Chen et al., 2013b).

Well recognized in academic literature as well as in the business community (Phan & Kim, 2015), the truck appointment system (TAS) constitutes an attempt to manage truck arrivals (Covic, 2017; Lange et al., 2020; Phan & Kim, 2015). The specifics of the TAS vary and depend partially on the terminal’s intended use case of the TAS. Covic (2017) defines two use cases of the TAS; The first use case implies improving information on trucks’ arrival time (in comparison to when unscheduled access is deployed) to schedule terminal capacity and thereby increase yard operations efficiency. The second use case implies that schedules, limiting the number of trucks that arrive during certain time intervals throughout the day, are imposed to level truck arrivals and thereby increase terminal operations efficiency. The second use case is typically referred to in academic literature on the TAS and the former is only scarcely covered (Covic, 2017). As the second use case also implies improved information on truck arrivals in comparison to when unscheduled access is deployed, it also facilitates scheduling of terminal capacity. Furthermore, the second use case entailing levelling of truck arrivals, implies additional benefits which advocate for such system; By limiting the maximum number of truck arrivals during certain time intervals the terminal’s capacity utilization rate is further enhanced as well as the waiting times for idling trucks (Covic, 2017; Phan & Kim, 2015).

1.2 Problem areas

Huynh et al. (2016) emphasize that TAS is rapidly evolving and the advancement in technological capabilities between container terminals are differing. In practice, some TOs have implemented the TAS while many have not, for example APM terminals have implemented TAS in 26 out of their 75 terminals (APMT, n.d.). The inconsistent implementation across container terminals might be due to a lack of knowledge on how to design the TAS to maximize its effectiveness, how to integrate the TAS into the main service it seeks to facilitate, or due to different perceptions regarding the system’s effectiveness, resulting in a lack of buy in, sense of responsibility, and prioritization of the system (Morais & Lord, 2006).

For any purposeful system to be perceived a sensible investment for the investors, the drivers legitimizing an implementation of the system must be recognized and realizable. Moreover, the barriers mirroring the drawbacks of a system that can potentially hinder the realization of the drivers, must also be recognized and manageable. The direct costs related to the implementation and operation of a system, as well as indirect costs related to mitigating barriers, must not exceed the earnings of the system. Recognition of the drivers and barriers as well as knowledge of how to reinforce the drivers and how to mitigate the barriers, is therefore important when evaluating a TAS potential effectiveness. Lack of knowledge among TOs about the TAS should imply several negative consequences; Firstly, lack of knowledge about its effectiveness may cause TOs to distance themselves from an important business opportunity. Secondly, lack of knowledge about how to design the system and integrate it into the service it seeks to facilitate, may hinder realization of the drivers, or even undermine the business.

Academic literature on the drivers and barriers and how to reinforce respectively mitigate them by adjusting the system design is relatively rich (see for example Huynh et al., 2016 and Torkjazi, 2020). However, findings regarding how a generic TAS or different TAS designs affect the business model of TOs when incorporated to facilitate the service of container transactions between a TO and TCs, are scarce. Without some sort of analytical business model framework considering theoretical as well as empirical findings on the TAS, the system’s effectiveness is not likely to reach its full potential. This is because the TAS enforces certain requirements on the main service it seeks to facilitate which necessitates alignment between the two and hence modifications to the current business model (Veile et al., 2019). The business model in turn is a source for strategic and operational objectives and the system properties must therefore be reflected by its content. Deliberate modifications of the business model hence ensures that drivers are reinforced and that barriers are mitigated when a TAS is put into practice.

1.3 Aim and Research questions

The inconsistent implementation of TAS in different container terminals indicates that there are certain ambiguities surrounding the system. To address such ambiguity, this study seeks to present different components and options of TAS designs, that can be applied when designing the system. As the different design decisions come with their own drivers and barriers, they are important to understand when designing a TAS as well as to understand the potential effectiveness of the system. Furthermore, the TAS needs to be reflected in the business model of a container terminal as the business model highly influences the service of container transactions of which the TAS seeks to facilitate. Information on how to align the two seems to be lacking in academic literature. Therefore, the aim has been formulated as following:

> *To improve the understanding of the drivers and barriers of truck appointment systems' components and options and how they affect the content of terminal operators' business models.*

To achieve the aim of the study three research questions have been formulated. The first research question is formulated with the intention of understanding the drivers incentivizing an adoption of a TAS. Previous studies have investigated the drivers of the TAS both from a system perspective and from lower-level perspectives focusing on the drivers resulting from adjusting the system design in terms of components and options. Although literature on the drivers is relatively rich it is rather scattered and lack a holistic view on the drivers as well as their interrelations and causes. Moreover, few attempts have been made to compile the many developments that have been made to the TAS components and hence options and to collectively relate them to the drivers. The lack of a clear and holistic depiction of the drivers and their dependence on the system design might be the reason for why the system has only been adopted in some container terminals. Therefore, the first research question is formulated as the following:

> **RQ1: What components of truck appointment systems are related to perceived drivers of TAS?**

The second research question aims to improve the understanding of the barriers that may affect the possibility to realize the drivers of the TAS. As with the drivers, previous studies have investigated the barriers of the TAS both from a system perspective and from lower-level perspectives, but their interrelations and dependence on the TAS components and hence options, are lacking. The inconsistent implementation of TAS across container terminals might therefore also be a consequence of the lack of a clear and holistic depiction of the barriers. Therefore, the second research question is formulated as the following:

RQ2: What components of truck appointment systems are related to perceived barriers of TAS?

Lastly, the purpose with the third research question is to investigate how the TAS affects the content of TOs' business model when incorporated to facilitate the service of container transactions between a TO and TCs. When implementing a TAS, certain elements reflecting the systems' prerequisites should influence the service and hence the content of the business model. Academic literature on how to align the business model and hence existing service with the TAS to reinforce the drivers and mitigate the barriers, seems to be lacking. While previous research has mostly taken a narrow theoretical approach by optimizing certain components or options of the TAS design to improve the operations of either the TCs or the TOs, such approach will be futile if it is not reflected by the strategic and operational objectives. Therefore, the third research question is formulated as the following:

RQ3: What elements should be considered in a business model to address the perceived drivers and barriers of TAS?

1.4 Delimitations

Prior to the study one delimitation was established to narrow the scope of the study; Only container terminals' landside operations related to the service of container transactions between a TO and TCs will constitute the study object. This is because of the different characteristics of train, sea, and truck shipment (Jacobsson, 2020), which most likely influence the range of drivers, barriers and thereby ways to realize the drivers or manage the barriers.

Throughout the study additional delimitations have been made. Presentation and analysis of different algorithms or mathematical models that are used in literature to enable or facilitate different options of TAS components have been excluded from the study. Also excluded from the study are identification and analysis of the technologies or programming interfaces that must be established to enable information sharing between actors using a TAS. Lastly, the purpose of the study is not to measure and compare the effects of different TAS components and options, but instead to understand from a qualitative perspective how they relate to different drivers and barriers.

1.5 Disposition of the report

Below the structure of the report for the upcoming chapters is presented. This provides an overview of the aim with the upcoming chapters; each chapter is described separately.

Theoretical framework: aims to present a current state of research related to different TAS designs and how decisions regarding the design affect system outcome. A framework is presented in terms of components and options constituting earlier TAS designs as well as developed TAS components and options followed by identification of drivers and barriers related to such systems. Lastly, business models in the freight transportation sector are presented.

Methodology: presents the researchers' philosophical standpoint which has influenced the research, strategy, design, and methods. Methodological choices and processes such as the method for data collection and data analysis are in this chapter described in detail. Lastly, the applied quality criteria are discussed followed by a discussion regarding ethical, societal, and ecological considerations.

Empirical findings: presents a description of the three cases studied as well as the empirical findings regarding the TAS designs deployed and the related perceived or experienced drivers and barriers. The data presented was mainly collected from conducted interviews, however, some information was gathered from external documents.

Analysis: is the chapter in which the empirical as well as theoretical data are analysed according to the three research questions. Research question three is analysed using the framework business model canvas developed by Osterwalder and Pigneur (2010).

*Discussio*n: aims to answer the three research questions concisely based on the results presented in the analysis. Lastly, recommendations for future practitioners as well as limitations of the study are discussed with suggestions for future research.

Conclusion: serves the purpose of shortly summarizing and emphasizing the findings of the study with the aim of the study acting as a reference. The chapter highlights the most important contributions of the study.

2 Theoretical framework

In this chapter the theoretical data is presented. The theoretical framework is presented as following: In section 2.1 a brief overview of container terminals' operations and trucking companies' operations related to terminal transactions is given. In section 2.2, the basic TAS design is presented and in section 2.3 the drivers and barriers related to the basic TAS. In section 2.4, developed TAS components and options and their respective drivers and barriers are outlined. Finally in section 2.5, business models in the freight transportation sector are discussed.

Since the conceptualization of the TAS in the beginning of the 21st century (Torkjazi, 2020), several TAS designs have been developed in academic literature as well as in practice. Such developed designs primarily represent attempts to add to or optimize certain components of the TAS or attempts to integrate the TAS, that primarily target the gate operations, with the yard operations. While a TAS refers to any truck appointment system a TAS design in this report refers to a specific TAS that constitute a certain set of components and options; the options more specifically represent different ways to realize a specific component.

Although the different TAS designs often are related to the same drivers and barriers, a specific TAS is also characterized by individual drivers and barriers. Moreover, a specific design can be a solution to the barriers relating to another design but at the same time relate to barriers possible to mitigate through yet another design. Because of the multiple developed TAS designs that partly relate to certain drivers and barriers, partly represent attempts to mitigate barriers identified in previous designs, it is appropriate to distinguish these designs when presenting the theoretical data on drivers and barriers. Furthermore, as many of the early designs are similar (they largely constitute the same set of components and options) and to a large extent share the same drivers and barriers, these can be presented as a benchmark to the designs that have been developed subsequently. Such early designs (hereafter referred to as the basic TAS design) hence enable identification of the fundamental drivers and barriers of the TAS.

The theoretical framework will be structured according to the logic presented in the previous paragraph; Applying such chronological perspective entails a holistic but also detailed view on the different TAS designs and their individual as well as collective drivers and barriers.

2.1 Container transactions between a terminal operator and trucking companies

The main actors that are involved in the container transactions are the container TO that can either be an external company or the port authority, and the TC that exchange information and goods (Torkjazi, 2020). If the port authority does not operate the terminal, they most often own the port being responsible for larger infrastructural investments at the port (Morais & Lord, 2006). By understanding the relations between these different actors in terms of the information exchange, business relations and the physical flow of goods, it is possible to identify how TAS would affect each actor to design an effective TAS (Huynh et al., 2016).

2.1.1 Container terminals' operations

The terminal operations involve different operations that need to operate in conjunction with each other to produce an efficient container flow through the container terminal (Morais &

Lord, 2006). According to Morais and Lord (2006), Abdelmagid, et al. (2022), Huiyun et al. (2018), Torkjazi (2020) the terminal can normally be divided into three main operations that each perform specific tasks that can be described as:

The gate area: is the first area that a truck driver arrives to when about to perform a container transaction at the terminal. The gate area can consist of one or many gate lanes that the truck driver must pass through before entering the yard aera. In this area the truck driver interacts with the TO, performing operations such as security, container checking availability and storage location.

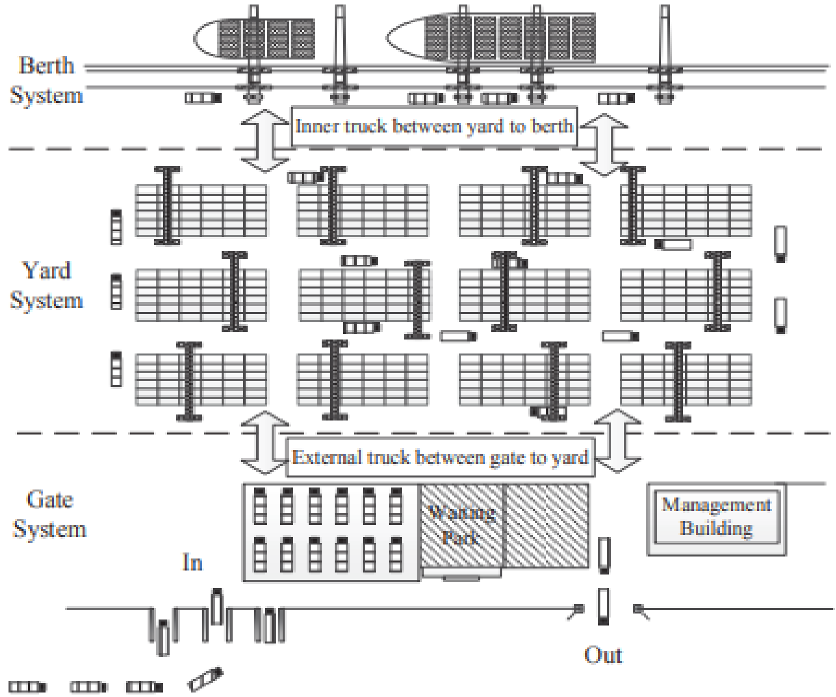
The yard area: is the interface between the berth area and the gate area. One primary operation in this area is to perform container transactions by loading or unloading full or empty containers to or from trucks that are either being exported or imported (Huynh & Walton, 2008). Additional activities that may take place is inventory management, or container tracking. Morais and Lord (2006) mention that the yard can contain different container handling equipment to manage and organize the containers at the yard, for example automated stacking cranes, straddle carriers, reach stackers, forklift trucks, or top pick handlers.

The berth area: is the entry point for vessels to enter and exit the terminal. The main activity in the area is to load and unload full or empty containers to/from ships by ship-shore cranes and to identify container information.

A typical layout of a container terminal is illustrated in figure 1. Huiyun et al. (2018) pinpoint that these three areas need to be considered due to interrelations between the areas that cause a complex system to coordinate. However, Huynh and Walton (2008) advocate that balancing operational resources between the areas can be difficult and that ship-to-shore transactions in the berth area often are prioritized over road operations which can result in resources such as cranes are being moved from the gate area to support the berth area. Hence, decreasing the terminals capacity to perform container transactions to serve incoming trucks.

Figure 1

A general layout of the areas at a container terminal



Note. From *Truck Appointment at Container Terminals: Status and Perspectives,* by Huiyun et al., 2018.

2.1.2 Trucking companies' operations

The operation for a typical TC starts at a depot with each truck performing a predetermined number of tasks each day. The number of tasks can vary depending on for example the distances to the different locations. The truck usually ends its shift back at the depot once it is finished for the day (Ioannou et al., 2006). Pickup or drop-off orders are normally received from either a shipper or a cargo owner that wants to move goods. Once the orders have been accepted by the TC a dispatcher compiles the orders, incorporating certain routes for each truck driver. Those schedules can include orders other than the once to and from the container terminal (Torkjazi, 2020). However, one of the tasks for some TCs is to pick up or drop off containers at the terminal. During this process the truck drivers interact with the terminal's processes when performing the container transaction (Zhang & Zhang, 2017). When the truck arrives at the terminal, the first destination is at the inbound gate area where the arrival is confirmed and then processed (Ioannou et al., 2006). Depending on if the truck brings an export container or picks up an import container, the truck either goes to the export- or the import yard. Beyond these two separate flows it is also possible to perform dual transactions which for the import flow means that a truck arrives with a container and unload it and pick up another container before leaving the terminal at the outbound gate. For the export flow, a dual transaction implies that the TC unloads the export container before picking up another import or empty container before leaving the terminal through the outbound gate. Once a transaction in the container terminal is performed, usually the next step is to reach the destination at a certain time point to deliver or pick up a container.

2.2 The basic truck appointment system design

In this study, the basic TAS design equals the TASs studied and reported by Giuliano and O'Brien (2007) and Morais and Lord (2006). These were among the earliest implemented and studied TASs. In their study, conducted in the Ports of Los Angeles and Long Beach, Giuliano and O'Brien (2007) evaluated the reduction in TTT and port related truck emissions in nine container terminals having implemented a TAS. Albeit the external pressure to implement the TAS, no directions were given to the terminals regarding the design of the system according to the authors. Ultimately it meant that each of the nine terminals were given complete freedom in structuring the TAS. Similarly, Morais and Lord (2006) studied the effects of TASs, and other solutions implemented in six North American west coast container terminals on the TTT and greenhouse gas emissions. The terminals belonged to the Ports of Los Angeles, Long Beach, Oakland, and Vancouver. In all six of the terminals the structuring of the design were determined with complete freedom and hence alike what was reported by Giuliano and O'Brien (2007). However, the TAS designs deployed across the different container terminals were rather similar and did not only share components but also to a large extent the same options.

The components and their related options reported by Giuliano and O'Brien (2007) and Morais and Lord (2006) to be present in the studied TASs, are listed and explained below and illustrated in figure 2 with their dependencies. Both the components and options are categorized based on their dependence on other components and options. 'Primary components' refer to components that are independent on other components and options. 'Secondary components' on the other hand are components that are independent on other secondary components but dependent on primary components and certain primary options. The components and options constituting the basic TAS design, are further illustrated in figure 2. In the figure, the components and options dependence of other components and options are marked with lines.

Primary components

Scheduling strategy: According to what scheduling strategy, individual appointment system (IAS) or block appointment system (BAS), appointments are provided (Abdelmagid et al., 2022). The different strategies are explained in a separate paragraph.

Obligation: Whether the TAS is optional, mandatory, or mandatory for import containers.

Information required from the TC: Whether the TC makes an appointment based on container-ID or truck-ID. The former option implies that the TC specifies the container and hence transaction (Torkjazi, 2020) meanwhile the latter option implies that the TC can book several appointments per transaction.

Primary booking technology: The technology marketed at first hand for booking an appointment. Appointments are mainly booked by calling the terminal or by using the web-based port community information system.

Missed appointment handling and re-scheduling: Whether a missed or skipped appointment (no-show) implies that a new appointment must be booked or if the truck may queue in the non-appointment lanes (walk-ins) (derives from the component of 'obligation' and the option of 'optional' as a mandatory TAS implies that a new appointment is required) (Maguire et al., 2010). However, for the sake of simplicity this component will be regarded a primary component in this study.

Appointment lead-time: The breaking point for when it at latest is possible to book a transaction (Huynh et al., 2016; Zhao & Goodchild, 2013) which can be either the same day or the day before. The appointment lead-time is used to enable scheduling of capacity.

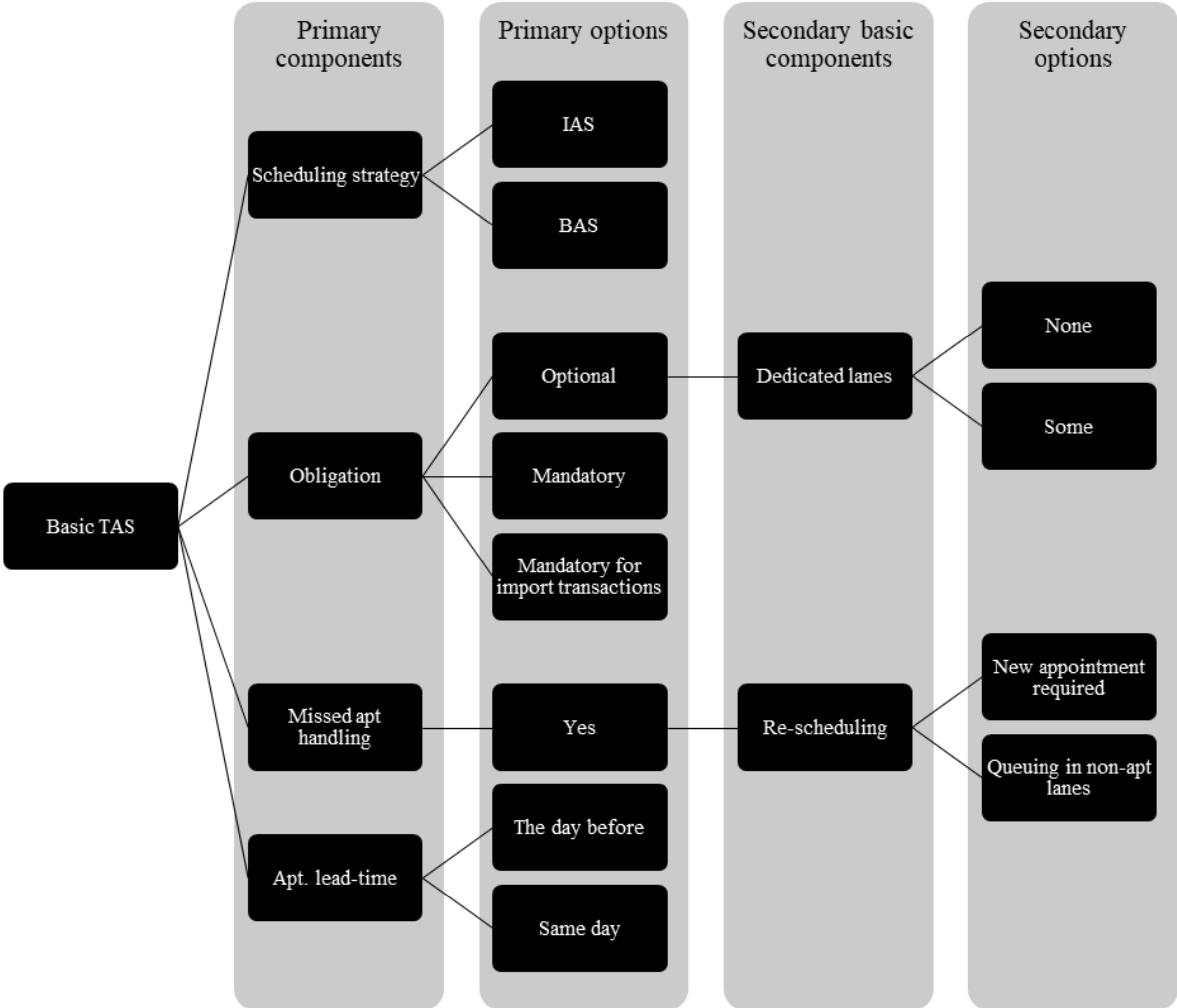
Secondary components

Dedicated lanes: Whether the TAS is coupled with separate lane(s) at the gate entry or not (derives from the component of ‘obligation’ and the option of ‘optional’ as a mandatory TAS implies that all lanes are used for appointments) (Huynh et al., 2016). The dedicated lanes ensure that trucks with appointments get access to their booked appointment window while trucks without appointments get access whenever terminal capacity is not fully utilized (Huynh & Walton, 2008).

Information provided by the TO: Whether the information on cargo availability is provided or not (if a container is ready to be picked up) when the TC books an appointment (derives from the component of ‘Information provided by the TC’ as container status can only be provided through container identification) (Huynh et al., 2016).

Figure 2

The components and options constituting the basic TAS design



The component of scheduling strategy and its two options of IAS and BAS require further explanation other than already made. Different designs of TAS can be categorized into different types and two of the most common types are: Individual Appointment Systems (IAS) and Block Appointment System (BAS) (Abdelmagid, et. al., 2022). Although it was not stated by neither Giuliano and O'Brien (2007) nor Morais and Lord (2006) which one of the two systems that was used in the different terminals, the general description of the TASs indicated that BASs were deployed in all the container terminal.

One major difference between the different IAS and BAS is how they are controlled where IAS is the simplest system and is based on estimated arrival times, communicated by the TC to the TO. Contrary to BAS, which is a system in which the control is shifted, and the TO decide the booking conditions. The booking conditions between the systems can easily be explained that in IAS only one appointment is booked for each truck and in BAS, appointments are divided into blocks with multiple trucks being served within the same appointment window (Abdelmagid, et. al., 2022). The parameters that IAS consist of is the start of the first appointment, number of trucks at the beginning of the day, the interval between each appointment, and a buffer between each appointment to handle walk-ins and no-shows. The interval between each appointment is based on the average processing time required to serve each truck at the gate (Huynh, 2009). In contrast, BAS is built on several blocks that each have a separate appointment interval during the opening hours at the terminal where the trucks are allowed to arrive whenever within the timespan. Each truck that arrives within the block is served first come first served. What distinguishes BAS is that the allowed number of trucks for each block is decided based on the capacity and expected walk-ins/no-shows (Böse, 2011). Figure 3 illustrates a block in a BAS between 10-11 o clock where six trucks are allowed to arrive at the gate, each grey box represent an available appointment. As no prioritization between the trucks is established, the first truck that arrive will be served. In contrast figure 4 illustrates an individual appointment system with an interval of ten minutes between appointments.

Figure 3

Illustration of a block appointment system (BAS)

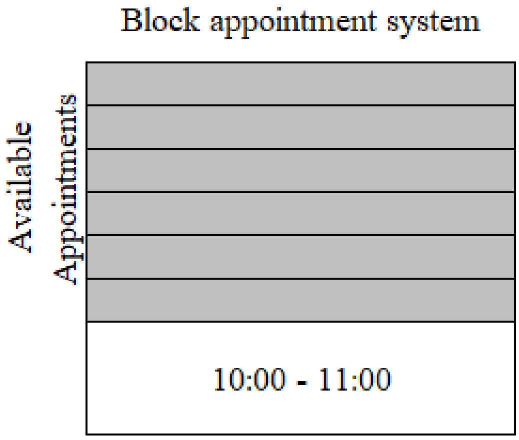
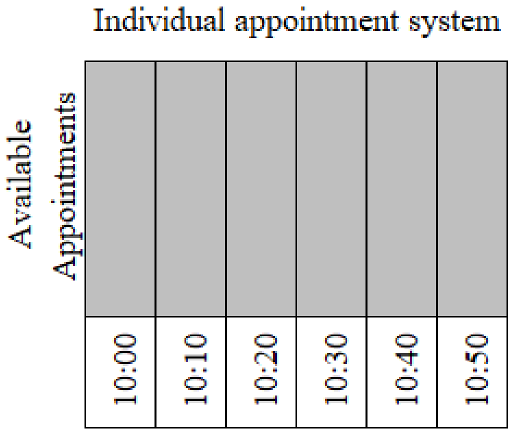


Figure 4

Illustration of an individual appointment system (IAS)



Huynh (2009) simulated how IAS and BAS compared in relation to turn time in the container yard and yard crane utilization. Different scenarios were simulated by changing the variables of no-shows, late arrivals, and walk-ins. The results showed that the use of IAS was preferable for the truck drivers as it lowered the turn times compared to the control simulation, thus punctuality from the trucks without too many walk-ins are important to obtain the positive results, otherwise, the intervals between bookings need to be extended. However, BAS increased the yard crane utilization since the trucks arrive in blocks, it is almost always some trucks in line to be served by the yard cranes. Although the increase in yard crane utilization it did increase the turn times.

2.3 Drivers and barriers related to the basic truck appointment system design

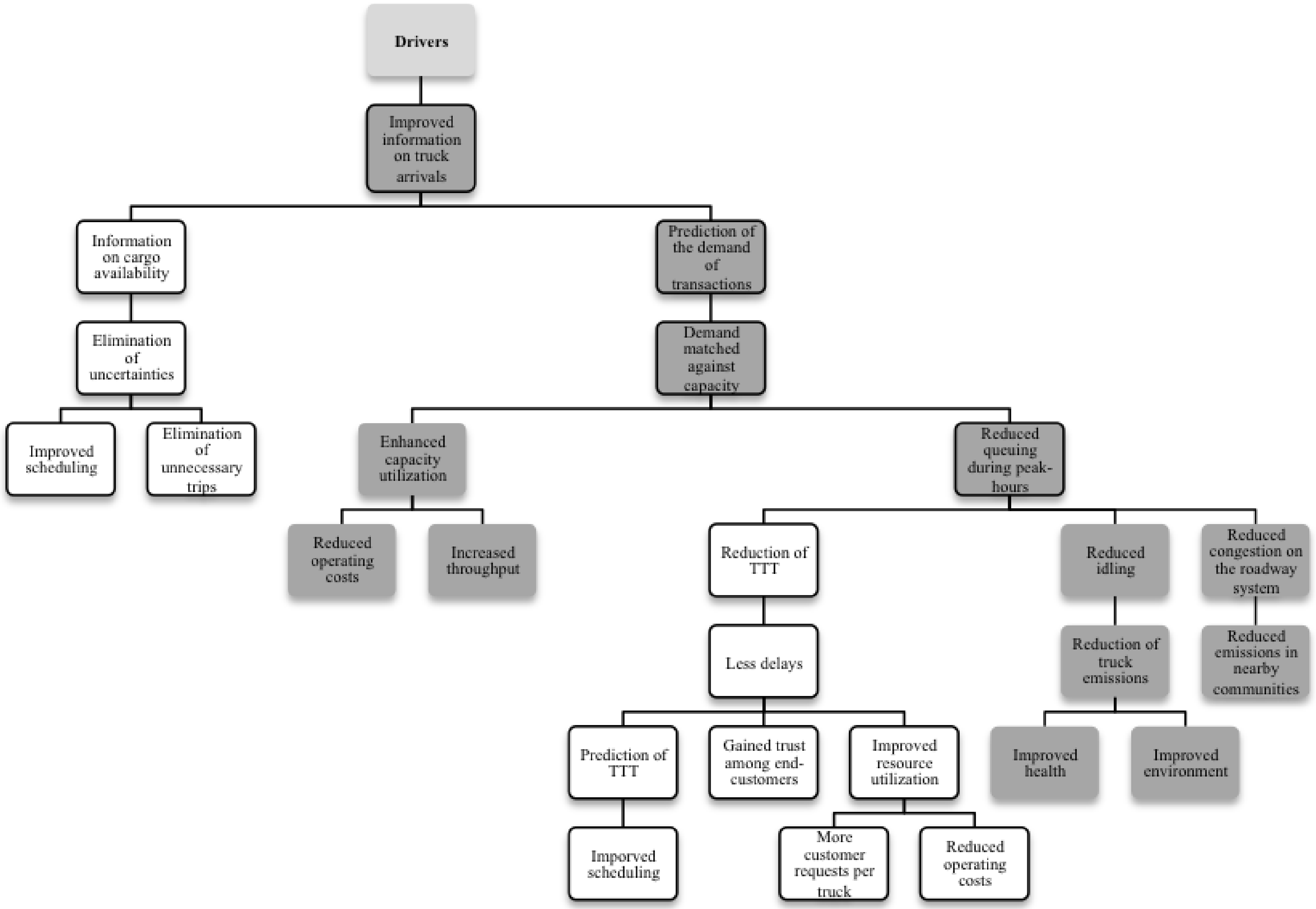
In this section the drivers and barriers related to the basic TAS design will be presented. In academic literature, the TAS has generally been advocated as a sufficient means for improving TCs' and TOs' operations efficiency as well as local air quality. However, Giuliano and O'Brien (2007) and Morais and Lord (2006) reported various barriers in their independent studies that affected the performance of TAS when implemented in different container terminals. According to Torkjazi (2020), TAS designs (and hence related drivers and barriers) reflect the degree of consideration to the objectives of the TCs respectively the TOs. Hence, in this section it is appropriate to make a distinction between the drivers and barriers perceived by the studied TOs that operated the TASs, and the drivers and barriers perceived by the TCs that used the TASs, in the two studies.

2.3.1 Drivers related to the basic truck appointment system design

In this section the drivers related to the basic TAS design, components and options are presented. In figure 5 the drivers related to the basic TAS design, and their identified interrelations are illustrated; The white cells with bold lines mark the drivers perceived by the TCs and the grey cells mark the drivers perceived by the TOs. The cells in grey with bold lines mark the drivers perceived by both actors. The hierarchy has been compiled according to the following logic: If underlying yet same-level drivers are perceived by different actors, their shared overlying driver is perceived by both actors.

Figure 5

Drivers related to the basic TAS design



Terminal operators' perspective

Two primary incentives for implementing the TASs were reported by Giuliano and O'Brien (2007) and Morais and Lord (2006) and are commonly cited when the TAS is dissected in subsequent academic literature: reduction of truck emissions within or in connection to the container terminal and reduction of TTT. The first driver was the main intention with the TASs implemented in the terminals studied by Giuliano and O'Brien (2007). Extensive queueing at terminal gates implying a concentration of idling trucks had by that time become alarming; while idling trucks on the one hand emit more emissions than moving trucks (Torkjazi, 2020), high diesel engine emissions on the other hand cause health- and environmental issues (Namboothiri & Erera, 2008). Giuliano & O'Brien (2007), however, found no evidence for reduced truck emissions. In contrast, Morais and Lord (2006) reported significant reductions in truck emissions in the container terminals they studied that had implemented the TAS. The latter results have been supported by subsequent studies on the effects of TAS as several independent studies have reported reduced congestion and queueing at gates and especially during peak hours. The explanation repeatedly cited is that the TAS enable the terminal to level truck arrivals throughout the terminal's opening hours (Abdelmagid et al., 2022; Giuliano & O'Brien, 2007; Heilig & Voß, 2017; Huynh & Walton, 2008; Ioannou et al., 2006; Maguire et al., 2010; Morais & Lord, 2006; Namboothiri & Erera, 2008; Torkjazi, 2020; Zhang & Zhang, 2017; Zhao & Goodchild, 2013). A side effect from leveling truck arrivals is lesser congestion on the roadways system and hence reduced truck emissions in the nearby communities (Giuliano & O'Brien, 2007; Maguire et al., 2010).

Another significant incentive for container terminals to implement a TAS is the possibility to predict and hence better manage the demand of container transactions in relation to gate- and yard capacity (Giuliano & O'Brien, 2007; Morais & Lord, 2006; Torkjazi, 2020). When predicting workloads, labor, and equipment both in the gate operations as well as in the yard operations can be better scheduled, creating efficiency wins at the terminal through improved resource utilization (Huynh & Walton, 2008; Maguire et al., 2010; Namboothiri & Erera, 2008; Torkjazi, 2020). Ultimately, information on the number and frequency of truck arrivals contributes to improving resource utilization, gate- and yard efficiency, operational costs, and accelerated throughput (Morais & Lord, 2006).

Trucking companies' perspective

The second incentive cited by Giuliano and O'Brien (2007) and Morais and Lord (2006) as well as in subsequent literature, reduction of TTT (Huynh & Walton, 2008), has shown not only to be a source for reducing truck emission due to reduced idling, but also for improving truck operations efficiency. TTT is usually applied to explain the time a truck spends within the outer entry gate and exit gates (truck transaction time) as well as outside the outer entry gate (gate wait time) (Giuliano & O'Brien, 2007; Huynh & Walton, 2008). However, according to Huynh and Walton (2008) the term is insufficient when viewing TTT as a function of yard capacity utilization which is the essence of TAS. That is because delays caused by inefficient gate processes up until the inner gate entry, which have nothing to do with yard capacity utilization, is then reckoned. The term truck transaction time is therefore often applied as it only considers the time a truck spends between the inner gate entry to the exit gate (Zhao & Goodchild, 2013). When leveling truck arrivals at the terminal gates, queues are targeted resulting in reduced TTT.

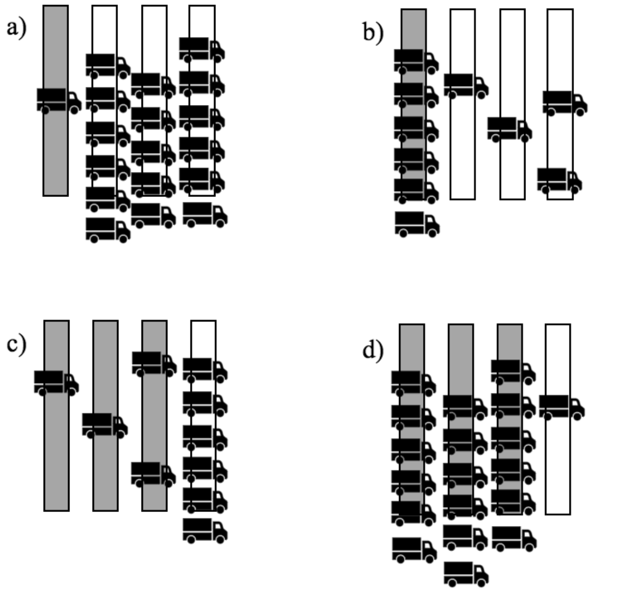
According to Ioannou (2006), a TAS enabling decreased fluctuations in queuing time, implies that TTT is more predictable and hence improve the conditions for scheduling trucks as well as for complying to such schedules. An immediate effect for the TCs is hence gained trust among current as well as potential end-customers. Furthermore, a greater proportion of transportations carried out on time enable TCs to better adapt to the Just-In-Time principle that increasingly gains attention in the freight transportation sector. Moreover, a shorter TTT implies that more customer demand requests can be served per truck and therefore tractors and drivers can be better utilized to minimize operating costs (Namboothiri & Erera, 2008; Torkjazi, 2020). An apparent benefit for the TCs is hence increased productivity.

According to Giuliano and O'Brien (2007) and Morais and Lord (2006) the TTT is strongly dependent on the proportion of trips carried out with appointments. Hence, to ensure a short TTT the TAS must be designed to incentivize usage. In an optional TAS dedicated lanes for trucks with appointments is used for this purpose. The dedicated lanes ensure that trucks with appointments get access to their booked appointment window while trucks without appointments get access whenever terminal capacity is not fully utilized (Huynh & Walton, 2008). However, assuming that trucks are served according to the first-in-first-out principle, trucks will queue with other trucks sharing the same appointment window. Thereby, the use of dedicated lanes requires that enough lanes are applied so that truck drivers with appointments always have a shorter TTT than trucks without appointments queuing at the non-appointment lanes. Then there will be few appointments to fill with trucks without appointments which will further be subject to high waiting times (Huynh & Walton, 2008). Hence, there is an apparent negative network effect related to the TAS; the more users the TAS receives, the less incentivized are truck drivers to use the TAS (Øverby & Audestad, 2021) unless additional lanes dedicated for trucks with appointments are applied. As the system gains users TTT will decrease if there are enough lanes dedicated to appointments users and finally stabilize when all trucks use appointments, and all lanes are dedicated for appointments. This relation explains why a mandatory system implies a reduction in the TTT. In the case of a mandatory TAS no such negative network effects will arise as then all lanes are dedicated for appointments. However, the primary incentive for TCs in that scenario is to ensure passage through the gate (Torkjazi, 2020).

Figure 6 illustrates the network effects prevalent in an optional TAS where different proportions of dedicated lanes for trucks with appointments (grey areas) versus without appointments (white areas), occurs. The different scenarios a) to d) also highlight how the level of TAS usage evolves if the dedicated lanes for trucks with appointments are expanded to meet such demand. In scenario a) and c) trucks are incentivized to use the TAS as they access the gate faster. In scenario b) and d) more lanes dedicated to trucks with appointments are necessary as otherwise trucks will be incentivized to not use the TAS as then they access then they access the gate faster. Hence, to ensure that a high proportion of trips are carried out with appointments enough lanes must be dedicated to trucks with appointments to ensure that the TTT is minimized.

Figure 6

Different ratios of dedicated lanes for trucks with appointment versus without and their relation to the proportion of trucks using the system



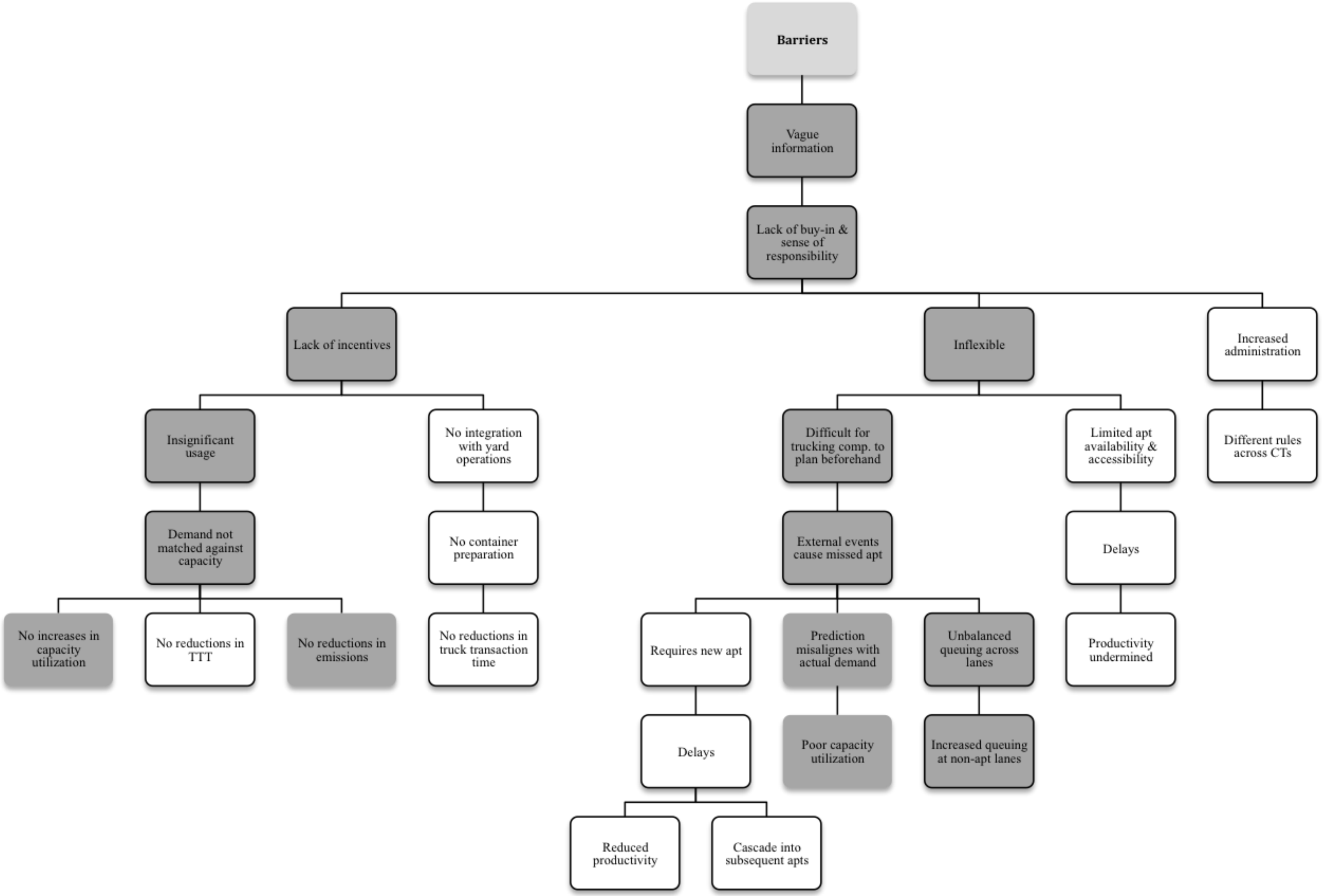
Both Giuliano and O’Brien (2007) and Morais and Lord (2006) reported that all terminals that they studied had incorporated information on container availability in their TAS design. When TAS provide TCs with container status and more specifically cargo availability and -readiness (Zhao & Goodchild, 2013), another benefit deriving from the application is that unnecessary trips to the port is eliminated (Heilig & Voß, 2017). This is because of that absence of cargo status risk that truck drivers arrive at the terminal only to find that the container is not available or ready for pick-up (Morais & Lord, 2006). Moreover, by eliminating uncertainties regarding container status, unnecessary activities related to finding out about container status are reduced (Morais & Lord, 2006) meanwhile planning is improved (Giuliano & O’Brien, 2007). Fewer trips to the terminal also imply reduced queues and hence reduced TTT and emissions related to port traffic.

2.3.2 Barriers related to the basic truck appointment system design

In this section the barriers related to the basic TAS design, components and options are presented. In figure 7, the barriers and their identified interrelations are illustrated; The white cells with bold lines mark the barriers perceived by the TCs and the grey cells mark the barriers perceived by the TOs. The cells in grey with bold lines mark the barriers perceived by both actors. The hierarchy has been compiled according to the following logic: If underlying yet same-level barriers are perceived by different actors, their shared overlying barrier is perceived by both actors.

Figure 7

Barriers related to the basic TAS design



Terminal operators' perspective
Giuliano and O'Brien (2007) found no evidence for reduced waiting times or truck emissions in their study. The authors attributed the poor performance of the TAS to the circumstances under which it was implemented where an external legislator was the main prosecutor. This, they advocated, consequently resulted in a lack of buy-in and strategic commitment from the TOs which led to few or no attempts to streamlining the current operations. Giuliano and O'Brien (2007) more specifically reported that it was not compulsory for the TCs to use the TAS and no incitements or punishments were applied nor accomplished to encourage such usage. Some of the terminals coupled the TAS with a priority system at the gate through dedicated lanes to reduce the TTT, however, no priority was given to truck drivers using the TAS once inside the terminal, contrary to what was expected by the TCs.

The local regions' dependence on the terminals for international trade, according to Giuliano and O'Brien (2007) implied that the legislation did not enforce any further regulations on the container terminals. This, they advocated, risked being perceived negatively by the port and terminals who already had a general perception that the TAS did not relate to nor improve the terminal operations.

Giuliano and O'Brien (2007) presented several reasons for why the container terminals did not consider the TAS an effective operational strategy. Firstly, in many of the cases neither the port authorities nor the TOs considered the congestions and air pollutions related to port traffic to fall under their responsibility. Rather they viewed it as an increase in the data burden. Secondly, the TAS was considered an insufficient approach to improving information flows and reduce vehicle emissions compared to technology improvements such as optical character recognition and Global Positioning System. The benefits of the TAS were also seen as subordinate other measures already taken by the terminals; information regarding container availability was already integrated in the current information systems and investments in cleaner dock vehicles had led to significant reductions in vehicle emissions. Thirdly, the terminals did not regard the drayage TCs as customers and reducing TTT was therefore not considered an objective. Rather, they served shipping lines and major shippers and resources were hence allocated according to such contracts. Lastly, the TOs reported that an increase in the proportion of appointments would imply an increase in TTT for trucks with an appointment as then the queues would shift from one lane to another.

According to Morais and Lord (2006), the TAS showed significant performance levels but relied on extensive collaboration between the actors; Difficulties for TCs in predicting the arrival time at the container terminals implied problems with overbooking. This also followed as the systems were set-up so that several pick-ups could be booked for a single container. This allowed for the TCs to reserve multiple appointments to ease scheduling. Such system and uncollaborative set-up resulted in a high proportion of cancelled or missed appointments and ultimately in unoccupied gates intended for trucks with appointments; At the same time traffic lanes intended for trucks without appointments showed significant queues.

Trucking companies' perspective
As the terminals studied by Giuliano and O'Brien (2007) neither adjusted their yard operations to prepare containers for trucks with appointments to reduce the transaction time nor achieved

noticeable reductions in waiting times at the gate entry, the TCs' expectations of the TAS were not met. According to Giuliano and O'Brien (2007) the main failure of the TAS was the fact that it did not provide any clear incentives or benefits for the TCs. Huynh (2016) state that an optional TAS could negatively affect the time savings of the system. Likewise, Morais and Lord (2006) argued that to achieve buy-in from the TCs, clear benefits, and incentives to use the system must be provided. Although some of the terminals studied by Giuliano and O'Brien (2007) coupled the TAS with a priority system at the gate, the scant usage of the system meant that it was impossible to observe any positive effects of the TAS on the TTT; Ultimately the lack of benefits resulted in an overall negative perception of the TAS and insignificant use of the non-compulsory system. While most of the TCs used the system, it was to an insignificant proportion of their total amount of trips. Morais and Lord (2006) reported the same correlation between the proportion of appointments and transaction time; with a low level of usage in combination with dedicated lanes for the appointment trips, capacity limitations even resulted in an increase in the transaction time. They also explained a low level of usage as insufficient buy-in from the TCs.

While lacking the benefits expected by the TCs, using the TAS implied additional constraints for the TCs and required complying with rules regarding appointment lead-time and booking procedures (Giuliano & O'Brien, 2007). In addition to the appointment window constraints sometimes already prevalent at the containers' destination or pick-up point, the TAS, according to Namboothiri and Erera (2008), implies multiple constraints for the TCs. TCs scheduling and routing decisions according to Covic (2017) are based primarily on the dispatcher or recipients demand request in the absence of a TAS. The rollout of a TAS, however, implies that routing and scheduling must also be determined based on the availability and design of the TAS which may obstruct for the TCs to satisfy customer demands (Torkjazi, 2020). As multiple TCs are competing for specific appointments that relate to the container terminals peak hours, the TCs will have an especially difficult time in booking appointments based on productivity-maximization. As the TCs' revenue stream is based on a fixed price per move, but the drivers are paid by the hour, waiting times between container moves will hence increase the operating cost per move. To benefit rather than being obstructed by the constraints related to the basic TAS design TCs must carefully plan and organize its operations (Namboothiri & Erera, 2008). As reported in the article, the selection of appointments must be made with care as otherwise trucking operations productivity will suffer.

Although the TASs evaluated by Giuliano and O'Brien (2007) did not require from TCs to book a new appointment when an appointment was missed or cancelled, the system was perceived by TCs as insufficient, especially when scheduling several transactions in one day. This was perceived negatively as one delay then would cascade into the subsequent transactions resulting in several missed appointments. Zhao and Goodchild (2010) highlight that static time windows are often missed both because of foreseeable and unforeseeable external events. Morais and Lord (2006) also highlighted the insufficiency for TCs to book a appointment 24 hours in advance. According to the authors planning an exact arrival time in advance is difficult when there are multiple transactions taking place during the day each carrying individual constraints and circumstances which are difficult to plan for. Such circumstanced relate to traveling times, transaction times, and potential congestion, which ultimately imply great uncertainties for the truck driver. According to Morais and Lord (2006), for the TCs serving multiple container terminals this also meant keeping track on yet another information system (deriving from the lack of a consolidated information system across the container terminals).

2.4 Developments of the basic truck appointment system design

Ever since the studies by Giuliano and O'Brien (2007) and Morais and Lord (2006) were published, many alternative designs have emerged, both in practice and in academic literature. The development of alternative designs mainly derives from different perspectives on the TOs' responsibility and necessity regarding facilitating the TCs' operations. Abdelmagid et al. (2022) use the term *truck appointment scheduling problem* to describe the problem of applying TAS to on the one hand improve the performance of the terminal operations by managing the truck arrivals at the container terminal, while on the other hand considering and managing the constraints it enforces on the TCs as well as the TOs. The TAS problem is further complicated by the fact that the components of the TAS design usually benefits one of the actors while disadvantaging the other (Torkjazi, 2020), which will be elaborated upon in this section. Consequently, it is difficult to determine a solution that integrates the objectives of the stakeholders while still offering the TOs, who usually invest in the system, enough benefits. According to Torkjazi (2020) an effective TAS requires that the objectives, capacity, and constraints of both TOs and TCs are incorporated. This difficulty highlight why literature on the TAS predominantly focus on the drivers and barriers of one of the two stakeholder.

Figure 8 visualizes the basic TAS design (black cells) combined with the developed TAS components and options (white cells) incorporated in developed TAS designs. Both the components and options are categorized based on their dependence on other components and options and the lines in figure 8 highlight such dependencies. In figure 9 the drivers related to the basic as well as developed TAS designs, and their interrelations are illustrated; The white cells with bold lines mark the drivers perceived by the TCs and the grey cells mark the drivers perceived by the TOs. The cells in grey with bold lines mark the drivers perceived by both actors. The cells with black text mark the drivers related to the basic TAS design and the cells with green text mark the drivers related to the developed TAS designs. Similarly, figure 10 illustrates the barriers related to the basic as well as developed TAS designs and their interrelations. In the figure the cells with black text mark the barriers related to the basic TAS design and the cells with red text mark the barriers related to the developed TAS designs. Both hierarchies have been compiled according to the following logic: If underlying yet same-level drivers or barriers are perceived by different actors, their shared overlying driver or barrier is perceived by both actors.

Figure 8

The components and options constituting the basic and developed TAS designs

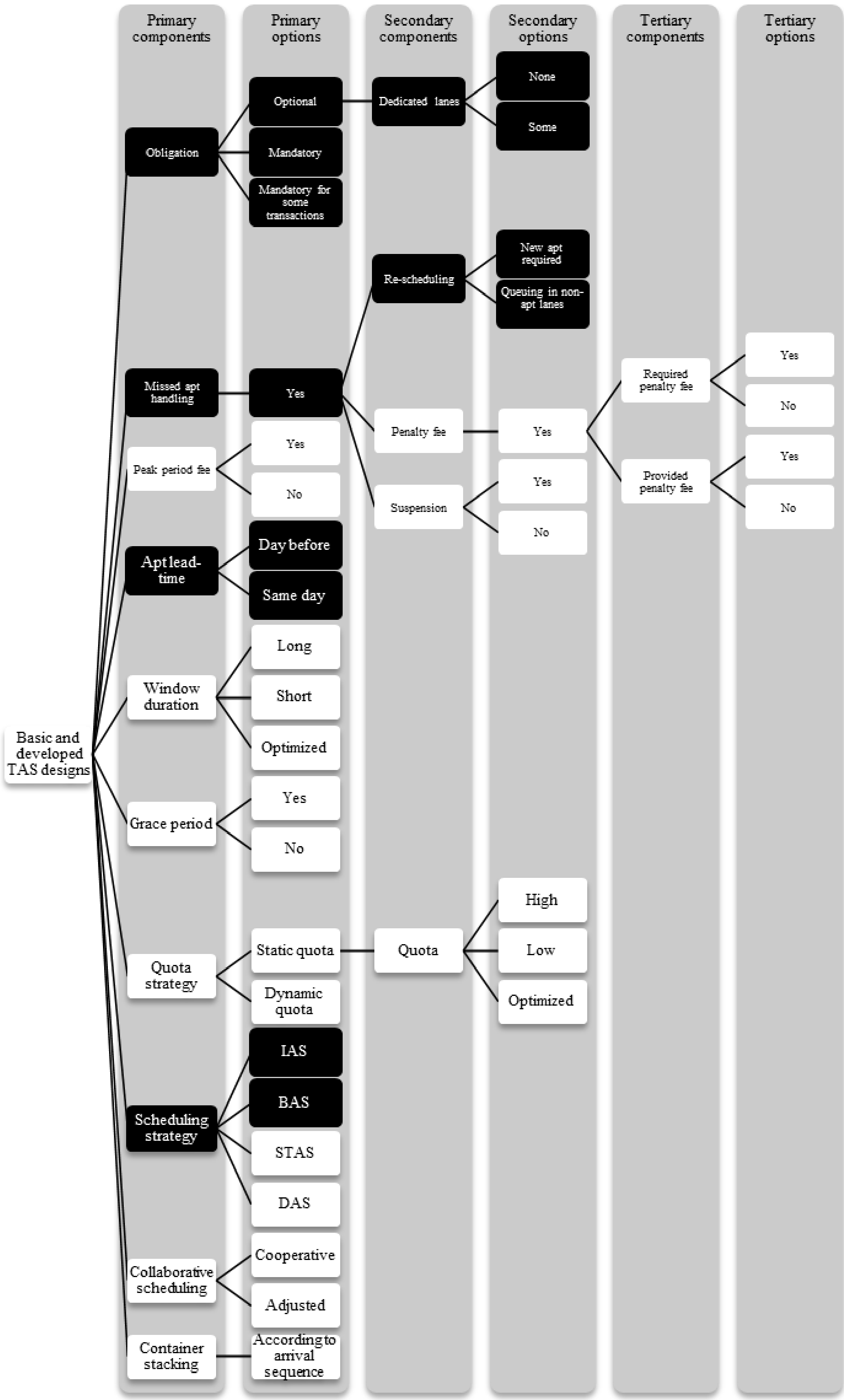


Figure 9

Drivers related to the basic as well as developed TAS designs

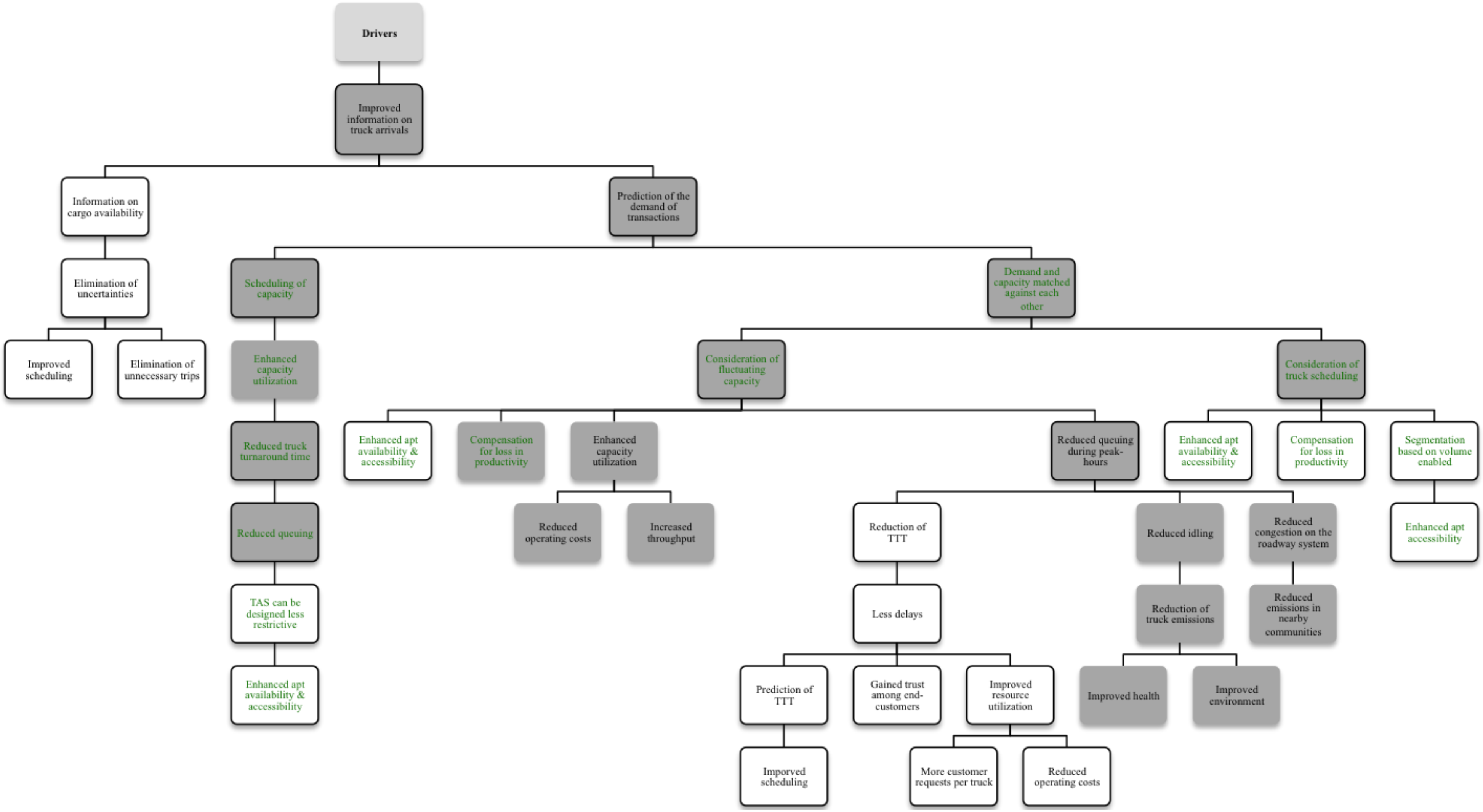
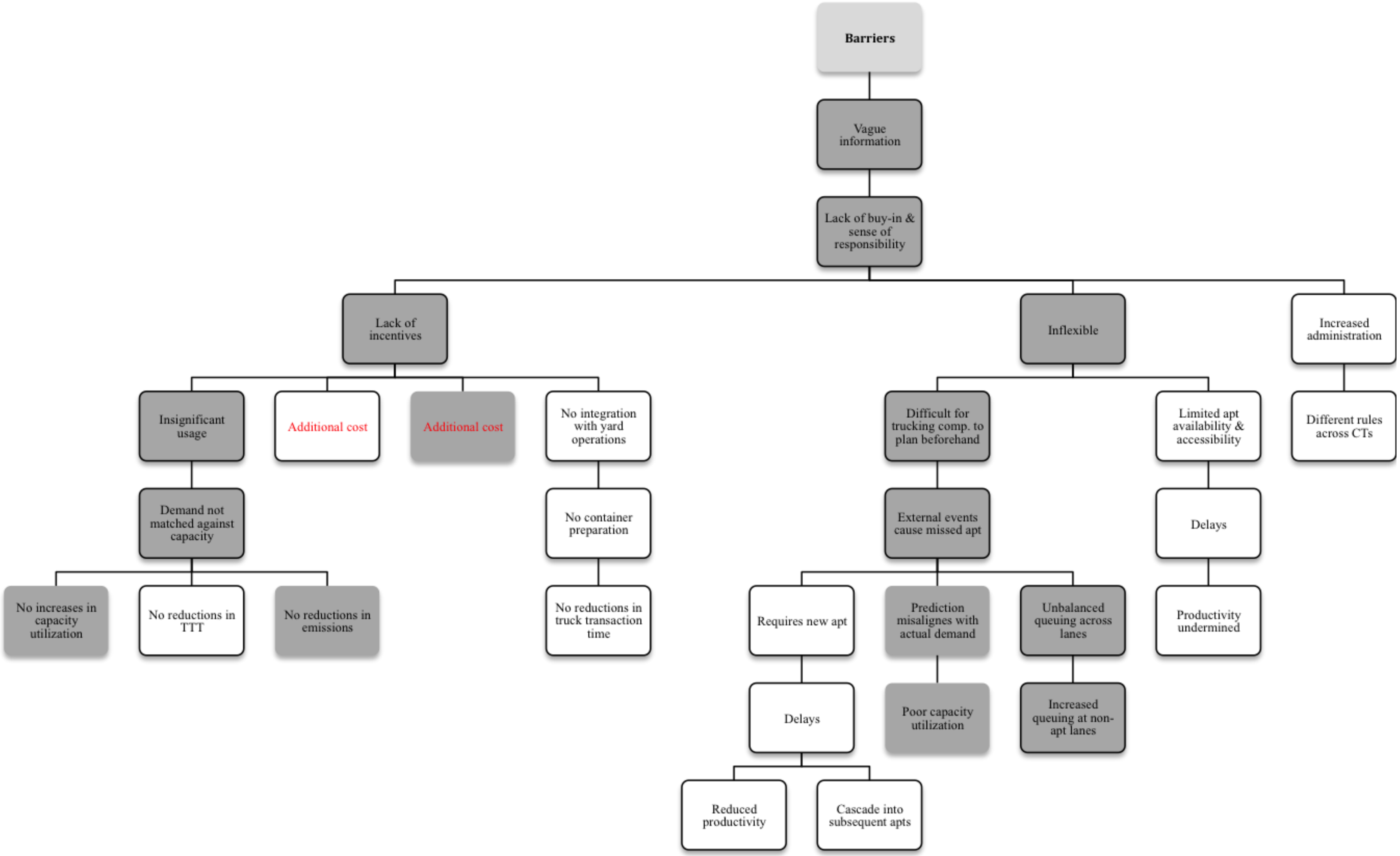


Figure 10

Barriers related to the basic as well as developed TAS designs



In this section the developed TAS designs presented in academic literature with the purpose of reinforcing fundamental drivers; mitigating fundamental barriers; or providing additional drivers, will be the sole topic. To enhance the presentation of the developed designs these will be divided into three categories that focus on: developed options, developed components; and integration with the yard operations.

2.4.1 Developed options of the basic truck appointment system's components

According to Huynh and Walton (2008) the studies performed by Giuliano and O'Brien (2007) and Morais and Lord (2006) highlighted container terminals lack of technical know-how regarding the components of the basic TAS design and their influence on the objectives of TOs respectively trucking operations. In this section subsequent literature that have sought to optimize components of the basic TAS design with the aim of incorporating the objectives of the two actors, are reviewed. Such components are appointment window duration, quota strategy, quota, scheduling strategy, and collaborative scheduling.

2.4.1.1 Developed options of the component appointment window duration

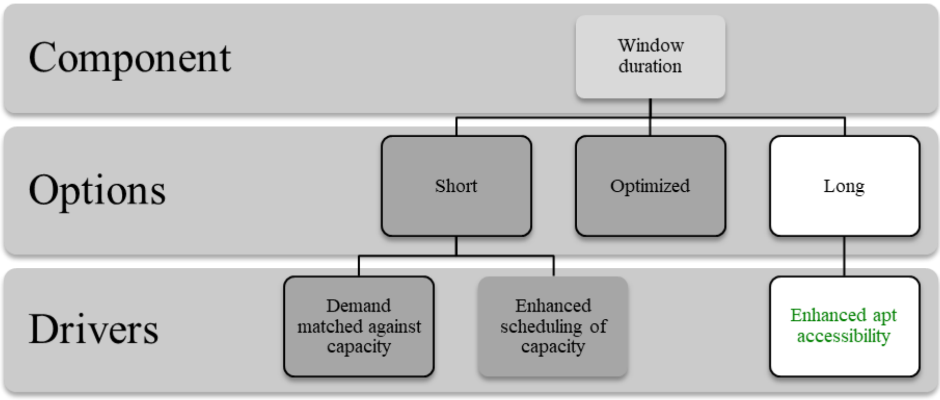
To level the arrivals throughout the opening hours, TOs provide TCs with arrival schedules. More specifically TOs divide the opening hours into several subsequent appointment windows based on a pre-determined timely duration of the appointment windows (Zhao & Goodchild, 2013). The application of a time window rather than a precise time, aims to account for disturbances the truck may encounter upon the appointment which otherwise would cause a delay (Torkjazi, 2020). This arrival schedule is then made available to the TCs who are expected to book usually one of the appointment windows (Abdelmagid et al., 2022).

Namboothiri and Erera (2008) evaluated TCs' productivity levels when applying three different window durations (30, 60, and 120 minutes). Window duration according to Namboothiri and Erera (2008) affects both terminal operations productivity as well as trucking operations productivity. According to the authors, shorter window duration enables better predications of trucks' arrival times for TOs but decrease productivity for TCs. Short time windows imply that TOs can better even out the terminal related traffic to improve resource utilization (Ioannou, 2006). However, shorter time windows also imply that TCs must increase their fleet size to meet them which adds to their costs (Ioannou, 2006) In their study the authors concluded that applying a window duration of 120-minutes enabled the TCs to serve more customers with a lesser fleet size. When reducing the window duration by 50% they proved that a 4% increase in fleet size was required to achieve the same service level. Although the authors advocate that TOs should consider the window duration from the TCs' point of view, they admit that the implications of a shorter window duration might not be too detrimental for the TCs' productivity levels.

Likewise, Torkjazi (2020) investigated how appointment window duration affected TCs' operating costs when TOs applied window durations spanning from 30 to 300 minutes. The authors concluded that narrower time windows resulted in higher drayage costs for the TCs and vice versa. In their study, testing a wider set of durations, they also proved that the impact of time window duration on trucking operations productivity levels were more decisive in the lower span and completely faded once the window duration exceeded 120 minutes. They, however, also emphasized that while shorter time windows imply higher drayage operating costs it also provides TOs with greater control over the arrival patter of trucks. Lastly, the authors highlighted the importance of a wider time window duration to minimize the number of missed appointments caused by travel time variation due to highway congestions. In figure 11 the drivers related to the component of window duration and its related developed options are illustrated. The cells with black text mark drivers already identified through the basic TAS design and the cell with green text mark a driver emerging from the related developed option.

Figure 11

The drivers related to the component of window duration and its related options



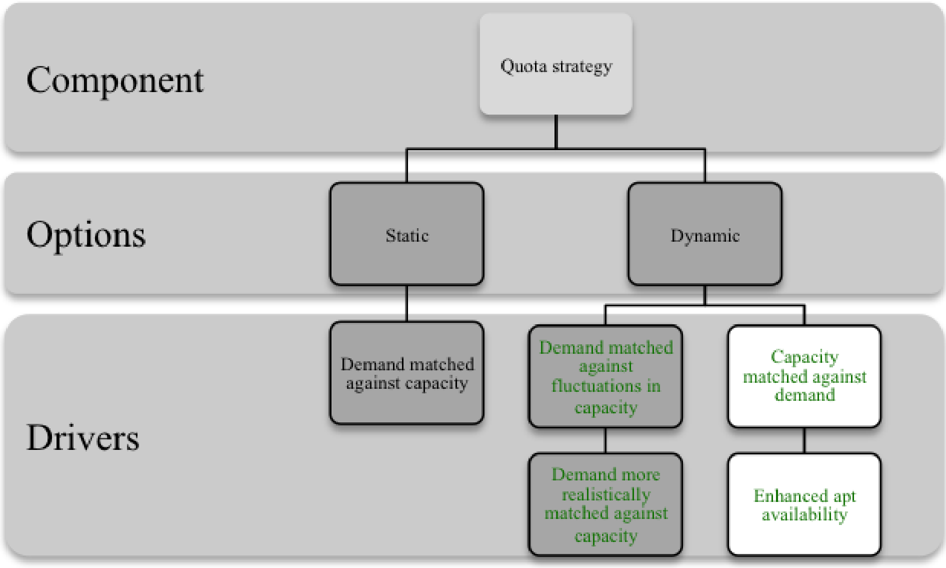
2.4.1.2 Developed options of the component quota strategy

Having determined an arrival schedule, a ceiling on the number of trucks allowed into a single appointment window is set (Torkjazi, 2020). This ceiling is referred to as quota and mirrors the number of trucks that can maximally be served by the available yard cranes. As the yard cranes also serves other operations such as vessel-, rail- and warehouse operations, the quota is also set to avoid conflicts across the different operations. When the quota is filled, TCs must choose a different appointment window.

According to Abdelmagid et al. (2022) there are mainly three different strategies for setting quotas: quotas are provided equally throughout the opening hours (hereafter referred to as static quota strategy); quotas are only provided within certain peak periods (hereafter referred to as dynamic quota strategy); and appointment windows and quotas are provided depending on the berthing schedules of vessels (Vessel Dependent Time Windows, VDTWs). While the two former strategies relate to whether quotas in a TAS should be static or dynamic, VDTW is forwarded as an alternative to the TAS. According to Chen et al. (2013b) the purpose and benefit of the VDTW is that it can more easily be integrated with the terminal operations than a TAS. As alternative solutions to improve the performance of the gate- and yard is out of the scope in this thesis report, only the former two will be presented. In figure 12 the drivers related to the component of quota strategy and its related developed options are illustrated. The cell with black text mark a driver already identified through the basic TAS design and the cells with green text mark drivers emerging from the related developed option.

Figure 12

The drivers related to the component of quota strategy and its related options



According to Huynh (2016) the strategy of setting fluctuating appointment quotas throughout the day offers greater flexibility to the TCs than a flat quota across all appointment windows; The dynamic quota strategy enables the container terminal to schedule resources based on the peak periods. However, the strategy also enables the terminal operations to take into consideration the available equipment and staffing level which varies throughout the workday. Although he states that static quotas imply less administrative work and better levelling of equipment and staff for the TO, such strategy he advocates is suboptimal; the fluctuations in container-volume resulting from vessel scheduling and seasonal trends, require a more realistic approach to the determination of appointment quotas. Moreover, as different types of transactions require different gate- and yard operations, processing time vary depending on the type of transaction. Consequently, the number of transactions possible to perform within an appointment window of a certain length must be reflected by the quota.

Focusing on the TCs' scheduling problems when utilizing the TAS, Namboothiri and Erera (2008) developed an optimization model for planning routing (pickup and delivery sequences) and scheduling based on the available set of appointments and for picking the best suited appointments. The aim with the model is to ensure maximum revenue for the TCs by enabling them to serve as many customer requests as possible while reducing the operating costs by minimizing the vehicle fleet size. When developing the model, Namboothiri and Erera (2008) found that the number of customer requests that can be served by a truck during a day is highly determinant of small variations in quota; In their study they found that truck productivity increases linearly with total quota (the sum of quotas set throughout the day), and that fleet size decrease linearly with an increase in total quota. Applying a total quota below the number of requested appointments implies that customer requests cannot be met. Increasing the total quota in that scenario implies the greatest rate of increase in customer requests that can be served. Conversely, applying a total quota above the number of requested appointments implies that the rate of increase in customer requests that can be served is lower. These relations hold to a large extent disregarding whether a static or dynamic quota strategy is deployed (assuming a window duration of 60 min). The authors therefore state that the minimum total quota should reflect the number of requested appointments. This relation was also confirmed by Torkjazi (2020) who varied the ratio of quotas to the requested appointments from 3:1 to 0.8:1. He proved that when decreasing the ratio from 3:1 to 1.5:1 only a slight linear increase in the TCs operating costs was evident. However, decreasing the ration from 1.5:1 to 1:1 implied a significant linear increase in the operating costs. When decreasing the ratio from 1:1 to 0.8:1 customer request is no longer possible to satisfy and hence the operating costs decrease (assuming a window duration of 60 min).

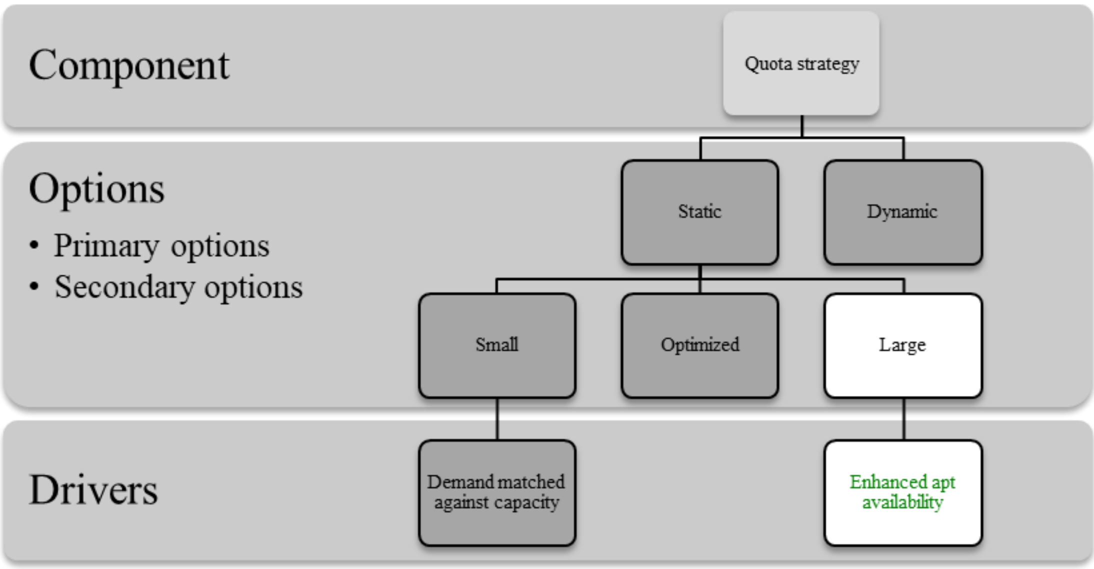
Torkjazi (2020) further proved that TCs' ability to perform dual transactions benefit from higher quotas; When more appointments are available for booking then the possibility to perform dual transaction increase. Dual transactions imply a lowered operational cost and the rate of cost decrease is greater the more dual transactions that are performed. However, Namboothiri and Erera (2008) concluded that truck drivers driving shorter distances and hence more locally, are less affected by total quota in ensuring high productivity levels than TCs acting less locally. This they advocate, likely derive from the fact that truck drivers driving short distances tend to achieve a higher proportion of dual transactions

Huynh and Walton (2008) evaluated the reduction in TTT and crane utilization when imposing different quotas in the Port of Houston's Barbours Cut Container Terminal. Imposing quotas in the time windows would apart from leveling the truck arrivals at the container terminal, mean that the TOs could schedule the terminal resources and capacity to maximize terminal efficiency and enable increased throughput (Huynh & Walton, 2008; Torkjazi, 2020). According to Huynh and Walton (2008), quotas positively impacted on both objectives up to a certain point after which the opposite effects were promoted; deploying very low quotas had negative effect on both TTT and crane utilization. The authors explain increased TTT to be a result if capacity exceeds the demand while not budging from the quotas. Such practice leaves the trucks waiting until the next appointment meanwhile the cranes are being underutilized and throughput is being undermined (Huynh & Walton, 2008; Torkjazi, 2020). High quotas, on the other hand, implies that resources can be fully utilized during peak-hours but at the expense of higher congestion (Torkjazi, 2020).

Huynh and Walton (2008) proposed a methodology that allows TOs to establish the optimum number of quotas regarding both TTT and crane utilization and hence both actors' objectives. The methodology was developed with the intention of being applied daily (thereby considering the appointment lead-time) to in a dynamic fashion match demand against available resources. This methodology more specifically implied maximizing the quota while not exceeding the resources of the terminal operations. Furthermore, the methodology bases the calculation of optimum quotas on the probability that certain proportion of no-shows, which allows for some slack. The authors however admitted that the methodology somewhat prioritized the terminal operations efficiency over trucking operations efficiency as a maximum TTT ensuring a certain service quality were not included in the methodology. In figure 13 the drivers related to component of quota strategy and its related developed primary and secondary options are illustrated. The cells with black text mark drivers already identified through the basic TAS design and the cell with green text mark a driver emerging from the related developed option.

Figure 13

The drivers related to the component of quota strategy and its related primary and secondary options

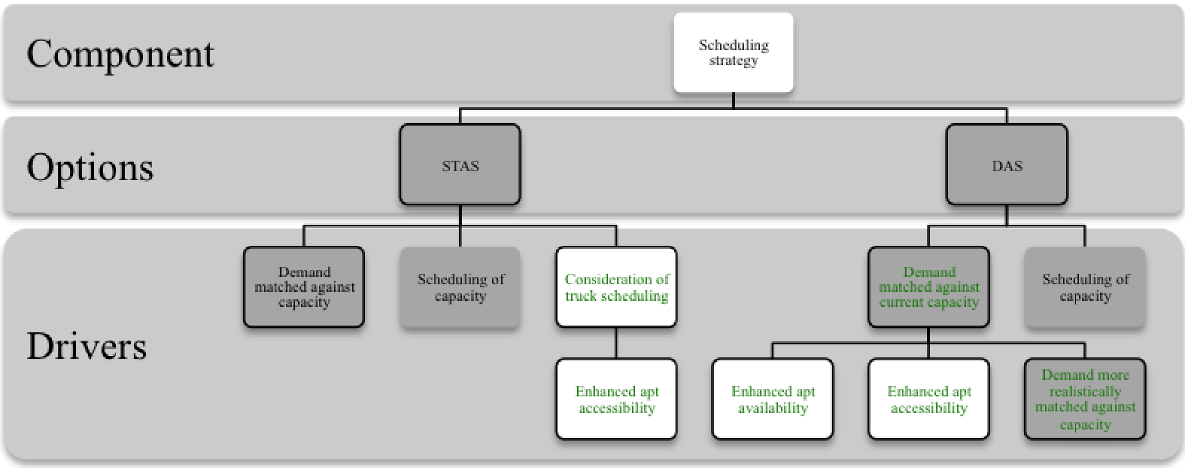


2.4.1.3 Developed options of the component scheduling strategy

According to Abdelmagid (2022) two additional scheduling strategies have arisen in literature to solve the truck scheduling problem, namely static appointment system (STAS) and dynamic appointment system (DAS). When comparing STAS and DAS, there are some differences between the two systems. The first major difference is that in STAS the TO provides the final appointment schedule and in DAS the system assists the truck driver to make appointment in uncongested periods (Chen et. al., 2013a). The second difference is that the booking in a STAS must be done a day in advance which affects the flexibility of the system (Torkjazi, 2020; Chen et. al., 2013a). Once all truck drivers have assigned a preferred arrival time, the algorithm optimize the appointments for the upcoming day to achieve as low average waiting time with as few changed appointments as possible in relation to the set quota for each appointment window (Chen et al., 2013a). DAS on the other is an provides an algorithm that make it possible for the TC to make same day appointments. DAS provides an algorithm that calculate the waiting times for each appointment instead of being limited by quotas as it is in STAS which give the TCs more appointment opportunities (Chen et al., 2013a). What happens in practice in a DAS is that the TCs log in to the online system and make a request for a suitable appointment. The appointment is then evaluated and if the suggested appointment result in a long queue or waiting times depending on the terminals current conditions, the suggested appointment will be declined, and another request will have to be made by the truck driver. However, since data is updated in real time, the system can assist the drivers to pick a relevant appointment based on the current situation at the terminal (Torkjazi, 2020). Therefore, the suggested appointment will vary depending on which appointments that have been confirmed prior to the booking. (Chen et al., 2013a). In figure 14 the drivers related to the component of scheduling strategy and its related developed options are illustrated. The cells with black text mark drivers already identified through the basic TAS design and the cells with green text mark drivers emerging from the related developed options.

Figure 14

The drivers related to the component of scheduling strategy and its related options



2.4.1.4 Developed options of the component collaborative scheduling

The lack of built-in flexibility in TAS designs and hence consideration for the TCs' constraints and objectives, is a recurring issue when dissecting early as well as recent academic literature on the TAS. While the issue has been one of the main reasons for optimizing the appointment window duration as well as quota, the more recent and pervasive method includes incorporating some level of collaboration between the TO and the TCs (Ioannou, 2006; Torkjazi, 2020). Such approach opens for other alternatives than simply having to accept or reject an appointment (Torkjazi, 2020). Hence, in this section different approaches aiming to improve the TAS, is presented.

Ioannou (2006) suggested a mandatory TAS, and an optimization algorithm based on the Traveling Salesman Problem with Time Windows (TSPTW) to achieve *cooperative time windows.* When coupled, the algorithm optimizes the time windows of the TAS by considering the objectives and constraints of both the TCs and the TOs. The optimization algorithm specifically evaluates the level of feasibility and operational costs when TCs include different wide time windows suggested by the TO (in the study these were four hours long) to different truck routes. Thereby it enables the TC to decide on a single narrow time window within any of the wide time windows (in the study this was two hours long) based on their constraints such as travel time, hours of operation, and time windows at the customer location. The narrow time window which is container-based and not truck-based, is then forwarded by the TC and the truck that performs the transaction to the minimal operational costs is chosen. The TO then modifies the narrow time window based on terminal resource limitations and the congestion in the terminal, and final time windows are forwarded to the TCs. If a TC does not consider any of the wide time windows operationally feasible, not economical, or both, it may negotiate for another set of wide time windows or reject them all.

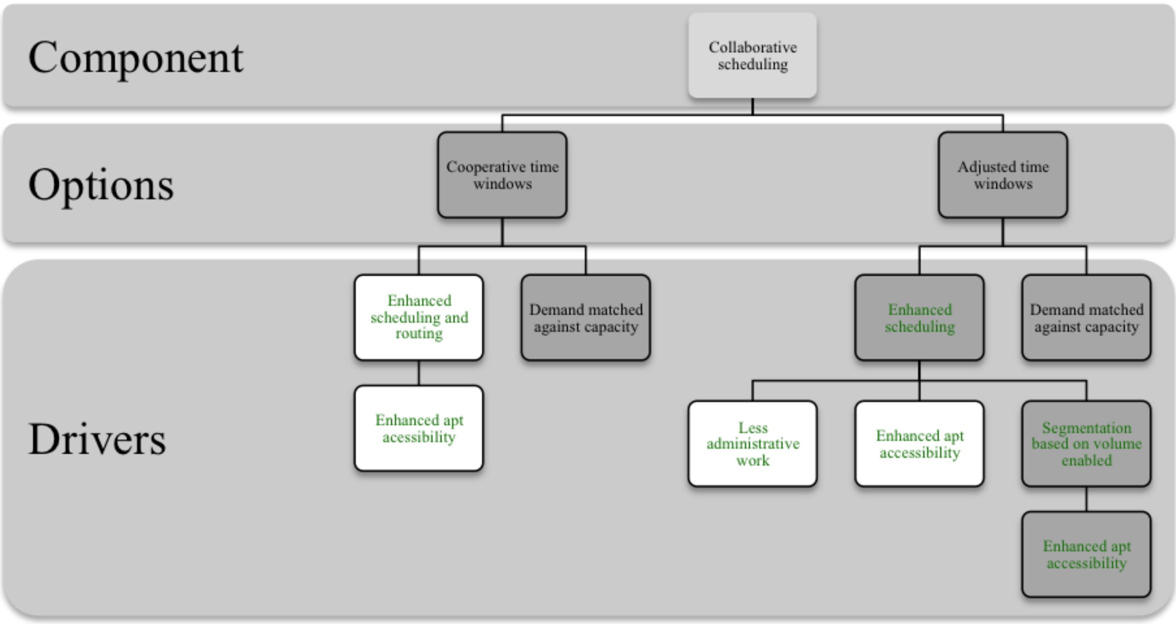
The author tested the TAS, and optimization algorithm based on data collected in several terminals by Giuliano and O'Brien (2007) and evaluated the effects on the container flows outside and within the entry gates through simulation models. In their study they found that when deploying the approach, both the ques within and outside the gate entries were reduced while terminal operations efficiency increased. Ultimately, the system solution enables TCs to meet customer requirements to a minimum operating cost while imposing a TAS with appurtenant time windows to improve terminal operations efficiency.

Torkjazi (2020) advocates that the negotiation process between TCs and TOs regarding appointments such as that proposed by Ioannou (2006), is not only impractical but implies unfair handling of different TCs. Instead, he proposes a TAS and a mathematical model in which TCs request an appointment the day before that is either confirmed or replaced with another mandatory appointment by the TO. Although altered mandatory appointments may require rescheduling and rerouting of trucks, the suggested TAS is forwarded as an optimal and equitable approach; According to the author, the objective of reducing TTT through appointment quotas and the objective of reducing TCs operating costs, are conflicting objectives that need to be balanced. Experimental results carried out by the author showed that the number of vehicles necessary decreased as well as the operating costs of TCs when the proposed TAS was applied. The operating costs were reduced by 11,5% through the proposed TAS in comparison to TASs that only focuses on minimizing the TTT. The study is based on a port setting like the Ports of Los Angeles and Long Beach (evaluated by both Giuliano and O'Brien (2007) and Morais and Lord (2006)) and the TAS was further experimentally tested based on real port data.

When evaluating all the appointment requests for a specific day, the mathematical model incorporates non-uniform appointment quotas reflecting daily fluctuations in terminal resources, labour, and expected operations. Thereby it considers the objectives and constraints of the TO related to gate- and yard congestion. However, the TAS and model also respects the objectives and constraints of the individual TCs as it considers the appointment windows at the end-customers location; The TAS design is integrated with the drayage scheduling model developed by Shiri and Huynh (2016) which considers the time for carrying out different activities related to import and export transactions. The suggested TAS and mathematical model considers the trucking operating costs of waiting in queues at the gate entry, of changing desired appointments, and of changing one or more of consecutive appointments carried out with the same truck. By considering the time-gap between two consecutive appointments when making changes to an appointment request, the risk of missed appointments due to a too short time-gap is minimised. Moreover, the algorithm limits the increase in trucking tour costs deriving from changes being made to the preferred appointment; this is enabled through a cost ceiling which is further determined on a company-individual basis. A TC scheduling several appointments at the container terminal earns a lower cost ceiling than a low-volume TC. High-volume TCs are in this way incentivised and prioritized as a greater proportion of the appointment requests are met. Segmentation and targeting of high-volume companies more specifically strengthens such relations as the value proposition is then enhanced which ultimately strengthens the TOs competitiveness (Kotler et al., 2017). In figure 15 the drivers related to the component of collaborative scheduling and its related developed options are illustrated. The cells with black text mark drivers already identified through the basic TAS design and the cells with green text mark drivers emerging from the related developed options.

Figure 15

The drivers related to the component of collaborative scheduling and its related options



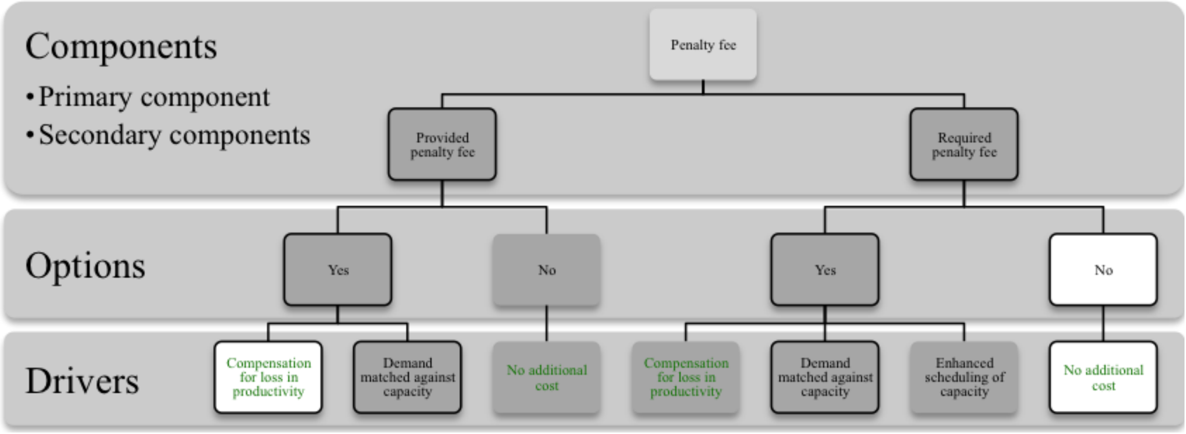
2.4.2 Developed components of the truck appointment system

This section aims to provide an overview of additional TAS components identified in literature other than the ones already highlighted from the basic TAS. Such components are penalty fee, suspension, grace period, and peak-period fee. Each component will be described together with its options and how it relates to the drivers and barriers.

Penalty fee: One component is penalty fee that can be built into the agreements of business rules (rules that define how the operations should be performed) (Huynh et al., 2016). Penalty fees are set to reflect if the expected service level is not met from neither the TCs nor the terminal to cover loss in productivity for the other actor. The fee for TCs (hereafter referred to as required penalty fees) can be charged for cancellations of appointments, no-shows, or the TO could be charged (hereafter referred to as provided penalty fees) for not performing within the expected service level, working as an incentive to meet commitments. The fees are generally more acceptable if the TO is open with how the generated revenue will be used (Huynh et al., 2016; Maguire et al., 2010). Since an appointment is an agreement between the terminal and the TCs, TCs battle to have penalties for both actors if compliance is not met and not only for the TCs (Huynh et al., 2016). When designing the required penalties, it is important to base the criteria on premises that the actors can control, for example to count the arrival of a truck in the beginning of the queue instead of at the gate since the truck driver cannot control the queue time. Port of Vancouver and port of Sydney are two ports that comply to a two-way penalty system. The TO in port of Vancouver compensates the truck drivers by providing a penalty fee if the turn time within the terminal is more than 90 minutes. TCs on the other hand cancel their appointments prior to the cut off time (where it is accepted to make cancellations), to avoid a penalty fee (Huynh et al., 2016). In figure 16 the drivers related to the developed component of penalty fee and its related options are illustrated. The cells with black text mark drivers already identified through the basic TAS design and the cells with green text mark drivers emerging from the developed component and its related options.

Figure 16

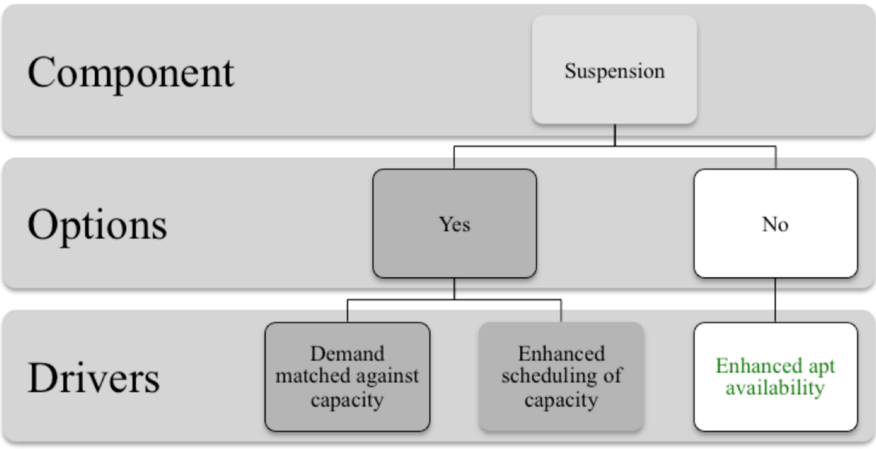
The drivers related to the component of penalty fee and its related options



Suspension: Another non-economical penalty if compliance is not met by TCs is to restrict a customer from making new appointments due to example unpaid fees, missed appointments or other oversteps (Huynh et al., 2016). In figure 17 the drivers related to the developed component of suspension and its related options are illustrated. The cells with black text mark drivers already identified through the basic TAS design and the cell with green text mark a driver emerging from the developed component and its related option.

Figure 17

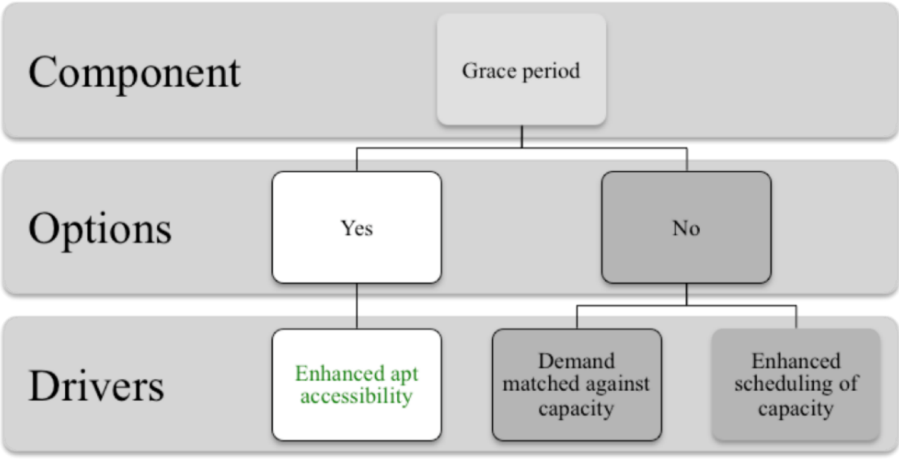
The drivers related to the component of suspension and its related options



Grace period: is described as a period outside of the time window in which the TCs do not have to pay any penalties, giving the TCs a longer appointment window to arrive within (Huynh et al., 2016). This safety margin allows the TCs to retain flexibility in their arrivals that might not be as precise due to disruptions that could occur during the trips. The grace period is decided by the TO and is adapted differently by different terminals; it can differ in length, number of periods, and how trucks that arrive within the grace period are prioritized compared to those who arrive within their assigned appointment window. By not applying any grace period the narrower time windows will enhance the possibilities for TOs to schedule their capacity based on more precise arrival patterns (Torkjazi, 2020). In figure 18 the drivers related to the developed component of grace period and its related options are illustrated. The cells with black text mark drivers already identified through the basic TAS design and the cell with green text mark a driver emerging from the developed component and its related option.

Figure 18

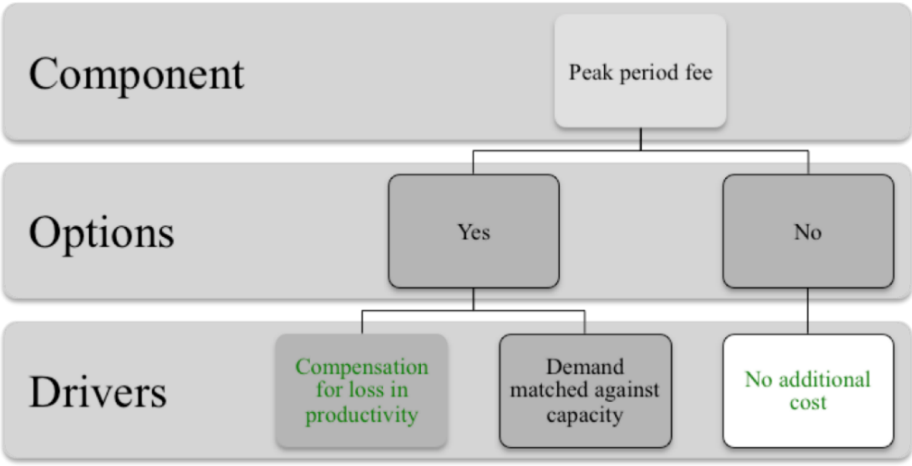
The drivers related to the component of grace period and its related options



Peak period fee: Peak period fees are used for charging TCs that arrive during peak periods while other times being free of charge to encourage TCs to arrive during off-peak periods (Maguire et al., 2010; Huynh et al., 2016). Morais and Lord (2006) describe the Pier pass program that was introduced in 2005 and that aimed to reduced truck congestion at peak periods. The terminal offered pick-up and drop-offs of containers at weekends and during nights. Financial incentives were enforced for container transactions that took place during off-peak hours to incentivise cargo owners to move goods during nights and weekends. According to Huynh et al. (2016), the ports of Los Angeles and Long Beach implemented peak period fees and it resulted in less traffic during peak hours since the traffic was shifted to nights and weekends. However, the traffic during peak hours did not decrease to the extent as expected. The peak period fee was introduced for every weekday between 08.00-17.00, hence not managing peak periods in the morning and afternoon peak periods. The truck drivers' perceptions of the success of peak period fees differed and an explanation to the different perceptions related to if the TCs could increase their earnings for off-peak periods or not. If not, they were left with longer working hours without increased earnings (Giuliano & O'Brien, 2008). In figure 19 the drivers related to the developed component of peak period fee and its related options are illustrated. The cell with black text mark a driver already identified through the basic TAS design and the cells with green text mark drivers emerging from the developed component and its related options.

Figure 19

The drivers related to the component of peak period fee and its related options



2.4.3 Integrating the truck appointment system with the yard operations

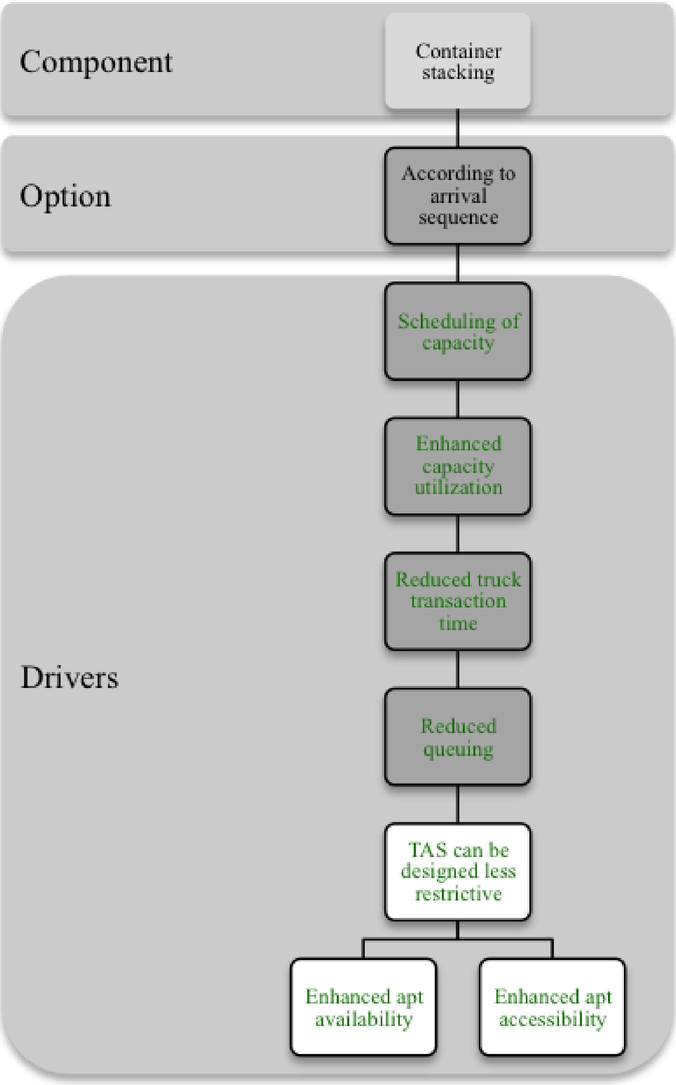
As Giuliano and O'Brien (2007) identified the lack of consideration taken to the yard operations when implementing the TAS, it opened for a new research area which several authors have tackled. This research area primarily focuses on the operational methods and effects when utilizing TAS to improve yard operations. In this section such methods and effects will be presented.

Actions that aim to reduce unnecessary activities performed in periods of peak hours when the capacity is fully utilized, are, according to Covic (2017) vital. Maguire et al. (2010) state that TOs must vouch for and harness the TAS by organizing yard operations to minimize truck transaction time. Re-marshalling implies that re-stacking of containers take place in down-time periods to match the container stacking sequence against truck arrival sequence. Thereby, re-marshalling aims to minimize the number of shuffle moves during container retrieval operations. To improve yard crane productivity and to reduce truck transaction time for import transactions, Zhao and Goodchild (2013) incorporated the TAS with a container location assignment algorithm. By feeding the algorithm with truck arrival information gathered by the TAS, the stacking sequence is matched against the sequence of truck or truck group arrival. Similarly, Covic (2017) proposed and experimentally tested the approach of combining a TAS with an algorithm to solve the re-marshalling problem for import container transactions. According to the author the re-marshalling problem (RMP) typically occurs in a yard block where systems of Rail-Mounted-Gantry-Cranes (RMGCs) are used. The algorithm and TAS was therefore tested through a simulation model of a yard block with different RMG-systems. In the approach the TAS provide with improved and increased information regarding trucks' appointment times which are fed into the algorithm to determine the retrieval sequence and hence the stacking sequence of containers. The algorithm then provides the RMGCs with a re-marshalling schedule that are added to other jobs performed by the RMGCs such as retrieval-, storage-, and shuffle moves. The deployed TAS design further lacks the component of quota with the aim of maintaining flexibility for the TCs.

Covic (2017) tested the effectiveness of his approach against yard block productivity by measuring truck transaction time respectively crane workload by measuring fluctuation in truck transaction time. In comparison to category stacking which, according to the author is the typical way of stacking in theory and practice, the approach enabled significant reductions in shuffle moves and appreciable reductions in re-marshalling moves due to improved information quantity and quality. By reducing the number of unproductive moves during retrieval operations by re-marshalling during off-peak hours, reductions in truck transaction times are achieved and thus the approach showed significant improvements in yard block productivity. Moreover, the approach showed important improvements regarding fluctuations in truck transaction times because of performance improvements in yard productivity. These conclusions were likewise drawn by Zhao and Goodchild (2010) in their former study (when assuming that trucks are served according to a first-in-first-out principle). According to Covic (2017) this implies that crane workload can be balanced without imposing quotas to improve yard block productivity while still ensuring flexibility for the TCs. Significant reductions in truck transaction time combined with preserved flexibility, the authors advocate should incentivize TCs to utilize such system. The appointment lead-time can be utilized to ensure that the booked import transaction can be prepared. In figure 20 the drivers related to the developed component of container stacking and its related option are illustrated. All cells have green text marking that none of them emerged from the basic TAS design but instead entirely emerge from the developed component and its related option.

Figure 20

The drivers related to the component of container stacking and its related option



Different TAS designs were tested by both Zhao and Goodchild (2013) and Covic (2017) to optimize the information fed into the yard operations. They combined their approaches with various settings regarding the proportion of on-time truck arrivals, the obligation to book appointments, the appointment window duration, and the appointment lead-time. This enabled assessment of their respective influence on the proposed algorithms' performance.

Obligation: In order to minimize the shuffle moves and the number of re-marshalling moves to do so, it was concluded that the algorithm benefitted the most from maximizing the proportion of booked appointments, however, not necessarily containing reliable information (Covic, 2017); When the system use is not characterized by significant deviations nor a large number of no-shows, having information at all was stated as more important than it being reliable. According to Zhao and Goodchild (2013), the benefits of the system are entailed even when arrival information is only gathered from a partition of the trucks. Reliable information entail stacking containers in a sequence that to a larger extent correspond to the arrival sequence.

While the authors for these reasons advocate for a mandatory TAS they state that the apparent benefits for the TC with the system should be enough motivating.

Appointment window duration: The performance of the algorithm varied somewhat depending on the RMG-system deployed as they exhibit different capabilities regarding handling very precise information (Covic, 2017). Overall, the window duration and hence the truck arrival precision, did not show any significant effects. A window duration of half a day based on an average dwell time (the time a container is waiting within the container terminal before being picked up by the next transport carrier) of five days, was generally enough to reduce the number of shuffle- and re-marshalling moves when aiming to preserve system flexibility. Especially for low resource RMG-systems lacking crossing capability, this held true. In their previous study, Zhao and Goodchild (2010) likewise proved that only deploying two windows throughout the opening hours of the container terminal, imply significant improvements in the received truck arrival information that is utilized to manage container rehandling. According to Zhao and Goodchild (2013), minimizing the duration of the appointment time window implies a positive influence on the system performance while dwell time is short. However, high dwell time reduce the effect of the window duration and hence no significant performance effects are achieved.

Appointment lead-time: Zhao and Goodchild (2013) concluded that maximizing the appointment lead-time have a positive influence on yard crane productivity and correlate with dwell time. As forwarded by Covic (2017) only extreme lead-times that are not realizable in practice as the planning horizon for TCs is limited, had any significant effect on the performance indicators. Assuming a five-day average dwell time, the author stated that an appointment lead-time of 12-24 hours is sufficient for re-marshalling to ensure maintained flexibility for the TCs.

Arrivals deviating from the appointment window and no-shows: All experimental tests carried out by Covic (2017) showed that truck arrivals deviating from their respective appointment window affected the performance of the system; Higher deviations spiralize the negative effects by inducing the number of unproductive moves caused by insufficient potential for re-marshalling. Ultimately, they increase the truck transaction time while implying increased crane workload. The authors therefore recommend that no-show should be discouraged. Zhao and Goodchild (2013) evaluated the robustness of the system by incorporating varying levels of inaccurate truck arrival information. The authors showed that the algorithm does not require the exact sequence of truck arrival information to obtain the desired benefits and only 20-40 percent of complete sequence of trucks were needed to maximize the rehandling operations. Desirable yard crane productivity and truck transaction time is accomplishable disregarding a 50% proportion of inaccurate truck arrival information if trucks do not arrive more than four hours in advance or after the appointment.

2.5 Business models in the freight transportation sector

A business model can be used to conceptualize or exploit a future business opportunity(Zott & Amit 2010). To design and re-create the current business model is a difficult task but still important to remain competitive. The business model mainly focuses on a focal firm, but it extends the boundaries to include other stakeholders as partners, suppliers, or customers.

Therefore, activities both inside the focal firm as well and partners' activities need to be addressed in the business model. The port community consist of interdependent operational companies that share activities and information, becoming stakeholders in a system that enable global trade (Córdova & Durán, 2014). Together these stakeholders need to develop and integrate solutions to pursue operational excellence and create a port community that is competitive and can compete against other national and international ports. Furthermore, not all the stakeholders in the community are directly affected by the service and hence the business model. However, these stakeholders are a part of the logistic chain and need to create a collaborative system by sharing strategic and operational data required by other to improve their performance.

Van den berg (2015) investigated if the port is a two-sided market but could conclude that a seaport does not meet the criteria for being a two-sided market. Instead, the author describes the seaport as a multiproduct company that vertically provide the supply chain members with products and services. Important to notice is the pricing structure at a seaport where all charges are typically influencing the transport cost that is transferred to the end customer (the importer or exporter), and that there are no formal business relations between the stakeholders at the seaport. This strengthens the vertical relation between the seaport and the stakeholders. According to Iivari et al. (2015), even if business models most often are applied to a specific company's offerings, it also serves a wider purpose in an ecosystem to understand the external environment. As an ecosystem is integrated between different firms, it is important to notice co-dependent processes and how value is co-created to diffuse the individual firm's business model into a co-developed business ecosystem.

2.5.1 The Business model canvas framework

Business model canvas is a framework commonly used to innovate the business model and to visualize how to capture value in one-sided markets with a buyer and a seller perspective (Taipale-Erävala et al., 2020). What the business model canvas does is that it presents nine different aspects that should be considered when setting a company's business. The aspects of the business model canvas are described by Taipale-Erävala et al. (2020) as follows:

Key partners: are important stakeholders in cooperation or collaborations that can make the business model feasible or strengthen it. They can be suppliers or other partner that can share resources or optimize the operations.

Key activities: are the activities needed to run the operations and to achieve the wanted value proposition to ultimately satisfy the customer demands.

Key resources: are the resources that make it possible to achieve the value proposition and to perform the key activities that makes the business model feasible.

Value proposition: is the value that the combinations of products and services add to the customers. By expressing a customer need the value proposition is there to solve those needs and to differentiate from other solutions.

Customer relationships: describe the relationships to the customer segments and influence the customer experience. The relationships often aim to increase sales or to retain or gain customers.

Channels: are the interfaces where the company interact with the customer to deliver the value proposition, for example sales, distribution, or communication channels.

Customer segments: are the different customer segments that need to be understood and incorporated into the business model.

Revenue streams: are the revenue that the products or services generate for the company providing the offer. Revenues are typically supposed to be maximized by identifying how much the different customer segments are willing to pay for the offering.

Cost structures: describe the costs related to the proposed business model and is usually aimed to be minimized.

3 Methodology

In this chapter the methodology for the study is presented. In section 3.1 the research strategy and philosophical assumptions are presented followed by the research design and sampling strategy in section 3.2. In section 3.3 the process of conducting the literature review and formulation of the research questions are outlined. The research method is given a thorough description in section 3.4. In section 3.5 the consideration of the quality criteria are discussed. Lastly, ethical considerations are addressed in section 3.6 followed by the societal and ecological considerations in section 3.7.

3.1 Research strategy and philosophical assumptions

Bell et al. (2019) describe research strategy as an overarching strategy of how researchers conduct research. The differences between the qualitative and the quantitative research strategy, run deeper than that quantitative research applies quantitative measurements and that the other does not. Their differences also lie in the relations between theory and research, ontology, and epistemology. Ontology refers to how reality is interpreted and is interconnected with epistemology that incorporates how reality can be understood to create knowledge and theory.

Quantitative researchers mainly rely on a deductive approach towards theory and research where theories are tested (Bell et al., 2019). This approach can be explained by the ontological assumptions of objectivism, viewing reality as objective, with the epistemology of positivism that reality consist of theories that is out there to observe and discover. This differs from a qualitative research strategy applying an inductive approach towards theory and research, meaning that theory can be built and created based on reality. This relates to the ontology of constructivism, that theory can be shaped by the researcher and the epistemology interpretivism meaning that theory can be created based on social interactions and differences between people without one single truth (Bell et al., 2019). The research questions involve generation of theory based on peoples' opinions which, according to Bell et al. (2019), relate to the qualitative research strategy, designs, and methods. The latter strategy of qualitative research constitutes the applied research methodology and further reflects the philosophical assumptions made by the authors of this master thesis.

3.2 Research design and sampling strategy

Bell et al. (2019) describe how the multiple-case study approach implies detailed and intensive analysis of two or more cases. Stake (1995) adds to such description by highlighting its outcomes and drivers which include to understand, highlight, and compare the nature and complexity of the cases. Moreover, according to Eisenhardt (1989) examining multiple cases rather than one case benefit the theoretical analysis as the context then to a greater extent is incorporated into the analysis. These qualities and characteristics of the multiple-case study design were considered to fit well with the aim and research questions of the study; In the thesis project a narrow but rather unexplored matter was under study which was considered to benefit from analyzing multiple cases.

When selecting the multiple-case study approach as research design the research aim and questions thus partially acted as outset. Although the co-supervisors had initially requested a multiple-case study design, this was not definitively decided upon until a more specified research aim had been formulated. However, as the project is shaped according to the co-supervisors` preference for a multiple-case study approach, the formulation of the research questions was naturally influenced by that preference through adherence to the co-supervisors. According to Bell et al. (2019) either one of the directions are common and can be applied although the approach in which research questions influence the selection of the research design receive greater attention than the approach in which the selection of research design influences the formulation of research questions.

The unit of analysis constituted container terminals where landside operations related to the service of container transactions between a TO and TCs take place. According to Heilig and Voß (2017) the design and operation of TAS has tended to fall under the responsibility of TOs or port authorities. TCs are instead users of the system. When addressing the research questions, TOs and TCs hence represented the primary source for data collection

Dyer and Wilkins (1991) express critique towards the multiple-case study design by advocating for an overly focus on the comparison between cases over examination of the individual cases. This, they suggest, undermines the qualitative approach where the open end and intensive examination represent main objectives. Such critique was considered in the project by emphasizing the individual analysis of cases rather than the collective one. The primary limitation of the case study design in general, Bell et al. (2019) highlight is heavily related to its idiographic approach; most researchers agree that the findings deriving from case study research is not generalizable over time and space. Adhering to such stands, the findings derived from this thesis project do not claim to provide a single solution to be generalizable to other cases, instead they are intended to improve the understanding by providing important information that needs to be considered when designing a TAS. Also, for this reason, other criteria than those concerning external validity and quantitative research in general, was applied when evaluating the quality of the applied research design. This is further elaborated upon in section 3.5. However, to improve the validity of the study each case was described in as much detail as possible to provide an understanding for the context at each terminal without revealing the anonymity of each case.

According to Stake (1995) maximization of learning should be the primary reason for selecting a specific case. Hence, criteria for selecting cases with the highest potential in maximizing the learning outcome regarding the research questions were developed. By first relating the research questions to the different aims of the five types of cases proposed by Yin (2003), an initial set of criteria were established. The research questions were considered best represented by the aims of the unique case and the revelatory case; the research questions address state-of-the-art TASs, and the inductive research approach implies an intent of presenting theory not yet presented in the related field of research. However, before any cases were identified and sampled, an opportunity relating to the co-supervisors' current relations with TOs were considered. Because of the considerable timeframe of the project such current and established relations were highly valuable to make the process of collecting data efficient. Through the application of the categorization of cases by Yin (2003) and the project opportunity, several potential cases were identified, and relevant persons were contacted for an interview request.

The criteria of uniqueness and revelation derived from the categorization of cases proposed by Yin (2003) were, however, further refined before initiating the definitive sampling. As the research questions and aim deals with the process of designing a TAS, both a case facing the transition as well as cases having undergone the transition, were considered two important groups to incorporate in the study. By ensuring high inter-variation between the two groups of cases in terms of the application of state-of-the-art TAS, new theory answering to the research questions would be enhanced. However, aspects of high intra-variation within the groups were overseen because of the objective to conduct thorough analysis rather than comparing aspects of variation. While the latter category of cases (those having implemented a TAS) were subject to sampling through related criteria, the former was decided upon based on the project context; As the thesis project had been initiated by the co-supervisors based on that specific case, no other cases and hence no additional criteria were considered.

The cases in the latter category were identified and sampled based on criteria relating to the prevalence of a container terminal and a TAS. These criteria were drawn on from the research questions and thus replaced the criteria derived from the categorization of cases proposed by Yin (2003); The criteria are considered more specific yet comprising the important aspects of Yin’s definitions.

3.3 Literature review and research questions

The literature review was conducted in a narrative approach. Bell et al. (2019) advocate that a narrative review is suitable for interpretive researchers, aiming to improve the understanding of the research area. With a somewhat wider scope, the narrative review allows the researcher to be less constrained by explicit inclusion or exclusion criteria which enables including relevant theories during data collection that were not initially anticipated.

The literature review toke place both concurrently with the development of research questions, until a final set of research questions had been formulated, as well as after they had been formulated, as a means for addressing them. Reviewing current literature is an essential part of confirming the importance of the research questions and to identify gaps in the literature (Bell et al., 2019). Although a general research topic and a preliminary aim with the study were presented by the co-supervisors at the project outset, its direction needed further specification to align with the project constraints. Furthermore, the initial literature review acted to gain essential knowledge about the industry and related problems. Hence, initially a broad range of literature addressing the preliminary aim and topic were reviewed. Apart from using a wide list of related key words when searching for literature, snowballing was employed with regards to references and citations of relevant sources of literature.

When having received significant insights into previous research in the area, a first set of research questions were formulated. These have undergone several iterations of refinement based on the findings in the literature and after consultation with the co-supervisors. Bell et al. (2019) highlight that it is a general strategy within qualitative research to start with a set of broader research questions and then to gradually specify them in parallel with data collection. The research aim and questions appear in section 1.3.

Another round of literature review was conducted, however, in a more structured manner to address the research questions more efficiently. To answer the research questions, relevant theoretical data according to Bell et al. (2019) should be collected and presented accordingly. In this study a certain width was sought for and hence both a holistic as well as a detailed view of the different TAS designs were of interest. For this reason, significant key words were deployed in the search for literature. Bell et al. (2019) advocate that using key words enhances a relevant and bounded literature set. At the initial stage of the research project, the involved key words were rather generic and primarily included topics at a certain level of analysis. The following keywords were to find relevant articles:

- Business model
- Gate appointment system
- Terminal appointment system
- Truck appointment system

3.4 Research method

As previously mentioned, the case study design according to Bell et al. (2019) is often coupled with qualitative research methods as they collectively greatly enhance the purpose of qualitative business research. Furthermore, qualitative research methods are helpful as they provide with details and nuances which enable a rightful presentation of the nature and complexity of cases. Moreover, to ensure good quality of the theoretical reasoning and thus the theoretical analysis which, according to the authors constitute critical steps of the inductive approach, attention was highly focused on the procedures related to data collection.

Semi-structured interviewing was selected as the method for data collection in this thesis project. According to Bell et al. (2019) semi-structured interviewing is commonly preferred over unstructured interviewing when the qualitative research project has a rather clear focus at the outset as it enhances addressing of specified research questions. Moreover, the authors argue that in multiple-case studies some degree of structure is necessary to enable comparison between cases.

According to Bell et al. (2019) qualitative interviewing has both merits and demerits in relation to other qualitative methods. Out of these some are of greater relevance to this thesis; Among the merits with interviewing is firstly the possibility to detect aspects of motives, perceptions, and attitudes that may not be detected through observation. Secondly, interviewing is a lot more time-efficient and hence also less intrusive on the participants. Thirdly, interviewing has a greater breadth of coverage than observations which may only be possible to perform within certain groups of, for example, occupations. On the other hand, demerits related to qualitative interviewing in relation to other qualitative methods include greater lack of naturalism, greater reactive effects, and lesser flexibility in handling unanticipated but important topics that may arise during data collection.

3.4.1 Sampling strategy and sample size

Having chosen semi-structured interviews as the research method, potential interviewees were then identified and sampled. When sampling interviewees generic purposive sampling and more specifically snowball sampling were applied. According to Bell et al. (2019) such sampling methods incorporate different perspectives when addressing the research questions and the inclusion of snowball sampling implies an approach that is sequential and contingent. The application of snowball sampling in turn derives from uncertainties regarding what occupations and roles that have the primary responsibility and competence regarding the aspects under study. According to Bell et al. (2019) the snowball sampling method constitutes the only feasible alternative when a clear sampling frame does not exist. Moreover, the sampling method is useful not only to enhance data collection but to reveal networks of individuals.

Bell et al. (2019) argue that the generic purposive sampling strategy is a common approach in business research when different roles and perspectives are of interest. That is, to address the research questions, interviewees may be effectively and efficiently sampled in a way that ensures high inter-variation. Such approach was therefore considered appropriate to sample interviewees possessing relevant knowledge within the different case companies.

The initial criterion for identifying interviewees was based upon occupation. However, because of uncertainties regarding organizational roles and responsibilities, the criterion of occupation was rather viewed as a means for initiating data collection; The criterion of occupation involved three levels of occupations for the TO: operations manager, business developer and planner. Relevant occupations for the TCs were TC owner or TC production managers. As the role of the port authority was somewhat unanticipated, there were no criteria for occupation but the occupations that were involved with the TAS in this case were the IT-manager and the operations manager.

After having set up the criterion, the contact person at the TO at case A was contacted via e-mail to setup a meeting. After an online interview with the contact in which the aim of the project and the developed criterion was discussed, contact information to several employees within the container terminal was received, both to employees meeting the criterion and employees that do not. For case B and C, the approach was different; Both case companies wanted to reply to all questions in in a single interview. Hence, no further contact information to potential interviewees were obtained. Furthermore, at the end of each interview in case A, the interviewees were asked about other potential interviewees to incorporate other important perspectives. However, to focus the data collection on individuals that showed to possess relevant and significant insight into the studied topics, the criterion was developed concurrently with the interviews which aligns with the contingent sampling approach (Bell et al., 2019).

A total of nine interviews were conducted and table 1 summarizes all the interviewees together with their respective occupation and organizational belonging as well as the duration of each interview. Two interviews were held with interviewees in pairs, this was requested by the interviewees to save time. The interviewees interviewed in pairs were A:4 and A:5; B:1 and B:2. According to Bell et al. (2019) the required sample size in qualitative research greatly depends on the specifics of the research. Although the authors state that a commonly accepted minimum sample size does not seem to exist, Warren (2011) remarks that the number of 20-30 interviews seems to be accepted as the lower limit in published qualitative research. The author, however, state that the number of interviews necessary increase with the width of the qualitative scope and the intended level of comparison. As comparison does not represent the main objective in this thesis project (as advocated in section 3.2), a lower number of interviews will be considered acceptable.

Table 1

Description of interviewees

Interviewee	Occupation	Organization	Duration
A:1	Gate Manager	TO	30 min
A:2	Salesman - railway	TO	45 min
A:3	Customer partner	TO	30 min
A:4	Production manager	TC	45 min
A:5	Production manager	TC	45 min
A:6	Owner	TC	45 min
A:7	Yard planner	TO	30 min
A:8	Dispatcher manager	TO	30 min
B:1	Operations manager	Port authority	90 min
B:2	Information technology (IT) manager	Port authority	90 min
C:1	Project manager for TAS implementation	TO	60 min

It was difficult to find participants in relatively small and strategically important groups of occupations further willing to commit and share important data. This ultimately made it difficult to achieve a large number of interviews. According to Bell et al. (2019) clarity regarding the data collection procedures, such as choice of sampling method and argumentation for the number of interviews held, is to prefer over many interviews. In a thesis project the authors further state that the quality and detail of the collected interview data is to prioritize above reaching an accepted minimum number of interviews. Thus, to compensate the small number of interviews a certain level of comprehensiveness was sought for, both when preparing and conducting the interviews; The former by preparing several extensive questions and the latter by ensuring long durations of the interviews, which were planned to take 60-90 minutes each.

3.4.2 Data collection

Prior to each interview, a study information sheet was distributed to each of the interviewees from case B and C, containing some background information about the project and the interviewees potential contribution if choosing to participate in the data collection. The participants in case A were well informed about the research project beforehand and were hence not provided any additional excessive information about the study from the authors of this thesis. The respondents were further informed about their right to take part of the results once the research project was to be completed. An interview guide was prepared comprising written text to guide the interviews. The questions in the interview guide reflected the research questions but at a lower level of analysis. The business model canvas framework developed by (Osterwalder & Pigneur, 2010), acted as the basis for each question and the presentation of the results. Some general introductory questions were formulated for each interviewee. The general interview guide can be seen in appendix A.

As elaborated upon in chapter 3.4, the interviews were semi-structured and were further carried out via the digital meeting platform Microsoft Teams. Bell et al. (2019) describe online personal interviewing as an efficient method for both the interviewee and the researcher. It is also more flexible than face to face interviews and could result in a higher rate of participation. Some drawbacks that are mentioned by the authors is that a stable internet connection as well as transcription is needed, which is not the case in online text-based interviews. To be able to transcribe the content from the interviews each interview was audio recorded if accepted by the interviewee. All respondents except one accepted to be recorded. For that interview extensive notes were taken. All the interviews were discussed and summarized by the authors of this study directly after the interviews were completed to confirm a common understanding of the results.

Additional data was collected from different documents and websites. Documents can be used for different purposes in research. One purpose that documents can serve is to provide context of the cases which can help to understand issues and better relate and analyse the data collected from, for example, interviews (Bowen, 2009). Another reason to use documents can be to provide supplementary data to the knowledge base. Document analysis was applied to secondary sources as manuals of TAS, to identify drivers or barriers and issues that can appear when using a TAS and how they can be resolved. The websites of the three cases were a main input to describe the cases with relevant background information, hence providing a context to each case.

3.4.3 Data analysis

While qualitative interviewing enhances thick descriptions of investigated topics its unstructured element give rise to an ambiguous analytical path (Bell et al., 2019). However, some analytical strategies do exist, according to the authors, that guides the qualitative analysis. In this thesis project a thematic analysis strategy, which constitutes a common approach to qualitative data analysis, was applied to enable analysis of the collected data. According to Bell et al. (2019), a thematic analysis necessitates a more interpretative approach to coding than other analytical strategies but, however, consequentially might have a greater potential in revealing latent content in the collected data.

The gathered data was, however, managed before applying a thematic analysis to it by producing transcriptions which were further checked for flaws. Bell et al. (2019) advocate that managing data flaws is an important step before initiating coding and is further enhanced through transcription. The transcriptions were manually coded in parallel to the data collection. According to Bell et al. (2019) starting off the coding process early on entails better understanding of the data and the impression of a heavy workload is often somewhat reduced. The identified codes were further compared to find links. Descriptive first-order categories were initially identified and then expanded or collapsed to formulate analytic categories. From such categories it was then possible to develop themes. Reducing and hence, making sense of the data through codes, and further linking them to each other through categories, Bell et al. (2019) advocate is necessary to interpret data and to make theoretical inferences.

The identified themes contributed to a theoretical understanding of the gathered data which was applied to address the research questions. More specifically this process of interpretation, where various themes were identified from the data, meant that themes were screened based on their presence in theories discovered through the literature review. However, some themes relating to theories not identified through the literature review were developed by focusing the subsequent literature review on such themes before further analysis. Themes that on the other hand related to theories identified in the literature review, were subsequently applied to address the research questions. According to Bell et al. (2019) the screening of themes is greatly connected to the inductive research approach. The authors state that although connecting themes to prevalent theories is sought for in the inductive logic of inquiry, practical as well as conceptual constraints limit the possibility to do so. They further comment that inclusion of too many themes may hinder the depth of analysis in favor of width. Hence, in screening themes, both the timeframe and research questions were considered and only those that were considered most valuable to the research project were incorporated into the analysis.

3.5 Quality criteria

The appropriateness of applying the more common quantitative quality criteria of reliability, replicability, and validity to the case study research design and qualitative research designs in general, is, according to Bell et al. (2019) an ongoing debate among business researchers. Because of the ambiguity surrounding the relevance of quantitative quality criteria in qualitative research, they, according to the authors, are often bypassed in qualitative research. Nonetheless, Bell et al. (2019) persist in that the application of quality criteria is important to evaluate the quality of the conducted research. Lincoln and Guba (1985) have defined four quality criteria of trustworthiness - credibility, transferability, dependability, confirmability - and one of authenticity they argue are better suited for qualitative research. Hence, in this report, these five qualitative quality criteria will be employed to enhance the quality of the applied research methodology.

Bell et al. (2019) argue that the five quality criteria somewhat parallel some of the quantitative quality criteria, however, that their differences necessitate some new or different ways to meet them; Firstly, to entail credibility of the findings the researchers should adhere to good practice. For this reason, literature on research methodology was reviewed and applied in a transparent manner. Secondly, to entail transferability data collection should be characterized by a thick description. Hence, the criterion was especially considered in all procedures following from the interviews. Thirdly, to adhere to the criterion of dependability peer auditing of the research procedures should be ensured at least at the end of the research process but preferably also concurrently. Hence, by granting the supervisor as well as the co-supervisors access to rich documentation of the conducted procedures, this was entailed during the research process. Moreover, a purposive auditing in the form of an opposition held at the end of the research project, allowed for peer auditing. Fourthly, to entail confirmability, objectivity should be in the forefront during all procedures of the research process as well as in the presentation of the findings. Hence, personal opinions and values will be suppressed to the highest possible degree. Fifthly, to adhere to the criterion of authenticity various stakeholders with different perspectives involved in the social setting should be emphasized in the collection of data as well as in subsequent research procedures. The intent, the authors advocate, is to encourage participants and involved stakeholders to actively engage in changing the studied social setting for the better. To provide authenticity, the authors collected data from different occupations and roles within the TOs, the port authority, and the TCs. Unfortunately, all different roles were not interviewed in each case which made complete authenticity difficult to achieve. The authors will further seek to disseminate the findings to the entire port community to encourage all stakeholders of the port community to engage in the studied social setting.

3.6 Ethical considerations

Bell et al. (2019) discuss four ethical considerations in business research, namely, harm to participants, lack of informed consent, invasion of privacy, and deception. These four principles have acted as the foundation when mapping ethical considerations during this thesis project.

Research that could cause harm to participants are intuitively unacceptable, but the concept of harm involves several different aspects. Harm could be for example physical harm, stress, or harm for a participant's future career (Bell et al., 2019). The aspect of harm with the highest risk off occurrence in this study was concluded to be harm for future careers; how the participants formulate their replies in the interviews could potentially affect their prospects. Thus, anonymity was addressed both to enable credible answers and to minimize the risk for participants to be judged based on their opinions (Bell et al., 2019). To still differentiate between the different interviewees and hence highlight their contrasting perspectives when writing up the report, every interviewee was presented with an interviewee-number and their occupation. However, according to Bell et al. (2019) this might undermine anonymity efforts since a job position may be possible to track down to a single individual. Therefore, this information was carefully considered.

Informed consent is about giving the participants enough relevant information about the study to allow them to take an informed decision regarding participation (Bell et al., 2019). All interviewees in the study were informed about the aim of the study, interview techniques, recording equipment, and that participation is voluntary. To protect the privacy of the participants, only necessary information about the participants were collected which is the main suggestion forwarded by Bell et al. (2019). Also, interviewees had the possibility to refuse answering questions that they felt were intruding private realms which according to the authors is another important measure. Bell et al. (2019) mention that it is impossible for the researcher to identify sensitive topics beforehand, instead they suggest handling each interviewee respectfully, allowing them to withdraw at any time. Lastly, the participants were well informed about the project and intentions which were forwarded in a transparent manner to ensure that deception was not part of the study. This represents the main recommendation provided by Bell et al. (2019) regarding deception.

3.7 Societal and ecological considerations

The societal and ecological considerations of the research project have also been analyzed. First, the results of the study should have an indirect positive effect on environmental sustainability. In an implementation of such system, which should improve the TTT and decrease congestion at the container terminal area, the combustion of air pollutions and green-house gases will be reduced according to the International Energy Agency (2019). The research process was not considered to give rise to any substantial effects on the environment, especially since the data collection were conducted remotely, and transportation therefore was not necessary.

The societal considerations do not bring any remarks. The study partially aimed to investigate the potential to decrease the TTT through a TAS at container terminals, which Jacobsson (2020) mention could further minimize the emotional stress for drivers. Moreover, reduced emissions, because of shorter TTT, would decrease related health issues for all individuals passing through or being stationed at the container terminal as well as residents of the local regions (European Commission, n.d.). Decreased TTT could also result in strengthened terminal competitiveness resulting in increased market shares (Baccelli & Morino, 2020). By increasing the throughput in the terminal, it should give more job opportunities and provide the regional government increased tax revenue (Giuliano & O'Brian, 2007). Moreover, the findings of the study could result in lowering the barriers for implementing a TAS at container terminals. In the long run this could result in an increased need for certain competences within IT to develop new IT solutions that integrate the information from TAS in the operations.

4 Empirical findings

In this chapter the empirical data is presented. In section 4.1, each of the three cases are described. In section 4.2 and 4.3 the drivers respectively, barriers forwarded by the cases are presented. Lastly, in section 4.4 drivers and barriers forwarded by a truck appointment system developer are outlined.

4.1 Case descriptions

All three cases will be given a brief description to give an understanding of the context at each terminal. No additional components or options were identified from the cases other than TAS components and options already compiled in figure 8. Components and options of TAS that were used in case B and C will be presented and since case A has not implemented a TAS to level truck arrivals, the current situation of how trucks are managed will be described.

4.1.1 Description of case A

Case A is a port with one TO managing the container terminal. Approximately 800 000 twenty-foot equivalent units are transferred through the terminal each year. The container yard is managed with manual straddle carriers and other non-automated internal trucks and an automated gate has been implemented for trucks entering the terminal. Import containers are usually stacked two in height at the truck yard. The trend in the container terminal is that more and more cargo is shipped by train, yet the volumes going by truck are increasing.

The terminal currently does not have a TAS, but it is mandatory for all TCs to pre-notify the terminal which day they will arrive and which container to pickup to receive a visit code that allow them into the terminal. Bookings are primarily done via a web interface or an app, in which cargo availability is also provided. All trucks with a valid pre-notification are allowed to come to the terminal at any time of the day and the trucks are served according to the first come first served principle and there are no quota limiting how many trucks that can be served each day. When it comes to the lead-time, a pre-notification can be performed if the container number is available.

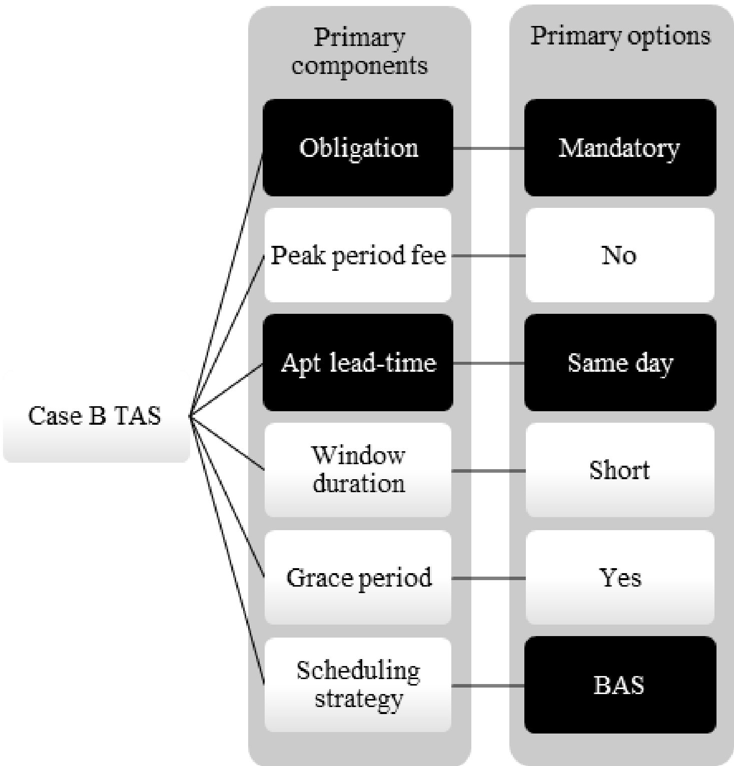
4.1.2 Description of case B

Case B is a port consisting of two different TOs operating one terminal each. Both terminals together handle 3,4 million twenty-foot equivalent units each year. The stacking heights in the terminals varies, three in height in the manual terminal and five in the automated terminal. A TAS is to be implemented in both terminals. The system implementation has been divided into three phases where the first phase (which is currently implemented), includes the IT infrastructure to handle all bookings via a web interface or mobile app. Figure 21 describes the TAS components and options that have been implemented in phase one by case B. The black cells mark the components and options already identified from the basic TAS design and the white cells mark the components and options already identified from the developed components and options. Booking an appointment is mandatory for all truck drivers visiting the terminal and the opening hours are divided by a BAS. No quota is set for each appointment window, meaning that all appointments will be confirmed and there are also no obligations for the truck drivers to comply with the booked appointments. The window duration is one hour but the truck drivers are allowed to arrive within an additional grace period of one hour time frame before and after the time window, resulting in a three-hour allowed arrival window. A simple graph is provided for truck drivers visualizing the terminals capacity, booked appointments at each time appointment window, and completed transactions in each appointment window. Bookings are done with container-id and can be done two weeks in advance up until immediately before the appointment.

In the second phase truck drivers will have to comply with their appointments and TCs will receive feedback on how well they comply with their appointments. If necessary, the terminals can then restrict the TCs access by for example limiting the number of appointments TCs can book if they misuse the TAS. In the third phase, the terminal will also implement a quota that limit the number of available times in each appointment window. The quota will be set dynamically to follow the available capacity at the terminal.

Figure 21

The TAS design marking phase 1 deployed by case B



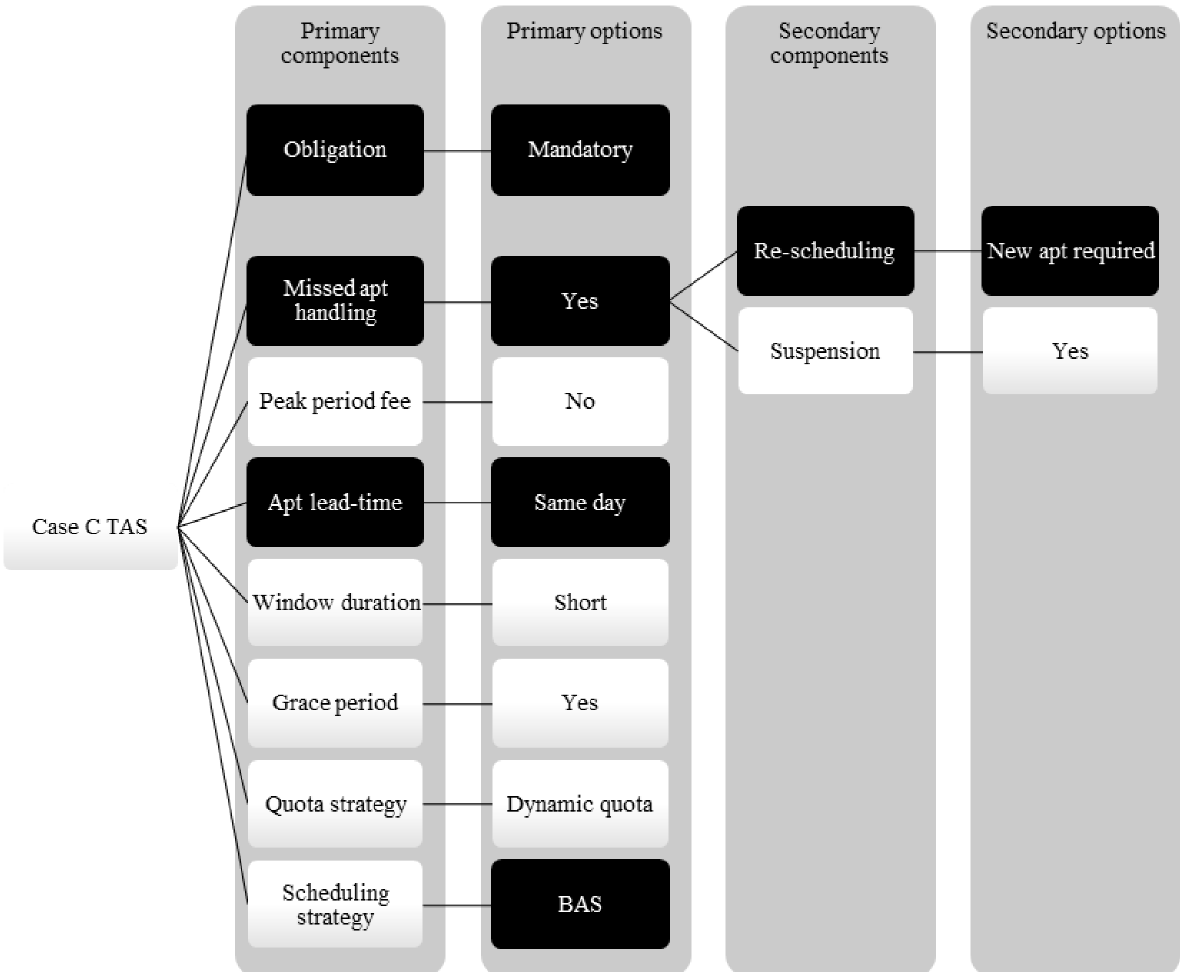
4.1.3 Description of case C

Case C is a large port with two terminal operators that together handle approximately nine million twenty-foot equivalent units in the four container terminals. The studied TO operates three of the four container terminals and some of the terminals have more automated yard operations than others. The TAS that have been implemented share the same features for all three terminals

Illustrated in figure 22 are the components and options used by case C. The black cells mark the components and options already identified from the basic TAS design and the white cells mark the components and options already identified from the developed components and options. The TAS is mandatory for all transactions at the terminals and a booking can be performed up until the start of the appointment if an appointment is available. The window duration is one hour with a safety span of 30 min at both sides of the appointment window resulting in a 2-hour appointment window in which the truck driver receives priority one and can usually procced immediately to the gate. Priority two is obtained if the truck driver arrives in the intervals one hour before or after the booked appointment window for priority one. Priority two is only proceeded if capacity utilization allows it. If an appointment has been confirmed but the truck driver is not able to comply with the appointment, it needs to be canceled and a new booking is required. All no-shows and canceled appointments are summarized by the terminal and if the rules are misused, the TCs' access are restricted for the upcoming week by limiting the number of possible appointments that can be booked by the TC. The quota is dynamic and varies between different appointment windows across the day depending on available terminal capacity.

Figure 22

The TAS design deployed by case C



4.2 Drivers forwarded by the cases

No additional drivers other than the ones already identified from the theoretical data were found in the empirical data. However, many of the already identified drivers were present in the empirical findings and some of the data will be presented in this section to give an overview of what drivers that were discussed by the interviewees.

4.2.1 Drivers related to 'demand and capacity matched against each other'

Matching demand and terminal capacity against each other was one of the highest-level drivers that was perceived in all three cases. Even if case A had not implemented a TAS, it was still perceived to be a main driver if congestion at peak hours becomes a problem. The same reasoning holds for case B which had not yet levelled the truck arrivals in phase one. However, case C had implemented a TAS to level truck arrivals due to the long queues that sometimes could cause congestion even at the motorways. The main driver for implementing a TAS was described by interviewee C:1, project manager for TAS as:

> *I think the main driver was to equalize a bit this peak situation… it was to even out the peaks and as a consequence also to reduce traffic like, let's say, like jams. Before all truck drivers came at 8:00 o'clock and we had quite some jam going back to the motorway sometimes. So, it's therefore a kind of consequence, less traffic, less jam, less pollution.*

If the TAS improved congestion was not straightforward and was advocated to be very dependent on the situation. In general interviewee C:1 said that the situation was improved during normal conditions:

> *Yeah, I think we have less jams. You know we had the jams even before the terminal, like going over the bridge to the motorway. And these jams we don't have anymore.*

There was a common agreement that long waiting times for the TCs at the gate limits the number of transactions the truck drivers can perform. Some of the TCs in case A have come to an agreement with the cargo owners/shippers that if the truck driver must wait for more than 30 minutes at the gate, a port delay fee is added to compensate for their loss in productivity. The delay fee is then forwarded to the cargo owner/shipper, but it is not even near a compensation for the loss in reputation and customer satisfaction. Interviewee A:5, production manager at a TC stated that:

> *On the whole, it does not cover anything when you have upset customers and you have trucking companies that are upset. It is a patch on the wounds, but it is not enough. The big loss is in customer service and that we cannot keep it up. It is hard to put an economical number on it but to keep the service is considerably more important than to charge a port delay fee.*

However, different TCs did differently, and some had decided to include the waiting time cost in the prices offered to the customers. In none of the investigated cases the TOs had any business relations directly with the TCs and did hence not offer any compensation for delays.

The most prominent driver to implement a TAS by all three cases was to avoid unacceptable queues and waiting times at the gate during peak periods. For case A the TTT was usually approximately 30 minutes and was not seen as a major issue and was the reason why a TAS has not been prioritized. If the situation would have been different interviewee A:2, salesman at the TO described that *"If it would be standing trucks outside for 2-3 hours every day, then* *of course we have to look at something else but for now, it runs good and if something is working, you might not put in the extra effort."*

4.2.2 Drivers related to 'scheduling of capacity'

Being able to plan the capacity at the terminal was one of the motives to implement a TAS mentioned by several of the interviewees in case A. The information gathered from TAS could have been used to improve the scheduling of labor and equipment, hence improving resource utilization. Many of the interviewees in case A confirmed this and an example was interviewee A:8, dispatcher manager at the TO who described what benefits a TAS could have as:

> *I can see enormous advantages from a terminal perspective because it would then in a different way allow us to forecast how much work we have for the upcoming day and days, but then we can plan our resources in a whole different way of course. So, I see only benefits from a terminal perspective.*

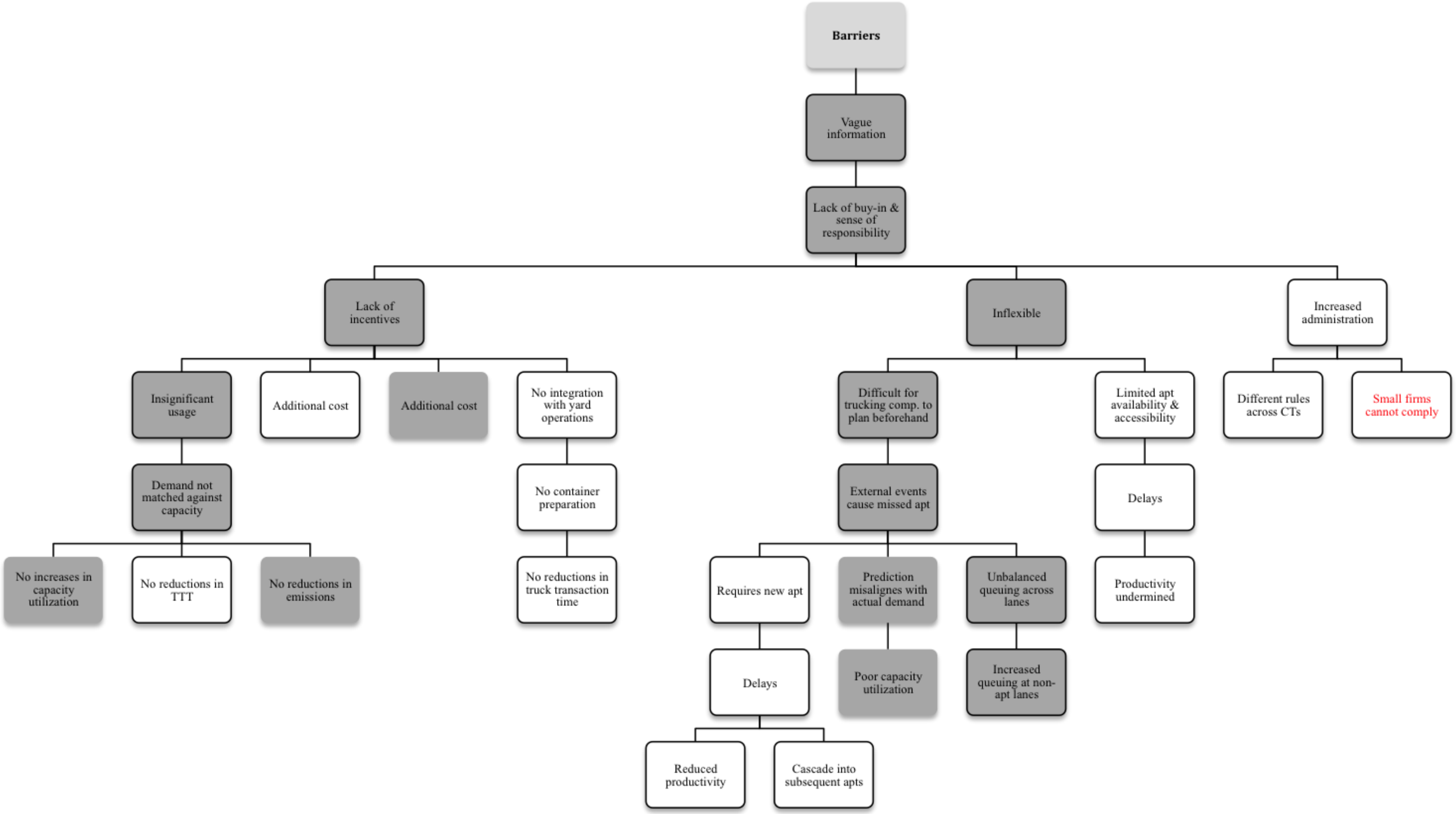
Elimination of uncertainties for TCs were perceived as a driver for the TOs to implement a TAS in Case A and B. Interviewee B:1 from the port authority described that the TCs at their terminals preferred to wait not knowing if the terminal can serve them instead of booking an appointment knowing that there are available resources to serve them, something that the interviewee could not understand since it is a waste of time. Interviewee A:2, salesman at the TO shared the same opinion that a TAS would ensure that the resources at the terminal are available to serve the TCs when they arrive.

4.3 Barriers forwarded by the cases

Figure 23 illustrates the barriers and their interrelations related to the basic and developed TAS designs as well as one experienced or perceived by the case companies. The white cells with bold lines mark the barriers perceived by the TCs and the grey cells mark the barriers perceived by the TOs. The cells in grey with bold lines mark the barriers perceived by both actors. The cells with black text mark the barriers related to the basic- or developed TAS designs and the cell with red text mark an additional barrier experienced by case companies B and C. The hierarchy has been compiled according to the following logic: If underlying yet same-level barriers are perceived by different actors, their shared overlying barrier is perceived by both actors. The five top level barriers identified in the empirical data and how they were described by the interviewees will be presented in the upcoming chapter. Each one of the barriers from the literature review were not mentioned in the empirical data, however one additional barrier was identified in terms of small TCs' difficulties to comply with the added administration required when adopting a TAS.

Figure 23

Barriers related to the basic- and developed TAS designs as well as the experiences of two of the case companies



4.3.1 Barriers related to 'vague information'

As the TO in case A said that they had not planned to implement TAS, it quickly became evident that the efforts to fully design a TAS had not been prioritized. More specifically implementing a TAS has not been a top priority due to short or no queues at the gate during normal conditions. This was supported by interviewee A:1, gate manager at the TO, who said that a design has not been discussed. A similar reasoning is described by interviewee A:2, salesman at the TO who said that TAS has been up for discussion several times over the years but that it has been hard to find a system that is balanced and fair to everyone involved. Since it has not been their top priority, they haven't put in the extra effort. However, interviewee A:6 and owner of a TC confirms that TAS has been up for discussion but described a contrasting view of how a TAS could work:

> *Yes, it has been discussed for maybe 10 years and the truck drivers have been very against it because the port, they want to assign us a slot when we can arrive. We want to do the opposite, when we are addressing a container, we should give the port a slot when we are arriving.*

From all the interviews it became evident that designing a TAS with business rules that are fair and efficient for all the actors is not a very straight forward process. Many different factors need to be taken into consideration and one solution does not fit all. Interviewee A:2, salesman at the TO gave an example of how unfairness could occur if priority lanes were implemented:

> *It is really difficult because it becomes a lot of unfairnesses, and things like that also, it is not really solved yet, but we are discussing in those terms… Then it is also like this that it can be misused a bit and we are not really there with a solution because we have like I said more local trucks that need to get in and out and cannot wait two hours or that happens very seldom. But if it would at the same time be as it works now, it would take about half an hour for a truck to enter and leave and faster is not possible and if there are no queues it does not matter if you have a vip or not because it goes just as quick anyway.*

Although case A had not yet actively discussed the potential TAS design, interviewee A:3 though that the system was going to be important to consider in the future due to its potential to improve the efficiency in the terminal. One component that was mentioned is the window duration. Interviewee A:3, customer partner at the TO said that:

> *It is nothing that has been discussed actively, not that I know of at least more than that we have had it in our minds when planning ahead because somewhere I even believe that it might be the future but how the setup should look like. I mean it does not have to be hourly slots, it could be half day-slots because that would still help or that sometimes of the days are time slots. The setup could look in different ways depending on how we want to use it.*

4.3.2 Barriers related to 'lack of buy-in & sense of responsibility'

One barrier that has been mentioned is lack of buy-in and sense of responsibility. If TTT is not a problem for the TCs, it can be difficult to create the urgency needed to develop and implement a TAS. This was highlighted by many sources in case A that said that a TAS has not been prioritized since the TTT is in general low and within acceptable limits. Combining a low TTT and the TCs' resistance to TAS, the TO in case A has prioritized the TCs' flexibility over their own interests. However, case B also had acceptable TTT of approximately 30 minutes, but the port authorities saw this as an opportunity to prepare and implement a system before it becomes an issue. Interviewee B:1, operations manager at the port authority said:

> *Now, we have no problems with queues. And I think that it is the best moment to introduce a system now because we have no problems with our queues, now our queues usually are 20 minutes, 30 minutes.*

4.3.3 Barriers related to 'limited appointment availability & accessibility'

A common barrier that was highlighted by both TOs and TCs was the need for TCs to find available appointments on short notice to not limit the flexibility for the TCs to plan and optimize their routes. Three prominent factors were mentioned for why this is important. Firstly, TCs can receive transport bookings with a short notice. Secondly, the data that is needed to perform a booking needs to be available for TCs before an appointment at the terminal can be booked. Thirdly, TCs face uncertainties such as traffic or external events that they cannot control and therefore want to inform the TO about their arrival as late as possible when their actual arrival is less uncertain. However, bookings seemed to be received approximately three days in advance in case A, but the detailed route planning was done one day in advance. This way of planning was described by Interviewee A:5, Production manager at a TC that said:

> *Most bookings are received three days in advance, maybe three days before we should be there, but some bookings can be received the day before. On average, it is three days in advance… The day before, the final planning is done and two days ahead, a rough scheduling can be done.*

Interview A:6, owner of a TC that mainly works with export containers have a similar experience that transport bookings can be received in a wide-ranging timespan: "W*e receive bookings… and sometimes it is very short notice, it can be the same morning and it can be three months in advance".* Since the necessary container information are first available once the container is loaded onto the truck, this can make it difficult for the TCs to notify and book appointments for export containers a long time in advance. This differs from import containers that can be notified to the terminal as soon as the transport booking is received by the TC since it consists of the necessary container information. Interviewee A:6, owner of a TC said that:

> *They e-mail us… that this container number is loaded, and they include the container number it has, and we make the announcement since we cannot do it before we receive the container number… On the other hand, import containers can be notified earlier since the container number is included in the booking.*

Lastly Interviewee A:2, one of the interviewees that highlighted the dilemma that the trucking operations are unpredictable, said that: "*Should you book an hour before or should you book the day before?... The trucks can get a puncture or must refuel then you might not find your slot and then what do you do*?"

Quota was a recurring theme in the interviews and that gained much attention in some of the interviews. There was a common conception between the TO and the TCs in case A that TAS could limit the capacity in the terminal and that this could make it hard for the TCs to book a suitable time that fit their schedule if all suitable times are taken. Interviewee A:5, Production manager at a TC know some truck drivers that drive to a port which has implemented a TAS, and those drivers have had bad experiences of the system:

> *Yes, we have been talking about it and it has been up for discussion throughout the years and the view from the truck drivers, our subcontractors, and our transport leaders here is negative. What we see that the truck appointment system in (…), as for example, I have some truck drivers there from time to time sometimes and it is cumbersome to even get a slot time down there since it is fully booked.*

The same interviewee described that they totally understand the benefits that it would give the terminal in terms of preparing and sorting the containers in advance if they knew when a container was to be picked up. A system that limits the truck drivers from making appointments is not feasible, but the interviewee presents an idea that the truck drivers can notify the terminal about their planned arrival but without any obligations to rebook the appointment if the time is missed.

This suggestion from interviewee A:5 aligns with how case B has designed the TAS in phase one. Phase one consists of a mandatory appointment system, but the TCs book an appointment window with the intention of arriving at that time but if the appointment is missed, the truck driver is still allowed into the terminal without the need for a rebooking. However, even if there are no obligations for the TCs to arrive during the booked appointment window, interviewee B:1, operations manager at the port authority estimated that the TCs comply with the time booking principles to a 50-60 percent ratio.

4.3.4 Barriers related to 'increased administration'

Issues that surfaced during some of the interviews are the extra administration as well as use of some sort of digital system to book appointments that follows in an implementation of TAS. Interviewee C:1, Project manager for the TAS implementation provided a view that small TCs can have more difficulties in adapting to new ways of working than larger firms.

> *So I think well for really small companies, I understand this might be sometimes a bit difficult, but the bigger companies they also see the advantages of the system like, I can book a slot I'm sure to come there and to enter the premises and to have operation there. So it's really from very positive to very negative view.*

In case B a similar view is presented by interviewee B:1, operations manager at port authority that said that:

> *Most of the trucking companies say that it's not interesting because they are paid and they prefer to wait at the gate and not introduce electronic systems or intelligence to develop and take advantage of them now. And when they think that they have to introduce more developers and more developing systems, usually they are not comfortable because they have no knowledge about it. Only big companies think that they can, like introducing it in their own systems. They know how to manage and how to take profit.*

What was apparent from all the cases is how the larger TCs are better prepared to cope with the administration and technology that a digital system requires. The larger TCs therefore also seem to have better potential to integrate new ways of working and to take advantages of a TAS.

4.3.5 Barriers related to ‘lack of incentives’

In none of the cases that had implemented a TAS, the information gathered from the TAS had yet been integrated into the yard operations due to different reasons. In case C, the information was too uncertain to base the yard operations on since there were too many cancellations, no shows, and too unprecise arrivals. Interviewee C:1, project manager for TAS at the TO explained it as “*At the moment we don't do well. We use the information that is delivered by truck but not the time stamp or something because it's changing so often. It´s not really good to use it for the yard operation.”* Case B which had not yet applied any obligations for the truck drivers to comply with their reserved appointments and did not yet have any routines at the terminals to use the arrival information to improve the terminal operations. Interviewee B:1, operations manager at the port authority described it as:

> *That could be no doubt it will be the future. But not today. You have to think that we have one manual terminal and the other one is fully automatic in the yard… If you have information on what will happen. It could be that you can plan the next movement. To try to take advantage of this information, for instance, if you at night in the automatic yard put in the right order of all the data that you have for the next hour. So, the first hour of the day you know and take advantage of the night to be more operational.*

4.4 Drivers and barriers forwarded by a truck appointment system developer

Some data regarding setting up business rules were gathered from an online TAS manual from a system developer of terminal operating systems. In the TAS manual some issues that can arise when deploying a TAS and what can be done to manage them, are described. In Navis (2003) it is mentioned that the issues related to TAS exist when demand exceeds the supplied number of appointments. When the TCs can book appropriate appointments, it is less likely to become a problem. However, the goal with the business rules is to create a fair system with a balanced service level for different actors. The system needs to be designed for large TCs and small. The administrator is the one responsible for making changes to create a fair system and might have to make exceptions or punish actors who intentionally try to cheat and take advantage of the system.

In a scenario when demand exceeds the supply of appointments, one problem that could occur is that TCs make several bookings even if they are not sure they will be used because of the shortage of appointments (Navis, 2003). TCs then either don’t show up, rebook, or cancel the appointments, affecting other users and the terminal negatively. Alternative solutions to this could be to require more information to make an appointment, increasing the threshold to book appointments on chance. The number of possible bookings for a driver could further be limited or how much in advance appointments can be booked. The system could also allow appointments not to be changed at a certain time, for example, one day prior to the booking or a penalty fee for cancelations or missed appointments can be charged.

It is not uncommon that the TAS is paid for by the TCs as an appointment system should allow the TCs to perform more transactions each day, hence increasing their revenue (Navis, 2003). The fee for using the TAS can differ in amount and how it is charged, sometimes it is charged per transaction or by a monthly subscription fee. The added cost for TCs can sometimes be forwarded to their customers that is also benefitting from the increased predictability. As the cost for the system is charged equally by all users, it does not affect the competition among TCs. Regardless, two essential factors for a successful implementation of TAS is first, to have a TAS that is well-integrated in the terminal operating system because the information on the available terminal capacity needs to be transferred to the TAS. Second, a TAS cannot be successful without the commitment from its users.

5 Analysis

In this chapter the drivers and barriers of truck appointments systems' components and options are analyzed as well as how they affect the business model of container terminals. In section 5.1 and 5.2 the drivers respectively barriers related to all identified components and options of truck appointment systems are dissected. In section 5.3 relations between overlying drivers and barriers are analyzed. Then in section 5.4 options considering such relation are construed. Finally, in section 5.5 truck appointment systems incorporating the dual perspective are analyzed from a business model perspective.

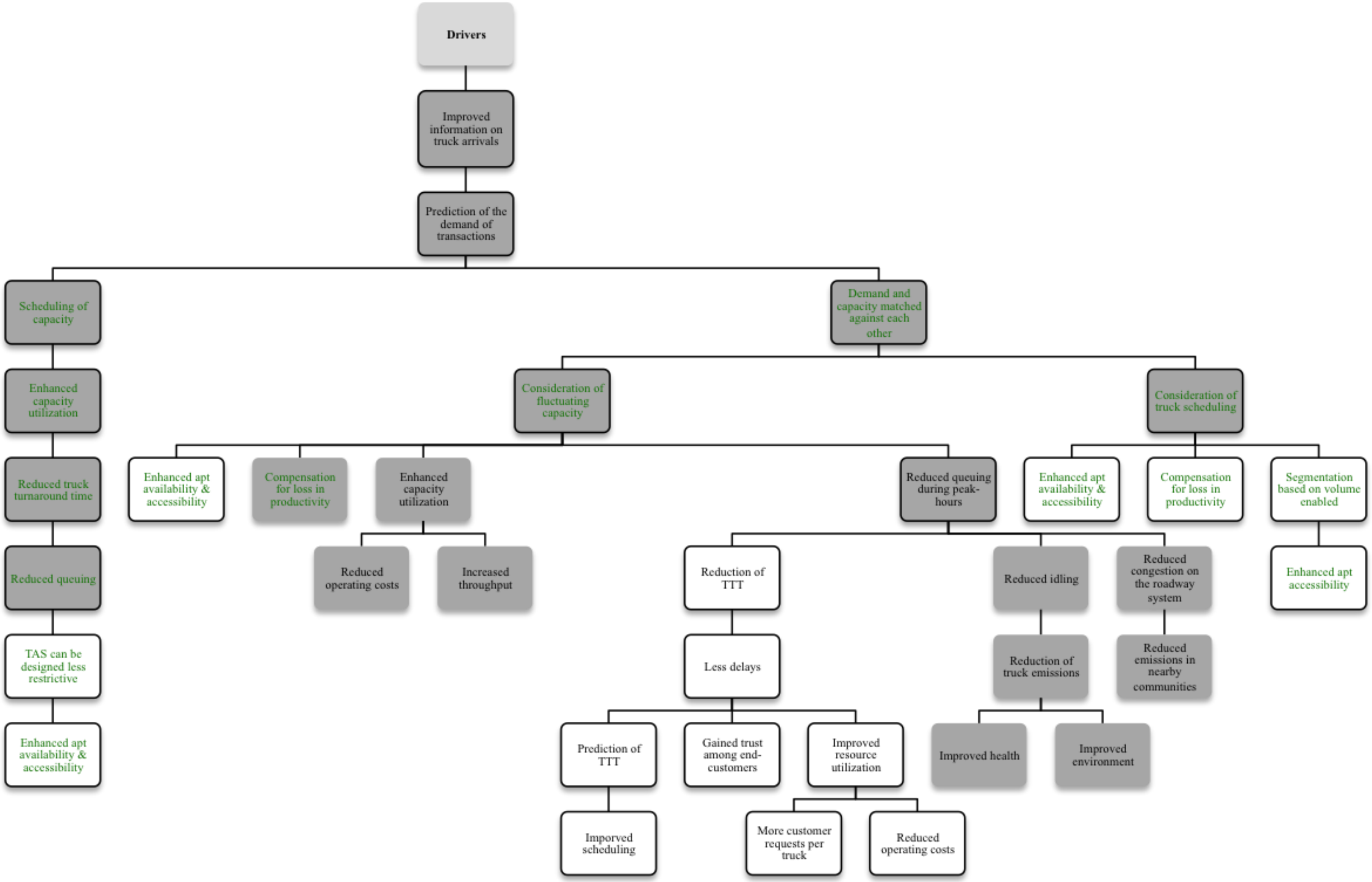
5.1 Drivers related to all identified components and options of truck appointment systems

Identification of the basic TAS components and options enabled further identification of different fundamental drivers related to the TAS perceived by both TOs as well as TCs and their interrelations, see figure 5. As several authors in academic literature have developed the basic TAS design to benefit any of the two actors or both, either by developing the components, developing the options, or by integrating the TAS with the yard operations, some additional drivers have emerged. These drivers and their interrelations were illustrated in figure 9. The empirical data, gathered from the interviews with the three cases as well as the TAS manual, did not lead to identification of any additional drivers wherefore the hierarchy illustrating the drivers related to the basic and developed components and options in figure 9, still holds. The additional drivers related to the developed components and options almost exclusively represent attempts to mitigate the barriers related to the basic TAS components and options; Only a few of the drivers represent incentives for implementing a TAS. For this reason, only the drivers representing incentives for implementing a TAS will be discussed in this section and those aiming to mitigate barriers will be left for section 5.2.

The hierarchy depicted in figure 9 descends from one primary driver (PD): 'improved information on truck arrivals'. PD in turn leads to two secondary drivers (SD): 'information on cargo availability' and 'prediction of the demand of transactions'. As the former driver is commonly entailed without a TAS the latter one (hereafter referred to as SD) and its implication has been the primary topic in academic literature on the topic and will for these reasons be the topic in this section. Excluding the former driver from the analysis enables depiction of the drivers according to figure 24. In figure 24 the drivers related to the basic as well as developed TAS designs, and their interrelations are illustrated; The white cells with bold lines mark the drivers perceived by the TCs and the grey cells mark the drivers perceived by the TOs. The cells in grey with bold lines mark the drivers perceived by both actors. The cells with black text mark the drivers related to the basic TAS design and the cells with green text mark the drivers related to the developed TAS designs. The hierarchy has been compiled according to the following logic: If underlying yet same-level drivers are perceived by different actors, their shared overlying driver is perceived by both actors.

Figure 24

Drivers related to all identified components and options of TASs



Two tertiary drivers (TD) can be derived from SD ('prediction of the demand of transactions'): TD1) 'scheduling of capacity' and TD2) 'demand and capacity matched against each other'. TD1 is a consequence of deploying the truck arrival information to schedule yard capacity; By minimizing and performing unproductive shuffle moves in the form of re-marshalling moves during yard cranes' idle times, yard capacity can be streamlined further resulting in reduced truck transaction time. TD2 is partially resulting from developed components and options aiming to facilitate trucking operations when implementing a TAS (which will be elaborated upon in section 5.2) and partially resulting from a more realistic perspective on capacity- and demand fluctuations. TD2 more specifically leads to two quaternary drivers (QD): QD1) 'consideration of fluctuating capacity' and QD2) 'consideration of truck scheduling' which will be evaluated in section 5.2. QD1 implies that demand is not only matched against a forecasted and roughly estimated capacity level which implies some degree of mismatch between demand and actual available capacity; Such determination of available capacity also considers deviations from a generic capacity level which opens for a more realistic approach towards matching demand against capacity; When considering seasonal, daily, hourly and even momentary capacity fluctuations, demand is more accurately matched against capacity. Although demand may not be perfectly levelled it ought to correspond to the available capacity.

Four quinary drivers (QUD): QUD1) 'enhanced appointment availability & accessibility', QUD2 'compensation for loss in productivity' (which both will be elaborated upon in section 5.2 due to their relations with the identified barriers), QUD3) 'enhanced capacity utilization' and QUD4) 'reduced queuing during peak hours' result from QD1 ('consideration of fluctuating capacity'). QUD3 and QUD4 correspond to those related to the basic TAS design but then again from a more realistic viewpoint deployed when considering fluctuations in capacity. When analyzing the hierarchy, it is evident that QD1 exerts several important incentives for both TCs as well as TOs for implementing respectively using a TAS. For TCs, QD1 implies reduced queuing during peak-hours (QUD4) which culminates in improved scheduling, improved trust among end-customers, reduced operating costs, and the possibility to perform more customer requests per truck. For the TOs QD1 implies reduced queuing during peak-hours (QUD4) which culminates in improved social and environmental footprints and enhanced capacity utilization (QUD3) which culminates in reduced operating costs and the possibility to increase throughput.

The different TAS components and options (basic and developed) either generate the new drivers or reinforce or suppress the existing ones. When observing figure 24 and considering the overall driver SD ('prediction of the demand of transactions') entailing all underlying drivers, there are two underlying drivers that are of more importance – TD1 ('scheduling of capacity') and QD1 ('consideration of fluctuating capacity'). QD2 ('consideration of truck scheduling'), QUD1 ('enhanced appointment availability & accessibility'), and QUD2 ('compensation for loss in productivity') are drivers that mitigate barriers rather than drivers for implementing a TAS and will therefore be discussed in section 5.2 (since TD2 ('demand and capacity matched against each other') then only gives rise to QD1 only QD1 will be considered). If TD1 respectively QD1 are entailed their underlying drivers are also entailed (there are no conflicts between their respective underlying drivers), therefore these two drivers are the only drivers that will be considered hereon. Hence, 'prediction of the demand of transactions' (SD) enables 'scheduling of capacity' (TD1) and 'consideration of fluctuating capacity' (QD1).

The theoretical data enabled identification of a total of 17 components (the empirical data did not lead to identification of any other components) of which ten were primary components, five were secondary components, and two were tertiary components. The drivers each of these components and their respective options give rise to were illustrated in figure 11-20 in section 2.4. Doing so facilitates identification of the components affecting any of the two drivers TD1 ('scheduling of capacity') and QD1 ('consideration of fluctuating capacity') either by its pure existence or by adjusting its related option. Such relations are illustrated in figure 25 respectively 26. In the figures, all identified components are listed, however, only the components written in black influence the related driver; The components written in blue do not influence the related driver. Both drivers are marked with grey and bold lines as they contribute to the drivers of both TCs and TOs.

Figure 25

Components related to the driver 'consideration of fluctuating capacity' (QD1)

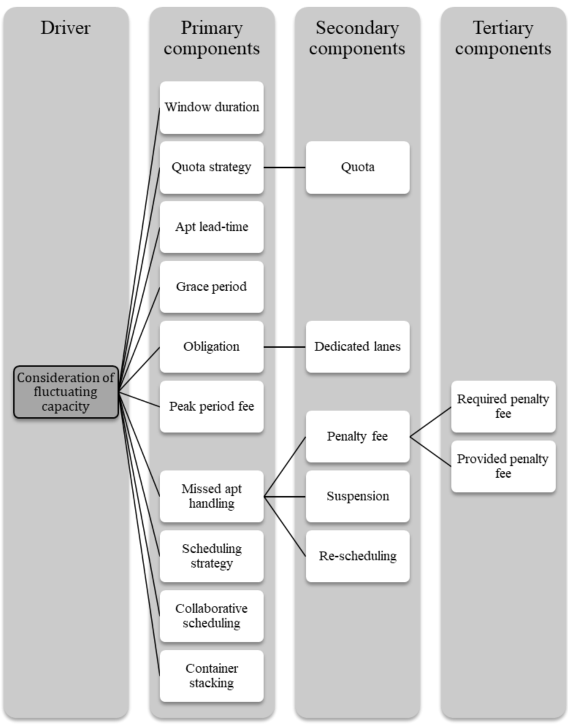
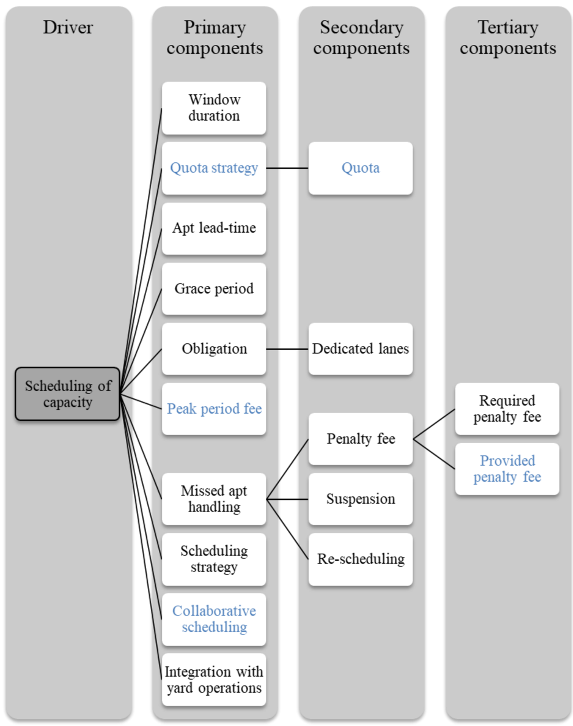


Figure 26

Components related to the driver 'scheduling of capacity' (TD1)

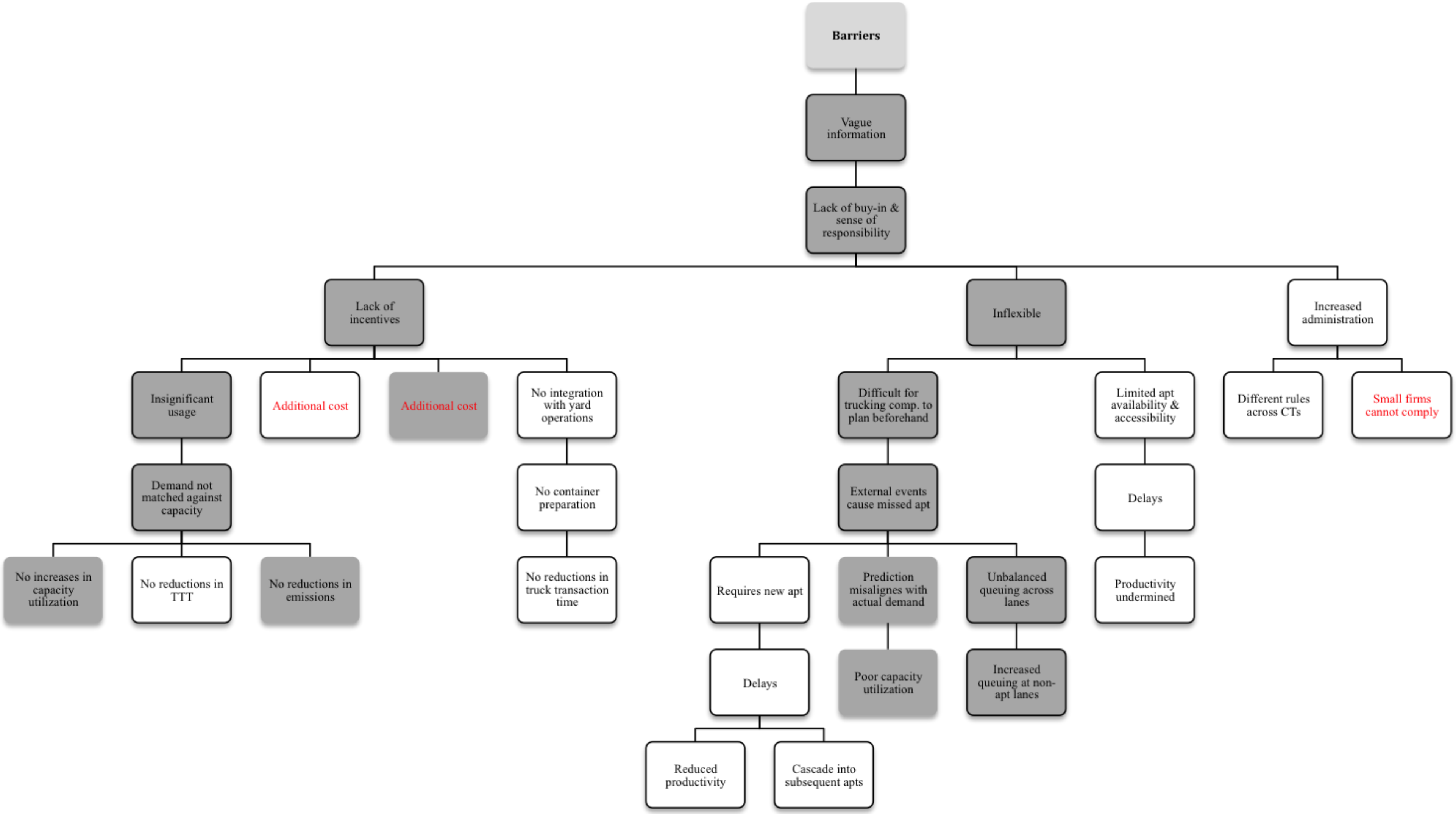


5.2 Barriers related to all identified components and options of truck appointment systems

As with the drivers, identification of the basic TAS designs, components, and options, enabled identification of the fundamental barriers and their interrelations, which were illustrated in figure 7. Two additional barriers related to the TAS emerged when developments of the basic TAS design in the shape of TAS components and options were identified. These barriers and their interrelations to the other barriers were illustrated in figure 10. Likewise, the empirical data enabled identification of one previously unidentified barrier and its interrelations to the other barriers identified in theoretical data were illustrated in figure 23. The theoretical data was further integrated with the empirical data to compile the barriers and their interrelations in a single illustration. These are highlighted in figure 27 through a hierarchy yet again specifying the barriers perceived by TOs respectively TCs; The white cells with bold lines mark the barriers perceived by the TCs and the grey cells mark the barriers perceived by the TOs. The cells in grey with bold lines mark the barriers perceived by both actors. In the figure the cells with black text mark the barriers related to the basic TAS design and the cells with red text mark the barriers related to the developed TAS designs as well as an additional barrier experienced by case company B and C. The hierarchy has been compiled according to the following logic: If underlying yet same-level barriers are perceived by different actors, their shared overlying barrier is perceived by both actors.

Figure 27

Barriers related to all identified components and options of TASs



The barriers depicted in figure 27 derive from the primary barrier (PB): ‘vague information’. Although PB was explained in early literature as a result from the system being enforced on the container terminals by external legislators with little know-how of the system, it also indicates the container terminals’ insufficient understanding for the drivers and barriers related to the TAS and how to design it to reinforce the drivers respectively mitigate the barriers. Either way, PB directly translates into the secondary barrier (SB): ‘lack of buy-in and sense of responsibility’. According to figure 27, SB gives rise to three tertiary barriers: (TB1) ‘lack of incentives’, (TB2) ‘inflexible’, and (TB3) ‘increased administration’.

TB1 (‘lack of incentives’) in turn gives rise to four quaternary barriers (QB): QB1) ‘insignificant usage’, QB2) ‘additional cost’ for the TCs, QB3) ‘additional cost’ for the TOs, and QB4) ‘no integration with yard operations’. While QB2 only arise if additional monetary fees are applied in the form of required penalty fees or peak period fees to compensate for TOs’ loss in productivity, QB3 only arise if provided penalty fees are applied to compensate for TCs’ loss in productivity. QB1 and QB4 on the contrary, both mirrors the hierarchy depicted in figure 25 related to QB6 (‘consideration of fluctuating capacity’) and hence likewise relate to all identified components. The reason for this is because if truck arrivals are not levelled against capacity, no improvements in queuing during peak-hours is achieved. Then no reductions in TTT and hence no incentives for the TCs to use the system will result. For the TOs insignificant usage of the system implies little levelling of truck arrivals which culminates in a lack of reduction in truck emissions as well as lack of improvements in capacity utilization.

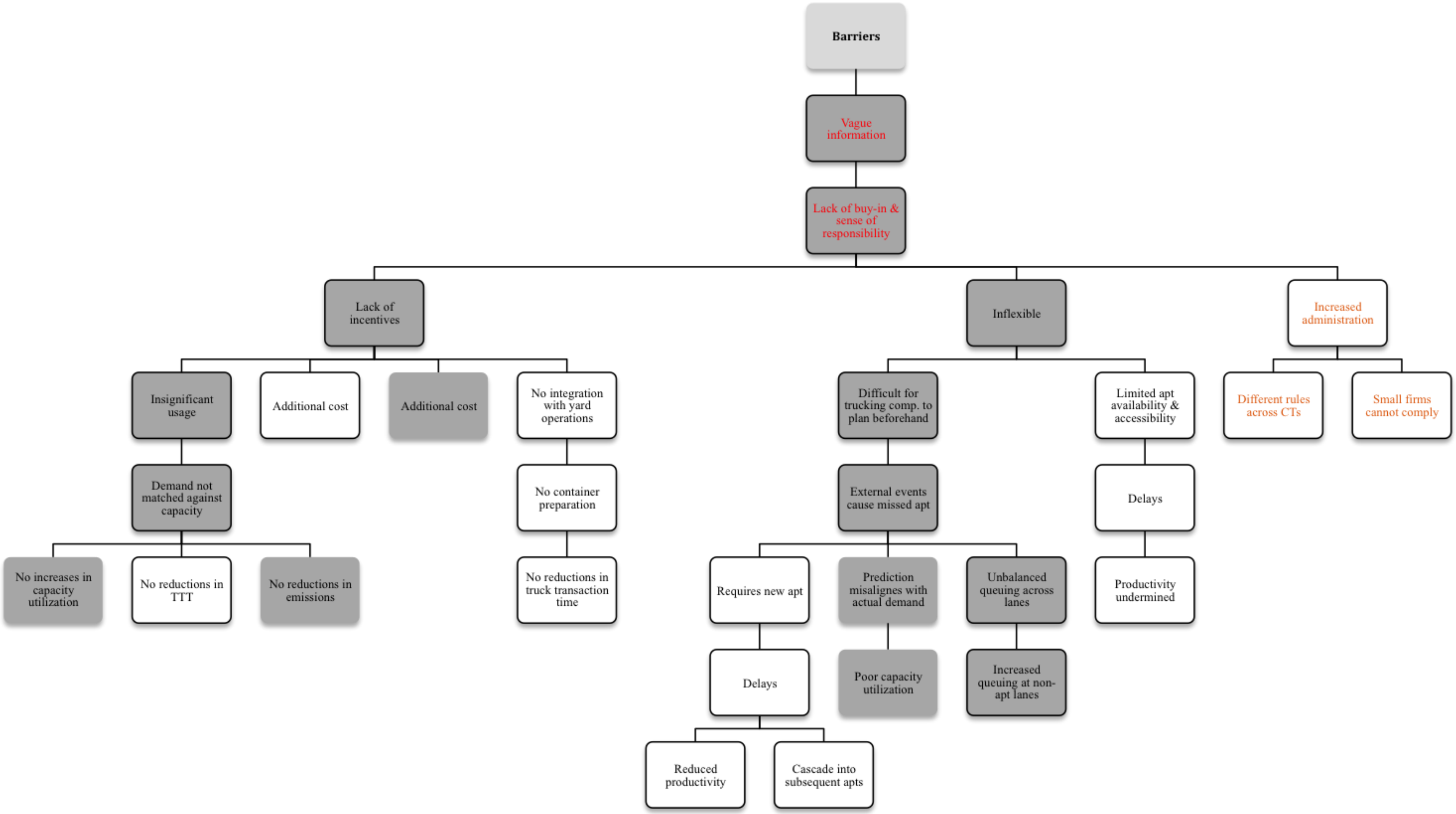
TB2 (‘inflexible’) in turn gives rise to two QBs: QB5) ‘difficult for TCs to plan beforehand’ and QB6) ‘limited appointment availability & accessibility’. QB5 mirrors QB6 as difficulties to plan beforehand implies that appointments must be booked based on great uncertainties risking that the appointment will be missed and that a new appointment must be booked. Ultimately this cause delays that in the worst-case cascade into subsequent appointments, undermining and reducing TCs’ productivity. Enhanced appointment availability & accessibility would balance the difficulties of planning beforehand. For the TOs difficulties in planning beforehand implies that TCs are more prone to missing their appointments and thereby the prediction of demand becomes misaligned with the actual demand which culminates in poor capacity utilization. Moreover, if the system is optional to use, several missed appointments cause unbalanced queuing across non-appointment lanes and appointment lanes, which culminates in increased queuing at the non-appointment lanes.

TB3 (‘increased administration’) has only been vaguely addressed by the identified components. However, it is self-explanatory that implementing any sort of booking system should increase the administrative burden for TCs; Adding constraints should increase the time and effort spent on scheduling and routing meanwhile the booking procedure should require some level of increased administration. Furthermore, as poor appointment availability and accessibility increase the risk for missed appointments, it should also increase the administrative work related to booking new appointments. Moreover, in addition to cooperative time windows, the different fees should, although not stated, imply some additional administrative work for the TCs. Thereby TB3 should be affected by all the identified components. However, the underlying drivers of TB3 ‘different rules across container terminals’ and ‘small firms cannot comply’, have seemingly not been sufficiently addressed by academic literature and therefore little can be said about their relations to the TAS components. TB3 will therefore only be addressed on a general level, implying that only the amount of administrative work will be considered and not the underlying barriers depicted in figure 27. Hence, the underlying barriers are left out of the analysis but will be approached in section 6.5.

Other barriers that were not directly addressed was the overall barrier namely PB (‘vague information’) and its direct implication SB (‘lack of buy-in and sense of responsibility’). These barriers and their insufficient acknowledgement in academic literature, validate the importance and hence purpose of this report; This report aims to inform TOs about the drivers legitimizing an implementation of a TAS and how they can be realized. Moreover, the report also aims to inform TOs about the barriers that can potentially hinder the realization of the drivers and how they can be managed. Without knowledge on how to design the TAS to maximize its effectiveness, different perceptions regarding the system’s effectiveness will result in a lack of buy in, sense of responsibility, and prioritization of the system. The barriers not sufficiently addressed by the developments presented in academic literature are illustrated in figure 28. While the cells with orange text mark the barriers of which future research should be focused, the cells with red text mark the barriers addressed in this study.

Figure 28

Barriers covered and excluded in the study



To sum up, the barriers to pay attention to when considering different TAS components and options are: SB ('lack of buy-in and sense of responsibility'), TB1 ('lack of incentives'), QB6 ('limited appointment availability & accessibility'), and TB3 ('increased administration'). TB1, QB6, and TB3 and their respective relations to the 17 identified components, are similarly to the drivers illustrated in figure 29, 30, and 31. Since the barriers reflect some of the identified drivers (those related to mitigating the barriers – enhanced appointment availability and accessibility and compensation for loss in productivity) such relations were possible to identify from figure 11-20 in section 2.4. The relations further concerns whether the components affect the barriers, either by their pure existence or when adjusting their related option. For the sake of simplicity, QB2 ('additional cost' for the TCs) and QB3's ('additional cost' for the TOs) simplistic relations to the monetary components are not illustrated separately but will be viewed as part of the overall barrier TB1 reflecting the barriers of QB1 ('insignificant usage) and QB4 ('no integration with yard operations'). In the figures, all identified components are listed, however, only the components written in black influence the related barrier; The components written in blue do not influence the related barrier. Two of the barriers are marked with grey and bold lines as they contribute to the barriers of both TCs and TOs, however, one is marked with white and bold lines as it only affects the TCs.

Figure 29

Components relating to the barrier 'lack of incentives' (TB1)

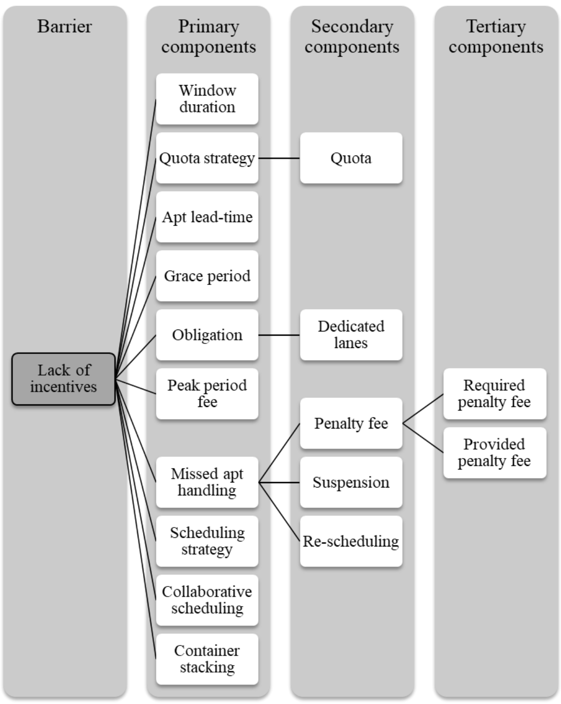


Figure 30

Components related to the barrier 'limited appointment availability & accessibility' (QB6)

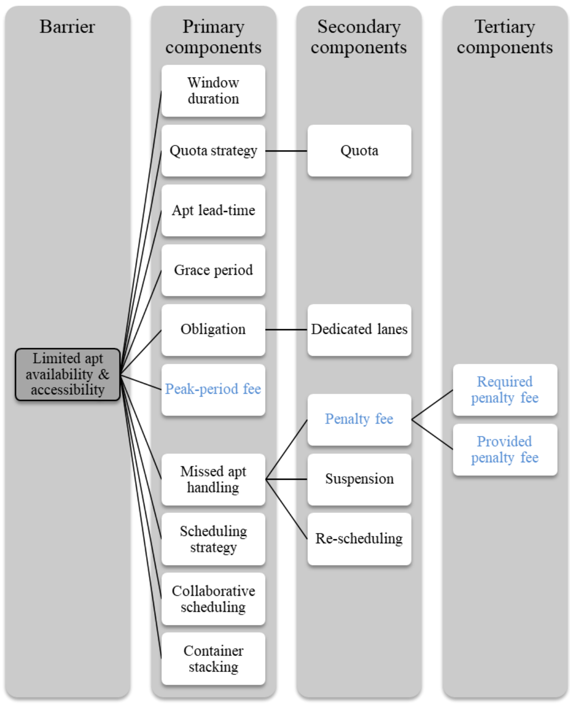
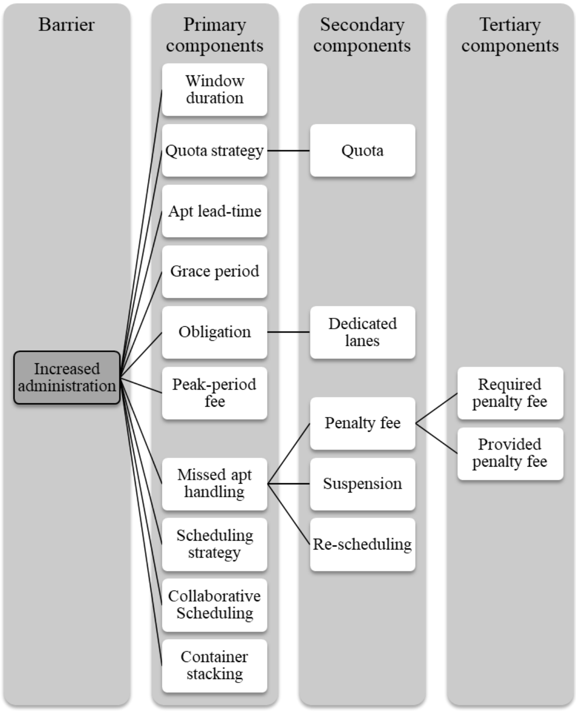


Figure 31

Components related to the barriers 'increased administration' (TB3)

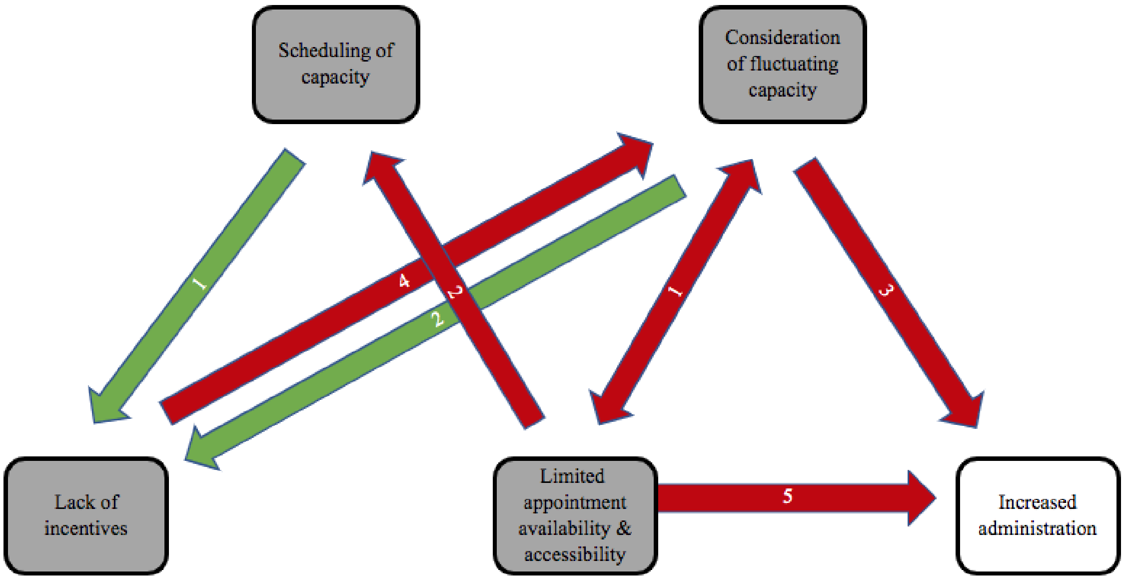


5.3 Relations between the overlying drivers and barriers

From figure 25, 26, 29, 30, and 31, it is evident that most of the components affecting the drivers TD1 ('scheduling of capacity') and QD1 ('consideration of fluctuating capacity') also affect the barriers of TB1 ('lack of incentives'), QB6 ('limited appointment availability & accessibility'), and TB3 ('increased administration'). Although there might be a positive relation between a specific component and these drivers and barriers (component reinforce a driver while mitigating a barrier) it might also be a negative relation (component reinforce a driver while reinforcing a barrier, component reinforce a barrier that mitigate a driver, or component reinforce a barrier that reinforce another barrier). In this study two positive relations have been identified and five negative between the two drivers and the three barriers which are illustrated in figure 32. The first positive relation (green arrow (1)) is between TD1 and TB1 as scheduling of capacity enables reduced truck transaction time which acts as an incentive for TCs to use the system. The second positive relation (green arrow (2)) is between QD1 and TB1 as matching demand against capacity enables reduced truck transaction time which similarly acts as an incentive.

Figure 32

Interrelations between the overlying drivers and barriers



The first negative relation is between QD1 ('consideration of fluctuating capacity') and QB6 ('limited appointment availability & accessibility') (red arrow (1)) and goes both ways; A TAS that is designed to maximize terminal operations efficiency and to minimize queuing during peak hours, will cause efficiency problems for TCs if the inflexible properties of the TAS components and options are not completely understood. While a TAS that is designed without consideration of the objectives and constraints of TCs have direct implications for the TCs, it also has indirect implications for the TO. A TAS design with limited appointment availability and accessibility is prone to poor predictions of actual demand and hence scheduling of capacity; Poor scheduling of capacity further implies problems for the TO in terms of fluctuations in capacity utilization and increased queuing at non-appointment lanes. As a TAS design with limited appointment availability and accessibility implies problems regarding scheduling of capacity a second negative relation arise between QB6 and TD1 ('scheduling of capacity') (red arrow (2)). The third negative relation is between QD1 and TB3 ('increased administration') (red arrow (3)); Introducing a booking system implies increased administration for the TCs. The fourth negative relation is between TB1 ('lack of incentives') and QD1 (red arrow (4)). A TAS design that lacks incentives for TCs to use the system, implies that demand is not matched against capacity which hinders the realization of drivers of the TAS. The fifth negative relation is between QB6 and TB3 (red arrow (5)). A TAS design that is prone to cause missed appointments imply that re-bookings must be made by the TCs causing increased administration.

From observing figure 32 some important conclusions can be drawn. Apparently, a TAS design that considers these barriers and hence the constraints and objectives of not only TOs but also of TCs, is necessary to realize the drivers of the system; The barriers seemingly limited to the TCs are, as illustrated in figure 32, also detrimental for the TOs. Moreover, while reinforcing the driver QD1 ('consideration of fluctuating capacity') implies that TB1 ('lack of incentives') is mitigated, it also implies that QB6 (‘limited appointment availability & accessibility’) and TB3 (‘increased administration’) are reinforced. In such instance, QB6 further mitigates the two drivers and reinforce TB3. Ultimately there is a conflict between the QD1 and QB6 that needs to be considered by TOs when designing a TAS as well as when integrating it into the existing business.

5.4 Options considering relations between the overlying drivers and barriers

The TAS designs, components, and options identified in this study partially incorporate the drivers and barriers of TOs and partially those of TCs. While some components and options are developed with the intention of reinforcing the drivers and mitigating the barriers for one of the stakeholder groups, some seek to balance the barriers and drivers of the two stakeholder groups (hereafter referred to as dual perspective). That prioritization of the barrier QB6 (‘limited appointment availability & accessibility’) over the drivers prevails among the developed TAS components and options, became evident in section 5.1 and 5.2; the drivers forwarded regarding the components were predominantly drivers related to mitigating QB6 rather than drivers for implementing a TAS. However, due to the conflicting relation between QD1 (‘consideration of fluctuating capacity’) and QB6, in such approach QB6 is mitigated at some level of expense of QD1.

This is where the TAS options come into play; While components have been developed with the intention of maximizing the effectiveness of the TAS for any of the two stakeholder groups or both, options have been developed in parallel to the basic TAS components with the same interest. Ultimately, this implies that components through their related options, can be further designed to prioritize either QD1 (‘consideration of fluctuating capacity’) or QB6 (‘limited appointment availability & accessibility’) or both. To identify the components possibility to deprioritize between these two and hence their possibility to incorporate the dual perspective, also the different options’ relations to QD1 and QB6 must be identified. Since no additional options were identified from the empirical data, the theoretical data will act as a basis for the analysis. Figure 11-20 sufficiently portrayed the relations between the developed options and the drivers and barriers. In the figures 11-20, each of the developed options were evaluated both based on the drivers they prioritize and on the drivers they give rise to.

Although the conflicting relation between QD1 (‘consideration of fluctuating capacity’) and QB6 (‘limited appointment availability & accessibility’) is necessary and critical to address to realize the drivers of the system, the other two barriers, TB1 (‘lack of incentives’) and TB3 (‘increased administration’), must also be managed and mitigated. As was stated in section 5.2, ways to mitigate TB3 have not been sufficiently addressed in practice nor in theory and will therefore only be evaluated in one dimension, namely increased administration, which does not fully address its two underlying barriers depicted in figure 28. However, the barrier should be mitigated when QB6 is as well as when fees are absent.

While TB1 (‘lack of incentives’) should not be prioritized over QB6 (‘limited appointment availability & accessibility’) and TB3 (‘increased administration’), TB1 should precede them. This is because TB1 has the potential to deteriorate the drivers of TAS ultimately limiting the effects of measures taken to mitigate QB6 and TB3. Focusing on TB1 implies taking measures to realize TD1 (‘scheduling of capacity’) and QD1 (‘consideration of fluctuating capacity’). For the component of obligation, the option of mandatory is preferred to realize the drivers of the TAS. While an optional TAS implies that missed appointments can be filled with trucks without appointments hence improving appointment accessibility, it is prone to fail in realizing the drivers of the system further incentivizing TCs not to use the system. To incentivize TCs to utilize the system enough dedicated lanes ensuring that trucks with appointments are benefitted, can be deployed. However, as this means that the ratio of dedicated lanes to the non-appointment lanes will have to increase as the system gains users, the option of mandatory is the only sustainable option long-term. Such option, however, implies that re-scheduling of missed appointments must be made as no none-appointment lanes are available. This greatly affects the flexibility of a TAS if the rest of the system is not designed with this in mind.

When it comes to the second component of the basic TAS design, appointment lead-time, the option of same day appointment booking mitigates QB6 (‘limited appointment availability and accessibility’) and hence TB3 (‘increased administration’) but also reinforces the two drivers; Although a longer appointment lead-time enhances scheduling of capacity the actual demand will not align with the predicted demand due to uncertainties inherent in the trucking operations causing missed appointments. Hence, deploying a shorter appointment lead-time enables a greater share of met appointments and hence alignment between demand and capacity assuming that scheduling of capacity can be facilitated in other ways such as on historical data.

The seek to balance QD1 (‘consideration of fluctuating capacity’) and QB6 (‘limited appointment availability and accessibility’) holds for all the components with developed options which is highlighted by figure 11-20. The options of window duration do so partially by introducing a long window duration and partially by finding a middle ground between the options of short and long; thereby the drivers of the TAS are enabled while appointment accessibility is enhanced. Regarding the quota strategy the system can be balanced in two ways; In a static system the quota can similarly to window duration be set high or according to a middle-ground to enhance appointment availability while still enabling demand to be matched against capacity. In a dynamic system the quota can be altered depending on fluctuations in available capacity as well as fluctuations in demand, which enhance appointment availability while enabling a more realistic approach towards demand. The scheduling strategy enables equilibrium when moving from the options of IAS and BAS to the options of STAS and DAS; the two latter options in addition to the drivers, incorporate flexibility to different extents. While STAS through its consideration of truck scheduling enhance appointment availability, DAS through its use of real-time data enhance both appointment availability and accessibility thus being more realistic towards internal and external fluctuations. As the name suggest, the component of collaborative scheduling balance the QD1 and QB6 by incorporating collaborative options. When applying any of the two developed options of cooperative time windows or adjusted time windows, QD1 is reinforced meanwhile QB6 is mitigated, however, to various extents. Moreover, when moving from the former option to the latter, control is shifted from the TCs to the TOs, and appointment accessibility becomes manipulable by the TO rather than by the TCs which decrease administration and enable purposeful segmentation which further increase appointment accessibility for high-volume TCs.

In contrast to the developed options, developed components do not necessarily seek to balance the QD1 ('consideration of fluctuating capacity') and QB6 ('limited appointment availability and accessibility'). Adding any form of penalty fee (required or provided) to a TAS, does not affect the appointment availability or accessibility of the system. The same goes for peak-period fee. Although it can be argued that increasing the cost for TCs during certain time periods affect their possibility to perform transactions and hence appointment availability and accessibility, no physical boundaries are set that absolutely limit the operations of the TCs. Hence, the labelling of fees as incentives rather than limitations. Beyond the barriers, the different fees are enablers of QD1 and required penalty fees also gives rise to TD1 ('scheduling of capacity'). These components can therefore be applied to ensure revenue streams or as additional incentives to level truck arrivals if needed. Suspension on the other hand has a reversed effect when it comes to appointment availability; when not applied it enhances appointment availability for those otherwise being suspended. Although a consequence of applying suspension might be enhanced appointment availability for those complying with the TAS, it is assumed to be a relatively small share of the total amount of appointments. However, if applied, suspension enhance the two drivers. Grace period is the only developed component seeking to find equilibrium between QD1 and QB6 as its application implies enhanced appointment accessibility. When grace period is not applied the two drivers are instead enhanced.

When applying TAS to improve container stacking operations in the yard, scheduling of capacity is the primary intention rather than matching demand against capacity. Although fluctuations in truck arrivals are not mitigated, capacity utilization is enhanced from introducing re-marshalling during yard cranes' idle times which reduces the number of shuffle moves performed during container transactions. Thereby re-marshalling reduces TTT and queuing throughout both peak- and off-peak periods. While targeting both capacity utilization and queuing, two major drivers of a TAS are satisfied without necessarily matching demand against capacity. This means that TAS can be designed to prioritize appointment availability and accessibility over matching demand against capacity thereby suppressing the conflicting relation between QD1 ('consideration of fluctuating capacity') and QB6 ('limited appointment availability and accessibility').

To facilitate the dual perspective some components and options are apparently favorable. While the components of obligation and re-scheduling should specifically be realized through the options of mandatory respectively new appointment required to first mitigate TB1 ('lack of incentives'), the rest of the components should be applied through options that mitigate QB6 ('limited appointment availability & accessibility') and hence TB3 ('increased administration'). All these components and related options contribute to the dual perspective as they also facilitate TD1 ('scheduling of capacity') and QD1 ('consideration of fluctuating capacity').

5.5 A Business model perspective on truck appointment systems incorporating the dual perspective

In this section the basic and developed TAS components and options that incorporate the dual perspective, are analyzed from a business model perspective. By analyzing the influence TAS, and hence the service of container transactions, has on the business model of container terminals, necessary modifications to align the service and business model should become apparent.

The business model canvas framework developed by Osterwalder & Pigneur (2010) has been adopted in this study to perform the analysis of the TAS from a business model perspective. The framework and its related aspects and interconnection with TASs representing the dual perspective, is presented in figure 33. The developed analytical framework should be viewed as a reference when incorporating a TAS of the dual perspective into the service of container transactions. More specifically, the elements specifying the business model aspects are meant to act as a reference for container terminals. Having considered the different elements, they may remain or be removed from the framework depending on their suitability in the specific terminal. To maximize the performance of a TAS, it needs to be designed and integrated according to the local condition of that specific terminal.

Figure 33

Business model for TAS

<table>
<tr>
<td rowspan="2">Key Partners
TCs
TO
Port authority</td>
<td>Key activities
Incorporating business rules
Truck appointment scheduling
Performing transactions based on appointment schedules</td>
<td rowspan="2">Value propositions

TCs
Available and accessible appointments on request
Short TTT

TO
Scheduling of capacity
Match demand against fluctuations in capacity

Port authority
Improved economical, societal, and environmental performance</td>
<td>Customer relationship
Self service
Collaborative appointment scheduling</td>
<td rowspan="2">Customer segments
High-volume TCs
Low-volume TCs
Small TCs
Large TCs</td>
</tr>
<tr>
<td>Key Resources
Collaboration with TCs
Know-how of different TAS designs</td>
<td>Channels
Web based interface
Mobile platforms
Integrated in the transport management system</td>
</tr>
<tr>
<td colspan="3">Cost structures
Provided penalty fees
Investment cost
Operating costs</td>
<td colspan="2">Revenue Streams
Required penalty fees
Subscription fees
Peak period fee
Terminal rent reduction</td>
</tr>
</table>

Note. Based on the Business model canvas framework from *Business Model Generation*, by Osterwalder & Pigneur, 2010.

In this study the aspects constituting business model canvas concern the container terminal and not the TCs nor the port authority. This is because the container terminal is the stakeholder typically providing and designing the TAS. Hence, the aspects of ‘Cost structures’ and ‘Revenue streams’ (which are the only aspects that are dependent on the owner of the system) account to the monetary flows from respectively to the TO. However, as the system is implemented with the intention of improving an existing service rather than with the intention of adding another service, the aspect of 'Value propositions' reflects the added value provided to all stakeholders when implementing the TAS. More specifically the emphasis on the value provided to the TO is due to the absence of an additional revenue stream related to the TAS that otherwise would incentivize the TO to implement the system. In the following sections each of the aspects and their related elements are discussed in detail.

Key partners
There are three key partners identified that are important to consider when operating a TAS. No other stakeholders of the port community and within the scope of this report were forwarded in the data as either directly affecting or being directly affected by the TAS. The three key partners are the TO, the port authority, and the TCs. The TO is the most common actor to implement and operate the system. However, the port authority can act as the initiator and co-designer of the TAS to be implemented by the TO. Lastly, the TCs are the users of TAS.

Key activities
There are three key activities incorporated with the usage of TAS. The first activity is to determine business rules related to TAS that need to be present and agreed upon between the TO and the TCs. Some form of agreement on how the TO and TCs should operate in the implementation of TAS should exist, even though the business rules might differ between terminals. The second and most obvious activity is truck appointment scheduling, this activity is essential and cannot be neglected; The TO must be flexible and might have to adjust components such as, quotas, appointment windows, and fees. Lastly, performing transactions based on the appointment schedules implies that re-marshalling is deployed in the yard area. Although this activity is not required to level demand against capacity it enables TOs to gain benefits of improved resource utilization which further influences congestion positively.

Key resources
To realize a TAS with the mentioned value propositions, two key resources are important to consider. Firstly, the TO needs the know-how of how to design the TAS to realize the drivers respectively mitigate the barriers of the system. If this resource is not available internally, consultants specialized in TAS could be a solution to support the TO when designing the TAS. Secondly, input from TCs is a valuable resource needed to design the TAS; TCs committed to collaborate and to create a fair system is needed for the TO to understand the TCs' perspective.

Value proposition
The value propositions mainly relate to the TO and the TCs. The two drivers TD1) 'scheduling of capacity' and QD1) 'consideration of fluctuating capacity' combined with the three barriers, TB1) 'lack of incentive', QB6) 'limited appointment availability & accessibility', and TB3) 'increased administration', can be directly translated into the value proposition; In order to reinforce the drivers respectively mitigate the barriers related to the TAS which have shown to be vital for the operations of both actors (see figure 32), components and options that incorporate the dual perspective is necessary to deploy. Ultimately such components and options balance the objectives and constraints of both actors. This is especially important due

to the contradiction between the driver QD1) ‘consideration of fluctuating capacity’ and the barrier QB6) ‘limited appointment availability & accessibility’; Whereas the other overlying drivers and barriers can be relatively easily solved by deploying specific components and options, the contradicting barrier and driver must pervade the entire TAS design and hence the value proposition to ensure terminal competitiveness. Not respecting the need for system flexibility will cause great spillover effects on the terminal operations.

The port authority is not the user of the system but can gain indirect benefits. Such indirect benefits relate partially to reduced emissions and partially to improved competitiveness. If the port can increase its competitiveness against other ports, it can attract more cargo to pass through the port. Increased throughput in the port should provide new jobs, increased generation of tax revenue, and economic growth in the region.

Customer relationship
The customer relationships to emphasize are those to the TCs; Because of the dependencies between the drivers and barriers, the TO must respect the constraints and objectives of the TCs. As all components and options constituting the TAS design are related to either the TCs’ objectives or their constraints, these can be chosen accordingly. Thereby, the relationships to the TCs can be catered to in many ways. The relationship to the port authority is indirectly improved when facilitating the TCs’ operations; A TAS that effectively manages the different drivers and barriers enhances the efficiency and hence competitiveness of the terminal while enabling reduced emissions.

Channels
The two common channels of communication in a TAS are through a web-based interface or a mobile platform. An additional channel that was identified is to integrate the TAS with the TCs’ transportation management system. As the technical aspects and programming languages to establish the information system is not within the purpose of this study, no further analysis regarding drivers and barriers for the different channels have been made.

Customer segments
Two major factors have been identified which combined create four different customer segments. The factors to be considered is the size of the TCs and the transaction volumes performed by the TCs. These different customer segments are important to consider since they operate differently and could benefit or be limited by different components of TAS in different ways. The understanding is that high-volume TCs spend more of their time waiting at the terminal because they perform more transactions each day. Hence, if appointments are not available at request, it can affect many upcoming appointments that could be delayed the same day. If a truck with many appointments during a day gets delayed, it will require administration to rebook or cancel upcoming appointments. The scenario is different for low-volume TCs; Rather than cascading into subsequent appointments, missed appointments risk that the trucks arrive to their destination point too late. However, low-volume TCs have the possibility to book appointments before their trucks leave the destination and start driving towards the terminal, as they usually have a few hours before arriving at the terminal. The second factor is the size of the TCs. A TAS need to be suitable for both large TCs and smaller once; The smaller TCs have less resources and/or incentives due to less scaling effects to integrate and administrate a TAS.

A TC is not necessarily in only one of the segments as a single company can have drivers both doing high-volume and low-volume transactions. The distribution of customer segments will differ between terminals and should be considered in the business model of TAS and incorporated during the design of the TAS to meet the requirements of the customer segments. However, everyone will probably not be satisfied, and a reasonable mindset is needed; If most of the TCs come to an agreement, a single small TC cannot be a dealbreaker for the system.

Cost structure
In addition to the operating costs and the capital investments needed to purchase a TAS, the main cost for the terminal could be if a penalty system is applied that require the terminal to pay a penalty fee to the TC if complies is not met regarding the accepted service level. However, provided penalty fees is probably only relevant in parallel with required penalty fees for TCs; The provided penalty fee can be an incentive for TCs to accept their required penalties if they do not comply with their booked appointments. Penalty fees could be a solution if agreed on by involved actors but can be complicated since in many cases no formal business relations exist between the TO and the TCs. A key factor is to design business rules that is in the control of the terminal and the TCs, it can be difficult but is necessary to create a fair system with clear boundaries for both actors. Something to be consider is that penalties will need additional administration and could cause more harm than benefits if the rules are unclear.

Revenue streams
There are some identified direct and indirect revenue streams that can be generated from a TAS. Firstly, an indirect revenue stream in terms of a reduced rental fees for the TO can be a solution if the port authority wants to incentivize the container terminal to implement a TAS. Secondly, a subscription fee to the TCs for using the system can be introduced to cover the cost of it. This can be a fair cost for the TCs as it is the same for everyone and does therefore not affect the competition between TCs. A small subscription fee could be introduced to increase the involvement from the TCs in developing the system. Thirdly, peak-period fees can be introduced as a mean to level out peak periods and to incentivize TCs to make transactions in off-peak periods. This can generate income for the TO, but the added income is sometimes used to improve the provided services for example through extended opening hours. Lastly, penalty fees can be introduced if agreed business rules are not complied with. However, added fees and costs for the TCs would increase their resistance towards implementing a TAS.

6 Discussion

In this chapter the three research questions are answered concisely based on the results presented in the analysis. In section 6.1, 6.2, and 6.3 each of the three research questions are specifically and individually addressed followed by section 6.4 addressing recommendations for practitioners. Lastly, in section 6.5, the limitations of the study are discussed and suggestions on future research in the related research area are given.

6.1 Research question 1

What components of a TAS design are related to perceived drivers of a TAS?

Several drivers of different levels related to TAS were identified from the theoretical as well as empirical data. These drivers were therefore compiled to detect their interrelations and thereby reflections of the terminal operations respectively trucking operations. 17 components consisting of ten primary components, five secondary components, and two tertiary components were further possible to distinguish from the same data. For each of the components a set of options, enabling realization of certain drivers, were detected.

Having clarified the drivers related to each of the options and hence components, the components were collectively related to each of two overlying drivers. This approach is valid since realization of an overlying driver implies that all related underlying drivers are achieved. The two overlying drivers to a large extent enable the same underlying drivers, however, through different components. These two drivers are TD1 (‘scheduling of capacity’) and QD1 (‘consideration of fluctuating capacity’). While the former driver enables scheduling of yard capacity which enhances terminal operations efficiency and thereby reduced queuing, the later driver enhances terminal operations efficiency and reduced queuing during peak hours by levelling truck arrivals. The components affecting these drivers either positively or negatively or not at all, were clarified and illustrated and it became evident that all the identified components affected QD1. More specifically, all the components related to the basic TAS design (‘obligation’, ‘dedicated lanes’, ‘missed appointment handling’, ‘re-scheduling’, ‘appointment lead-time', and ‘scheduling strategy’) and developed TAS designs (‘penalty fee’, ‘required penalty fee’, ‘provided penalty fee’, ‘suspension’, ‘peak period fee’, ‘window duration’, ‘grace period’, ‘quota strategy’, ‘quota’, ‘collaborative scheduling’, and ‘container stacking’), either positively or negatively affect the possibility to match demand against capacity when considering both fluctuations in terminal capacity as well as fluctuations in demand over time (QD1). It also became evident from the compilation that only components influencing the arrival information affect how well terminal capacity can be scheduled to correspond both with the level of demand as well as timely characteristics of the demand. These components are more specifically, ‘window duration’, ‘appointment lead-time', ‘grace period’, ‘obligation’, ‘dedicated lanes’, ‘missed appointment handling’, ‘penalty fee’, ‘required penalty fee’, ‘suspension’, ‘re-scheduling’, ‘scheduling strategy’, and ‘container stacking’. Hence, the importance of some of the components shift depending on which of the two overlying drivers that is prioritized by a TO.

6.2 Research question 2

What components of a TAS design are related to perceived barriers of a TAS?

Similar to the drivers, several barriers of different levels related to the TAS were identified from the theoretical and empirical data and were further compiled to detect interrelations and reflections of different stakeholder perspectives. Also, the barriers were related to each of the options and hence components to ultimately clarify the relations between each of three overlying barriers and the collective set of components. The three overlying barriers are affected by different components and options and have different implications for the TCs respectively TOs. When an overlying barrier is not mitigated the underlying barriers are not either. The three barriers are TB1 ('lack of incentives'), QB6 ('limited appointment availability & accessibility'), and TB3 ('increased administration'). While the first barrier mirrors the driver QD1 ('consideration of fluctuating capacity') by hindering realization of the driver if not mitigated, the second barrier implies limited appointment availability and accessibility which hinders realization of both overlying drivers and at the same time reduces and undermines the trucking operations efficiency. The third barrier implies an increased administrative burden for TCs.

As was previously stated, the first barrier mirrors QD1 and are therefore affected by the same set of components ('obligation', 'dedicated lanes', 'missed appointment handling', 're-scheduling', 'appointment lead-time', and 'scheduling strategy', 'penalty fee', 'required penalty fee', 'provided penalty fee', 'suspension', 'peak period fee', 'window duration', 'grace period', 'quota strategy', 'quota', 'collaborative scheduling', and 'container stacking'). The second barrier and its relation to the components were possible to identify through the drivers; Establishment of the drivers related to each component and related options, illuminated that most of the drivers were not drivers for implementing a TAS but rather drivers addressing that specific barrier. All components affect QB6 except for those related to fees since they do not restrict trucks from arriving at the terminal. The components that either positively or negatively affect QB6 are more specifically 'obligation', 'dedicated lanes', 'missed appointment handling', 're-scheduling', 'appointment lead-time', and 'scheduling strategy', 'suspension', 'window duration', 'grace period', 'quota strategy', 'quota', 'collaborative scheduling', and 'container stacking'. The third barrier is affected by all the identified components as it relates to appointment booking and re-booking as well as handling of fees; The correlation between the level of re-booking and the level of appointment availability and accessibility (QB6) implies that TB3 derives from the same set of components. At the same time, it is affected by the components related to fees which constitute the remaining components. As with the drivers, the importance of some of the components shift depending on which barrier that is targeted. However, such components are only limited to fees which highlights the importance of evaluating most of the components from different perspectives and hence the dual perspective.

6.3 Research question 3

What elements should be considered in a business model to address the perceived drivers and barriers of TAS?

To enable alignment between the TAS and the service it seeks to facilitate, a business model perspective has been applied. Applying a business model perspective to the TAS ultimately enables incorporation of the constraints and objectives of both a TO and TCs into the business model of the TO. As have been outlined throughout this study, the drivers and barriers related to the TAS reflect the constraint and objectives of both actors and must therefore be greatly considered by TOs when designing as well as when operating a TAS; The deployed TAS design consist of TAS components and options that each has multiple relations to the drivers and barriers and thereby they become a concern for both actors. To realize the system drivers and enable increased terminal competitiveness, the components and options must therefore be selected with great knowledge about their properties. By deploying components and option characterized by a dual perspective this should be ensured. In this study the TAS components and options that incorporates the dual perspective has been directly translated into elements in an analytical business model framework. The elements suggested to consider when incorporating a TAS to facilitate the service of container transactions have been presented in an analytical business model framework based on the business model canvas framework. The framework enables TOs to consider important aspects of their business model in terms of a TAS and hence the service of container transactions.

The elements that have been presented hence partly derive from the aspects of the business model canvas framework, partly derive from all the drivers and barriers which corresponds to the dual perspective. Since both TOs and TCs objectives and constraints need to be considered according to the dual perspective, they both represent key partners in the business model. The port authority indirectly gains value from an effective system and such gains coincide with the those of TOs and should therefore be included in the business model. Key activities include establishing business rules together with TCs, scheduling appointments, and performing gate- and yard operations according to such schedules; These activities include handling of the components and options constituting the dual perspective. The key resources constitute know-how about the components and options and how they relate to the drivers and barriers. Collaboration with TCs is important to ensure that the system succeed in targeting the drivers and barriers. The value proposition highlights the drivers of the system but also the conflicting relation between the objectives of a TO and TCs; The element ‘Available and accessible appointments on request’ mirrors the barrier ‘limited appointment availability and accessibility’ that if not mitigated, hinders realization of the drivers. Also, the value provided to port authorities are highlighted in the business model. The dual perspective is also clearly reflected by the elements related to the aspect ‘Customer relationship’. Although TCs perform some level of self-service both at the terminal as well as back in the depot, the key activities should include some level of collaboration depending on the system design. A system that is designed with consideration to the TOs objectives and constraints may not require scheduling to be performed in extensive collaboration and vice versa. This argument also holds for the aspect of ‘Customer segments’; To effectively target the drivers and barriers related to the TAS, variables such as transaction volume and company size should be taken into consideration. This is mainly because the administration as well as limitations in appointment availability and accessibility will struck different segments differently and thereby require segmentation. The components and options should therefore be chosen with this in mind. The channels in which the information exchange should take place have been delimited from this study, however, some existing channels have been identified throughout the study. Whether these sufficiently reflect the dual perspective is a topic for future research. Neither have revenue streams and cost structures been the focus of this study. Rather than providing an additional revenue stream as is the purpose with the services provided by the terminal, the system seeks to facilitate the service of container transactions. However, the aspect ‘Revenue streams’ highlights two important considerations: 1) by adding peak period fees TOs can facilitate the dual perspective through a less restrictive TAS given that TCs are willing to pay for it and 2) by providing improved value to port authorities lowered rental expenses can be entailed. The remaining revenue streams may act as tools to adjust the system’s level of dual perspective.

6.4 Recommendations for terminal operators

An interesting finding that emerged from the empirical data was the insufficient need to match demand against capacity; Two of the three TOs expressed that they did not experience issues with TTT and truck emissions. Although there are important drivers related to the TAS other than reduced TTT and truck emissions, namely improved terminal operations efficiency and all its related drivers, such scenario opens for a less restrictive TAS design; A less restrictive TAS design implies built in flexibility for the TCs while at the same time largely enabling the drivers presented in this study. A less restrictive TAS design can be obtained in different ways, partly by excluding certain components, partly by choosing certain options that not primarily aim so match demand against capacity. Moreover, if levelling of truck arrivals to reduce queues or level the capacity in the terminal is not a top priority, improved information sharing of truck arrivals which is entailed through a TAS, works to improve the terminal operations. This is partly due to improvements in scheduling of gate- and yard capacity, partly due to the possibility to perform re-marshalling in the container yard.

In the above-mentioned scenario, the implementation of an adequate TAS can be done in phases, with the first phase including gathering of arrival information such as arrival time and container-id for import containers. This makes it possible for the TO to 1) begin the implementation and 2) start taking advantage of arrival data to enable improved scheduling of capacity as well as introduce re-marshalling. The TCs will thereby not be restricted other than that they must provide with arrival information. This first phase could for example imply that no missed appointment handling is applied and therefore that TCs can perform transactions even if they miss an appointment. Also, the quota can either be absent or very unrestrictive to only limit unrealistically high peaks in demand. The first phase is based on mutual trust and presumes that TCs do their best to estimate their arrivals. With such system in place, it will be possible to calculate how accurately the TCs estimate their arrivals but also to validate improvements in terminal efficiency when applying arrival information. TCs arrival accuracy is important to measure since 1) it allows the TO to set reasonable window durations and 2) it increases the transparency because it provides the TCs with real data of how they perform, instead of basing it on assumptions. Validating how the arrival information have improved the TO´s operations allows the TO to 1) provide real data of the improvements that can be shared with TCs to increase their buy-in for using the TAS and 2) adjust or reevaluate the TAS if the results were not as expected.

With a TAS in place, the terminal is also prepared to move to a second phase of the implementation which is relevant if the situation changes due to increased demand or if truck arrival information is inaccurate. To handle increased demand, a quota can for example be introduced and to manage inaccurate arrival information, appointment handling can for example be applied to incentives the TCs to comply with their appointments. It is, however, important to bear in mind that moving towards a more restrictive TAS might come at the expanse of inaccurate data if limitations in appointment availability and accessibility are not addressed properly by adding or adapting other components and options to mitigate the barrier.

6.5 Limitations and future research

In this study a multiple-case study design was adopted but it became limited by the fact that few TOs as well as TCs were 1) available for interviews and 2) had implemented a TAS. That the study was affected by a low number of interviewees in case B and C (only two interviewees in case B and one in case C) implies that only narrow insights in the two cases were entailed. Moreover, only reaching a few case companies and employees implied that the TOs did not have any knowledge or experience with several of the components making it difficult to relate drivers and barriers in the empirical findings to these components. Such components were for example penalty fees, peak period fees, and container stacking. Furthermore, some of the TAS components and options such as 'collaborative scheduling' as well as 'STAS' and 'DAS' are, as far as the authors of this thesis report are aware of, still only developed at a theoretical level and could therefore not be observed in the empirical data. Hence, drivers and barriers could appear different for these TAS components once the components are put in practice.

Also, the business model canvas framework deployed in this study might not have been optimal for illustrating how a system such as TAS, influence the existing business model of a TO. This is mainly because the framework typically is deployed to illustrate how a product or service can be incorporated and not a system seeking to facilitate such product or service. This deficiency is highlighted by the presence of the aspect 'Revenue streams'; Generating revenue is not the direct purpose with the system but rather to provide value to the involved stakeholders. However, the framework was considered useful since its aspects appropriately reflect the important characteristics and requirements of TASs incorporating the dual perspective. This is especially evident for the aspect 'Value proposition' as its related elements equal the drivers related to a TAS that incorporates the dual perspective. Such drivers in turn are collectively entailed when a TAS consist of components and options that facilitate the dual perspective. However, future research on the topic may benefit from applying a different business model framework dealing with a system rather than a product or service.

The barrier related to increased administration for TCs were only addressed in one dimension in this report, namely the amount of administration. Furthermore, since administration was insufficiently addressed in the reviewed literature several assumptions were made regarding the components and options related to the barrier. Future research should therefore partially focus on such relations as well as on the other dimensions of the barrier and more specifically those related to its underlying barriers: 'different rules across container terminals' and 'small firms cannot comply'. Thereby, different segments of TCs would be better emphasized as well as the practicality of booking appointments.

The technical aspects of the TAS were delimitated from this study and future studies could therefore focus on this area. By reviewing different information technologies as well as information systems the entirety of TASs would be better captured.

With the contribution of this study, future research should focus on how different TAS components and options interact and how different combinations on a system level affect the drivers and barriers of TAS. Then, it would be possible identify if the current TAS components and options can create a successful and realizable TAS. If not possible, new components and/or options might have to be developed from the dual perspective to improve the system.

A possible extension of this study could investigate the level of consideration taken to the dual perspective in TAS designs implemented in different terminals. Thereby it would be possible to evaluate TOs' know-how regarding the designs effect on its performance. Another extension could be to quantitatively evaluate the different components' and options' effect on the overlying drivers and barriers; Doing so would enhance decision-making when seeking to design a TAS incorporating the dual perspective.

7 Conclusion

The aim of the study was: *To improve the understanding of the drivers and barriers of truck appointment systems' components and options and how they affect the content of terminal operators' business models.* The aim has been achieved through answers to three research questions which culminate in theoretical contributions. These contributions both individually as well as collectively provide as support to terminal operators either planning to implement a truck appointment system or terminal operators planning to re-evaluate an already implemented one.

Collectively the contributions inform terminal operators about important decision areas. To reap the systems' benefits, terminal operators both must make decisions regarding the system design as well as decisions regarding its level of reflection in the business model. The first decision area implies that terminal operators balance their own objectives and constraints against those of trucking companies. The second decision area implies that terminal operators transmit such approach and attitude across the operations involved in the service of container transactions. Individually the contributions target specifics characteristics of the truck appointment system. Profound understanding among terminal operators regarding the characteristics that ultimately determine system effectiveness is equally as necessary as understanding their interplay. Five contributions have been defined based on the results of this study. Each of these and their theoretical as well as practical implications are outlined in this chapter.

First, a framework compiling, categorizing, and clarifying the different truck appointment system components and options as well as their interrelations has been established. The framework facilitates a standardized way of reasoning regarding different truck appointment system designs incorporating a certain set of components and options. The framework has proved useful for clarifying different truck appointment system designs either conceptualized or deployed as well as for comparison. Moreover, understanding the drivers and barriers in terms of truck appointment system components and options, is important when designing a truck appointment system as it enables prioritization of certain drivers and barriers.

The second contribution is similarly a compilation and clarification of the drivers respectively barriers and their respective interrelations, influencing the effectiveness of a truck appointment system. These illustrations can contribute to current or potential practitioners of truck appointment systems by clarifying outcomes when facilitating certain overlying drivers or barriers. As the illustrations also consider the constraints and objectives of terminal operators respectively trucking companies, they highlight mutual constraints and objectives through the identified interrelations.

Third, overlying drivers and barriers realized through different sets of options and hence components, have been identified. Thereby, the components that need to be considered when designing a truck appointment system are highlighted.

Fourth, most of these overlying drivers and barriers have further been discovered to affect operations efficiency of both stakeholder groups through their positive or negative interrelations. Thus, the relations stress that options must be deployed that reinforce the drivers while mitigating the barriers. Moreover, one of the relations are conflicting and necessitates some level of balance between that driver and barrier which is achieved by deploying options incorporating a dual perspective. Thereby, the importance of considering the constraint and objectives of both terminal- and trucking companies when choosing among different options is highlighted.

Fifth, based on the dual perspective relevant elements to consider when seeking to incorporate the truck appointment system to facilitate the service of container transactions between a terminal operators and trucking companies have been suggested. Such elements enable alignment between the truck appointment system and the service by suggesting modifications to the current business model. Emphasizing the truck appointment system and the dual perspective in the business model is important to ensure that strategic and operational objectives mirror the constraints and objectives of both the terminal operator and trucking companies.

Increased knowledge about the characteristics of truck appointment systems; how to control them through its design; and how to ensure alignment with the service it seeks to facilitate, should increase the sense of urgency for the system as well as unify the perception of truck appointment system as a system with the capability of entailing strategic and operational objectives; Since the system entails improved gate- and yard operations efficiency, it enables terminals to target greater sizes of container vessels without compromising landside operations. The benefits deriving from a sophisticated truck appointment system are, however, not limited to container terminals; such benefits are accompanied by other benefits that intertwines with strategic and operational objectives of trucking companies. Although the level of flexibility entailed from unscheduled access will not prevail as terminals moves towards scheduled access, the benefits of reduced truck turnaround times enable more reliable terminal processes and enhanced resource utilization which are key to enable sustainable business growth. Also, port authorities and nearby regions are expected to benefit from such system; Improved terminal productivity and sustainability enhance the development of nearby regions which further highlights the importance of committing to seemingly futile details of the system design.

References

Abdelmagid, A. M., Gheith, M. S., & Eltawil, A. B. (2022) A comprehensive review of the truck appointment scheduling models and directions for future research, *Transport Reviews, 42*(1), 102-126, https://doi.org/10.1080/01441647.2021.1955034

APMT, (n.d.). Strategy presentation. Retrieved February 24, 2022, from https://www.apmterminals.com/en/about/our-company

Baccelli, O., & Morino, P. (2020). The role of port authorities in the promotion of logistics integration between ports and the railway system: The Italian experience. *Research in Transportation Business and Management*, 35, 100451. https://doi.org/10.1016/j.rtbm.2020.100451

Bell, E., Bryman, A., & Harley, B. (2019). *Business research methods* (5 edition). Oxford University Press.

Bisogno, M., Nota, G., Saccomanno, A., & Tommasetti, A. (2015). Improving the efficiency of port community systems through integrated information flows of logistic processes, *International Journal of Digital Accounting Research, 15*, 1–31. https://doi.org/10.4192/1577-8517-v15_1

Bowen, A, G. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal*, *9*(2). https://doi.org/10.3316/QRJ0902027

Böse, W. J. (2011). *Handbook of Terminal handling*. Springer.

Chen, G., Govindan, K., Yang, Z. Z., Choi, T. M., & Jiang, L. (2013a). Terminal appointment system design by non-stationary M(t)/Ek/c(t) queueing model and genetic algorithm. *International Journal of Production Economics, 146*(2). https://doi.org/10.1016/j.ijpe.2013.09.001

Chen, G., Govindan, K., & Yang, Z. (2013b). Managing truck arrivals with time windows to alleviate gate congestion at container terminals. *International Journal of Production Economics, 141* (1). https://doi.org/10.1016/j.ijpe.2012.03.033

Córdova, F., & Durán, C. (2014). A Business Model Design for the Strategic and Operational Knowledge Management of a Port Community. *Annals of Data Science, 1*(2). 191–208. https://doi.org/10.1007/s40745-014-0014-8

Covic, F. (2017). Re-marshalling in automated container yards with terminal appointment systems. *Flexible Services and Manufacturing Journal, 29*(3-4), 433-503. https://doi.org/10.1007/S10696-017-9278-6

Dyer, W.G., & Wilkins, A. L. (1991). Better Stories, Not Better Constructs, to Generate Better Theory: A Rejoinder to Eisenhardt. *The Academy of Management Review, 16*(3), 613-619. https://doi.org/10.2307/258920

Eisenhardt, M. K. (1989). Building Theories from Case Study Research. *The Academy of Management Review, 14*(4). https://doi.org/10.2307/258557

European Commission (2011), *White paper: Roadmap to a single European transport area towards a competitive and resource-efficient transport system*. Retrieved February 24, 2022, from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0144&from=EN

European Commission. (n.d.). *Clean Air*. Retrieved February 14, 2022, from https://ec.europa.eu/environment/air/index_en.htm

Frémont, A. (2013). Containerization and intermodal transportation. In J. Rodrigue, T. Notteboom, & J. Shaw (Eds.), *The SAGE handbook of transport studies* (p. 47-62). 55 City Road: SAGE Publications, Ltd. https://doi.org/10.4135/9781446247655.n4

Giuliano, G., & O´Brien, T. (2007). Reducing port-related truck emissions: The terminal gate appointment system at the Ports of Los Angeles and Long Beach. *Transportation Research Part D: Transport and Environment, 12*(7). https://doi.org/10.1016/j.trd.2007.06.004

Giuliano, G., & O´Brien, T. (2008). Extended gate operations at the ports of Los Angeles and Long Beach: a preliminary assessment. *Maritime Policy & Management, 35*(2). 215-235. https://doi.org/10.1080/03088830801956854

Guan, C., & Liu, C, C. (2009). Container terminal gate appointment system optimization. *Maritime Economics & Logistics, 11*, 378–398. https://doi.org/10.1057/mel.2009.13

Heilig, L., & Voß, S. (2017). Information systems in seaports: A categorization and overview. *Information Technology and Management, 18*(3), 179-201. https://doi.org/10.1007/s10799-016-0269-1

Heilig, L., Lalla-Ruiz, E., & Voß, S. (2017a). Digital transformation in maritime ports: analysis and a game theoretic framework. *NETNOMICS: Economic Research and Electronic Networking*, *18*, 227–254. https://doi.org/10.1007/ s11066-017-9122-x

Huynh, N. (2009). Reducing Truck Turn Times at Marine Terminals with Appointment Scheduling. *Journal of the Transportation Research Board*, *2100*(1), 47–57

Huynh, N., Smith, D., & Harder, F. (2016), Truck Appointment Systems Where We Are and Where to Go from Here, *Journal of the Transportation Research Board*, *2548*, 1-9. https://doi.org/10.3141/2548-01

Huynh, N., & Walton, C. M. (2008). Robust Scheduling of Truck Arrivals at Marine Container Terminals. *Journal of Transportation Engineering, 134*(8). https://doi.org/10.1061/(ASCE)0733-947X(2008)134:8(347)

Huiyun, Y., Xin, L., Lixuan, X., Xiangjun, L., Zhihong, J., & Zhan, B. (2018). Truck Appointment at Container Terminals: Status and Perspectives. *The Chinese Control and Decision Conference, 30,* 1954-1960. https://doi.org/10.1109/CCDC.2018.8407446

Iivari, M. M., Ahokangas. P., Komi, M., Tihinen, M., & Valtanen, K. (2016) Toward Ecosystemic Business Models in the Context of Industrial Internet, *Journal of Business Models, 4*(2), 42-59.

International energy agency. (2019). CO2 Emissions from Fuel Combustion, https://doi.org/10.1787/2a701673-en

Ioannou, P., Chassiakos, A., & Jula, H. (2006). *Cooperative Time Window Generation for Cargo Delivery/Pick up with Application to Container Terminals*. University of Southern California.

Jacobsson, S., Arnäs, P. O., & Stefansson, G. (2017). Access management in intermodal freight transportation: An explorative study of information attributes, actors, resources and activities, *Research in Transportation Business & Management*, *23*, 106-124. http://dx.doi.org/10.1016/j.rtbm.2017.02.012

Jacobsson, S. (2020). *Access management for road hauliers and rail operators in intermodal freight terminals* [Doctoral dissertation, Chalmers University of Technology]. Chalmers Research. https://research.chalmers.se/publication/516958

Kemme, N. (2013). *Design and operation of automated container storage systems.* Heidelberg: Physica-Verlag HD. https://doi.org/10.1007/978-3-7908-2885-6

Kotler, P., Armstrong, G., & Parment, A. (2017). *Marknadsföring: teori, strategi och praktik* (2nd ed). Pearson.

Lange, K. A., Kreuz. F., Langkau, S., Jahn, C., & Clausen, U. (2020). Defining the Quota of Truck Appointment Systems. [Conference Paper]. *Data science in maritime and city logistics: Solutions for Logistics and Sustainability, 30*, 211-246. ISBN: 978-3-753123-47-9. http://dx.doi.org/10.15480/882.3148

Lincoln, Y. S., & Guba, E. (1985). *Naturalistic Inquiry*. Sage.

Marchet, G., Perotti, S., & Mangiaracia, R. (2012). Modelling the impacts of ICT adoption for inter-modal transportation. *International Journal of Physical Distribution & Logistics Management, 42(*2), 110-127. https://doi.org/10.1108/09600031211219645

Maguire, A., Ivey, S., Golias, M. M., & Lipinski, M. E. (2010). Relieving Congestion at Intermodal Marine Container Terminals: Review of Tactical/Operational Strategies. *51st Annual Transportation Research Forum.* https://doi.org/10.22004/ag.econ.207280

Morais, P., & Lord, E. (2006). TERMINAL APPOINTMENT SYSTEM STUDY. Transportation Development Centre of Transport Canada

Namboothiri, R & Erera, A. L. (2008). Planning local container drayage operations given a port access appointment system. *Transportation Research*, *44,* 185–202. https://doi.org/10.1016/j.tre.2007.07.004

Navis. (2003) Maximize Productivity and Customer Satisfaction with Gate Appointments. https://www.aapa-ports.org/files/SeminarPresentations/05_OpsIT_Tiemroth_Eric.pdf

Osterwalder, A. & Pigneur, Y. (2010). *Business Model Generation.* John Wiley Sons Inc.

Perego, A., Perotti, S., & Mangiaracina, R. (2011). *International Journal of Physical Distribution & Logistics Management, 41(*5), 457-483. https://doi.org/10.1108/09600031111138826

Phan, M. H. & Kim, K. H. (2015), Negotiating truck arrival times among TCs and a container terminal, *Transportation Research Part E: Logistics and Transportation Review*, *75*, 132-144. https://doi.org/10.1016/j.tre.2015.01.004

Rodrigue, J. P., Slack, B., & Comtois, C. (2006). *The Geography of Transport Systems*, Routledge, New York, NY.

Shiri, S., & Huynh, N. (2016). Optimization of drayage operations with time-window constraints. *International Journal of Production Economics*, *176, 7-20*. https://doi.org/10.1016/j.ijpe.2016.03.005

Stake, R. E. (1995). *The Art of Case Study Research*. Sage.

Taipale-Erävala, K., Salmela, E., & Lampela, H. (2020), Towards a New Business Model Canvas for Platform Businesses in Two-Sided Markets, 8(3), 107-125.

Torkjazi, M. (2020). *New Models for Truck Appointment Problem and Extensions*. [Doctoral dissertation, University of South Carolina]. https://scholarcommons.sc.edu/etd/6014

Van Der Horst, M. R. & De Langen, P. W. (2008). Coordination in Hinterland Transport Chains: A Major Challenge for the Seaport Community. *Maritime Economics & Logistics*, *10*(1-2), 108-129. https://doi.org/10.1057/palgrave.mel.9100194

Van den Berg, R. (2015). *Strategies and new business models in intermodal hinterland transport*. Technische Universiteit Eindhoven.

Veile. W. J., Kiel, D., Muller M. J., & Voigt, K: I. (2019). *Ecosystem 4.0: A Supply Chain Perspective on Business Model Innovation* [Paper presentation]. The ISPIM Innovation Conference – Celebrating Innovation: 500 Years Since da Vinci, Florence

Warren, C. A. (2011). Qualitative interviewing. In Gubrium, J. F., & Holstein, J. A. (Eds.), *Handbook of interview research* (pp. 83-102). Thousand Oaks: SAGE Publications.

Yin, R. K. (2003). Case Study Research: Design and Methods. *Applied Social Research Methods*, 5.

Zhang, Y. & Zhang, R. (2017). *Appointment of Container Drayage Services: A Primary Literature Review*. International Conference on Service Systems and Service Management, 1-5 https://doi.org/10.1109/ICSSSM.2017.7996142

Zhao, W., & Goodchild, A. (2013). Using the truck appointment system to improve yard efficiency in container terminals. *International Journal of Maritime Economics, 15*(1). https://doi.org/10.1057/mel.2012.23

Zott, C., & Amit, R. (2010). Business Model Design: An Activity System Perspective. *Long Range Planning 43*, 216-226. https://doi.org/10.1016/j.lrp.2009.07.004

Øverby, H., & Audestad, J. A. (2021). *Introduction to Digital Economics* (2nd ed). Springer. https://doi.org/10.1007/978-3-030-78237-5

APPENDIX A

Interview Guide

Occupation:

Introductory questions

- What do You do in your current role?
- Were You involved in the evaluation and in deciding about the time slot system and if so, how?
- How do you think that the truck traffic to the container terminal will evolve in the next years?
- How did your gate- and yard operations work without a truck appointment system?

Main questions – features and design of the truck appointment system

1. How does the time slot system work?
2. What information content is gathered from the TCs/truck drivers or forwarding agents?
    a. How is the arrival information flow communicated?
    b. When does the arrival information flow take place?
3. Is it mandatory for TCs to use the time slot system? Why?
4. Does your organization charge extra for the service and if so, how?
5. How is the time slot system marketed to the TCs and forwarding agents?
6. What assets or knowledge have had to be added or expanded to the terminal operations to make the time slot system work?
7. Does the time slot system have different features for different TCs/truck drivers/forwarding agents?
8. How have TCs, forwarding agents and port authority/port terminal or any other stakeholder been involved in designing the time slot system?

Main questions - drivers

9. For what purpose does your organization use the truck arrival information?
10. What drivers did/do you see with a time slot system?
11. What drivers/benefits do you think TCs/truck drivers, port authority/port terminal, forwarding agents and other stakeholders see with the time slot system?
12. Who proposed/decided on the time slot system?
13. Who have invested in the implementation and operating of the time slot system?

Main questions - barriers

14. What barriers did/do you see with a time slot system?
15. What were/are the main costs related to the implementation and operating of the time slot system?
16. What barriers do you think TCs/truck drivers, port authority/port terminal, forwarding agents and other stakeholders see with the time slot system?
17. What is the container flow after they have left the container terminal, for example, do the trucks usually have an appointment window where they deliver the container?
18. Do the TCs mainly drive short or long distances?

Main questions - solutions

19. How were the barriers mitigated?
20. Were there any barriers that are not considered important to mitigate? Why?
21. What barriers implied/will imply greater costs to mitigate? Why?

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF SERVICE MANAGEMENT AND LOGISTICS
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden
www.chalmers.se

CHALMERS
UNIVERSITY OF TECHNOLOGY