Access management in intermodal freight terminals: The perspective of road haulier operations

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ABSTRACT

Given its possibilities of switching freight from road to more sustainable modes such as rail, inland water ways and seaways, intermodal freight transportation depends on environmental and economic variables. At the same time, intermodal freight transportation is essentially complex due to the variety of modes of transport and their corresponding actors. To reduce the complexity of such transport, the interaction of those actors and the exchange of information are crucial. In short, the more enhanced information exchange among actors, the higher potential of improving their management of access to intermodal terminals (e.g. railroad terminals and seaports). In this work, access management, refers to the management of the process of actors accessing resources for specific activities in transportation systems. Improved access management that relies upon increased information exchange among those actors might increase resource efficiency via the improved management of truck arrivals to terminals and of road haulier operations. The goal of this research is to clarify how access management affects resource efficiency in road haulage in intermodal freight transportation. Accordingly, the purpose of the research is to improve access management at intermodal freight terminals from the perspective of road haulier operators.

The thesis is a compilation of three papers that reports studies involving literature reviews, participant observations, interviews, focus group meetings, and time measurements. First, literature regarding access management and information exchange for road hauliers in intermodal freight transportation was studied. Second, a framework was developed in order to sort and analyse the identified information-related attributes required to improve access management for road hauliers. Third, a differentiation and segmentation framework with corresponding strategies are devised afford a better overview for analysing different access management service used by the industry, as well as to segment access depending on whether the terminal is a railroad terminal or a seaport. Fourth, an information exchange framework was developed and implemented in a smartphone app to measure and analyse the potential operational benefits of improved access management. The major contributions of this work, except the definition of access management, are clarifications of how contemporary access is handled, how access management can be improved, and investigations of the potential operational benefits of improved access management.

Key words: Access management, information exchange, differentiation and segmentation strategies, resource efficiency, road haulier operations, intermodal freight terminals

List of appended papers

Paper I:

Jacobsson, S., Arnäs, P. O. and Stefansson, G. (2017). "Access management in intermodal freight transportation: An explorative study of information attributes, actors, resources and activities". *Research in Transportation Business & Management*, Volume No. 23, pp. 106-124.

An earlier version of the paper was peer-reviewed and presented at the 14th World Conference on Transport Research, 10-15 July 2016, in Shanghai, China.

Paper II:

Jacobsson S., Arnäs, P. O., Stefansson, G. (2017). "Potential differentiation and segmentation strategies for improving access management: The case of haulier operations in intermodal freight transportation". Submitted to the *International Journal of Shipping and Transport Logistics.*

Earlier versions of the paper were peer-reviewed, presented and published in *The proceedings of the 28th Annual NOFOMA Conference*, 9-10 June 2016, in Turku, Finland, and at the 20th LRN Annual Conference, 9-11 September 2015, in Derby, UK.

Paper III:

Jacobsson S. (2017). "The potential benefits of access management in road haulier operations". Peer-reviewed, published in *the proceedings of the 29th Annual NOFOMA Conference*, 8-9 June 2017, Lund, Sweden. This paper won the best doctoral paper award at the conference.

An earlier version of the paper was peer-reviewed and presented at the 21th LRN Annual Conference, 7-9 September 2016, in Hull, UK.

The researcher's contribution to the papers

PAPER	FIRST AUTHOR	SECOND AUTHORS	RESPONSIBILITIES OF FIRST AUTHOR
I	Stefan Jacobsson	Per Olof Arnäs, Gunnar Stefansson	Primary responsibility for the literature review, the data collection, the data analysis, and the writing of the paper.
II	Stefan Jacobsson	Per Olof Arnäs, Gunnar Stefansson	Primary responsibility for the literature review, the data collection, the data analysis, and the writing of the paper.
III	Stefan Jacobsson		The first author is the sole author of the paper.

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Stefan Jacobsson

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Acronyms

AVEIS	Automatic vehicle and equipment Identification Systems
BAR	Bar coding
DSS	Decision Support Systems
EDI	Electronic data interchanges
ERP	Electronic resource planning system,
ETA	Estimated time of arrival
ICT	Information communication technology
IMG	Imaging systems
IS	Information systems
ISS	Information system supplier
IT	Information technology
ITU	Intermodal transport unit (i.e. standardised unit loads such as containers, semi-trailers, or swap bodies)
MCS	Mobile communication systems
NTM	Network for transport measures
Paper 1	Research paper 1
Paper 2	Research paper 2
Paper 3	Research paper 3
POD	Port operator D
REACH	Real-time access management by increased information exchange
RHA	Road haulier A
RHB	Road haulier B
RQ	Research question
Study 1	Empirical study 1
Study 2	Empirical study 2
Study 3	Empirical study 3
TOC	Terminal operator C

1 Introduction

The first chapter introduces the topic of this work. Section 1.1 describes the background of the research, after which Section 1.2 discusses the problem area and Section 1.3 introduces the concept of access management. From those three sections, the purpose and scope of the thesis are derived, as outlined in Section 1.4, which also articulates the three research questions that guide the thesis. After Section 1.5 presents the scope and delimitations of the research, Section 1.6 offers an overview of the contents of the thesis.

1.1 Background

The transport of goods, persons, and information are essential factors for human societies and economies (Rodrigue et al., 2006), as well as economic growth and creation of jobs (European Commission, 2011). Intermodal freight transportation operates in more or less all world trade markets (Lowe, 2005). Between 1995 and 2014, a total annual growth of all freight transportation modes (i.e. road, rail, inland water ways, pipelines, seaways and air) in Europe of 22.8% is reported (European Commission, 2016). Because road transportation shows the highest increase in annual volumes, intermodal freight transportation receives increased attention.

Given its possibilities of switching freights from road to more sustainable modes of transportation (e.g. rail, inland water ways and seaways), achieving the chief objectives of intermodal freight transportation depends upon environmental and economic variables (Lowe, 2005; Flodén, 2007). Successful intermodal freight transportation involves four major aspects (Lumsden, 2006): the availability of technology for switching freight among modes, the flexibility of transferring equipment such as straddle carriers, the handling of intermodal transport units (ITUs) – that is standardised unit loads such as containers, semi-trailers, or swap bodies – and the adaption of transportation units (e.g. railway wagons) to handle ITUs. For example, ITUs increase flexibility and preclude the need to manually load and unload during transhipments, which in turn reduce the spending of money and time and the risk of damage to goods (Woxenius, 1998).

The industrial network approach describes a system in terms of actors, resources, and activities (Gadde et al., 2003) and is used to describe, analyse and evaluate intermodal freight transport systems (Woxenius, 1998; Stefansson & Lumsden, 2009; Sternberg et al., 2013a). All transportation modes in intermodal freight transportation include many actors who use various resources for certain activities. Among those actors, resources, and activities, this work focus on hauliers who use trucks and ITUs to perform *road haulage*, defined as the transportation of freights to and from intermodal freight terminals, including road haulier operations (Woxenius & Bärthel, 2008).

The thesis considers only truck drivers´ tasks performed during normal workdays in all eight major road haulier operations: driving, loading, unloading, waiting, administration, service, handling freight, and breaks (Sternberg et al., 2014). When investigating those operations, it is possible to identify and elucidate the inefficiencies of truck drivers' workdays, as well as to consider terminal

companies that use terminals with equipment to perform transhipment, or when ITUs are transferred from one transportation mode to another (Woxenius & Bärthel, 2008), which influences road haulier operations. Another aspect of the approach is that intermodal freight terminals consist of four different terminal types (Lowe, 2005; Roso et al., 2009): railroad terminals, seaports, inland waterway terminals, and airports. In this research, *intermodal freight terminals* refer only to railroad terminals and seaports; the other two types are beyond the scope of the research.

1.2 Problem area

The worldwide trend of CO_2 emissions from fossil fuel combustion shows an exponentially increase from 1871 to 2012 (InternationalEnergyAgency, 2015). In 2012, the transportation sector represented 23% of all CO_2 emissions worldwide, and road transportation accounted for 75% of those emissions. By contrast, when measuring CO_2 emissions by tonne-km, according to NTM (NTMCalc, 2009) rail transportation has the least environmental impact. In light of the European Commission's goal of a 60% reduction in greenhouse gas emissions by 2050 (European Commission, 2011), the large growth of freight transportation mentioned in Section 1.1 poses a major challenge.

Given the variety of modes of transport and their corresponding actors, resources, and activities, intermodal freight transportation systems are essentially complex (Marchet et al., 2012). Moreover, they require information systems (IS) based on information communication technology (ICT) to exchange information, improve interactions among actors involved (Dürr & Giannopoulos, 2003) and, in turn, increase the resource efficiency for both transport and its various infrastructures (European Commission, 2011). However, the adoption and use of IS and ICT in intermodal transport remain relatively low (Marchet et al., 2012; Evangelista & Sweeney, 2014; Harris et al., 2015), which complicates improving interactions among actors in the systems (Giannopoulos, 2004) that are decentralised—that is, each mode makes decisions independently of the others (Sternberg & Andersson, 2014).

Prior research reveals a lack of communication among actors involved in intermodal freight transportation systems (Buijs & Wortmann, 2014). For one, trucks arrive at terminals unnoticed (Phan & Kim, 2015) and, needing to return from terminals, sometimes even empty (McKinnon & Ge, 2006) due to the lack of information exchange between hauliers and terminals. Additionally, the quality of real-time data and information exchanged is currently poor (SteadieSeifi et al., 2014), which forces decision makers to make choices regarding road haulier operations based on outdated information. Lack of communication also affects actors by complicating how they plan to use their resources efficiently (Mason et al., 2007; Zhao & Goodchild, 2010). The lack of communication occurs especially at points where different transportation modes meet (e.g., terminals), which causes bottlenecks (Islam et al., 2013) due to inefficient haulier operations (Sternberg et al., 2013b). Such congestions result in longer turnaround times for trucks as they travel through terminals, which negatively affects not only trucks' access to the terminals, but also the access of other modes of transportation there (Phan & Kim, 2015). Indeed, at terminals, an important performance measurement is truck

turnaround times (Lubulwa et al., 2011), which depend heavily upon how terminals plan their use of daily resources and operations (Bisogno et al., 2015).

To reduce some of the problems identified above (i.e., lack of communication and poor information exchange among actors involved, poor quality of real-time data, inefficient road haulier operations, and longer turnaround times at terminals), researchers propose different approaches. On the one hand, road haulier operations can greatly benefit from eliminating operational inefficiencies (e.g., long turnaround times at terminals) by increasing the exchange of information among actors involved (Sternberg et al., 2012). In other words, the better the information exchange among those actors, the better that they can manage their access to intermodal terminals. On the other hand, the resource efficiency of each actor and the global supply chain can benefit from exchanging information among actors via a common, standardised platform (Bisogno et al., 2015).

1.3 Introducing access management

In this work, *access management* refers to the management of the process of actors as they access resources for specific activities in transportation systems. In that sense, *management* means planning, organising, commanding, coordinating, and controlling (Fayol, 1916), while *access* means obtaining resources (e.g., a physical part of an intermodal freight terminal such as a priority lane or a certain time slot). By extension, *process* is a structured ordering of work activities with a beginning and an end, in which clearly defined inputs result in outputs that produce value for specific actors with less use of resources (Davenport, 1993). *Actors* are people or organisations, *resources* are owned by actors, and *activities* are actions performed by actors based on specific resources (Håkansson, 1987). Moreover, access management encompasses more than regular security systems with access control functionalities (Marchet et al., 2009; Marchet et al., 2012; Andersson & Sternberg, 2013; Urciuoli et al., 2013) and includes the management of various digital real-time services toward affording smoother, improved access of trucks arriving at terminals by automating gate access (Dekker et al., 2013), sending advance notifications (Stefansson & Lumsden, 2009), booking timeslots (Shiri & Huynh, 2016), or securing a priority lane (i.e., green lane) within the terminal for unloading or loading ITUs (Sternberg et al., 2012; Boile & Sdoukopoulos, 2014).

To better manage access to terminals, improved collaboration among actors involved and grounded on a real-time information exchange is necessary. A road haulier can request access to a certain resource at an intermodal terminal for loading an ITU by sending an advance notification of its arrival to the terminal. The terminal could thus respond to the notification and prepare the ITU for pick-up. Examples of other data and vital information that can be exchanged include estimated times of arrival (ETA), traffic information, emissions, and ecodriving-educated drivers. Consequently, if a road haulier presents the appropriate information from, for example, sensors in a vehicle, the infrastructure, or another authority, then the vehicle can gain access for a time slot for loading or unloading.

Ultimately, improved access management that relies on increased information exchange among actors might increase resource efficiency via the better management of truck arrivals at terminals and of road haulier operations such as

loading and unloading (Zehendner & Feillet, 2014). To improve access management, five digital real-time services that currently operate in intermodal freight transportation are identified, all of which derive from increased information exchange but vary in terms of service intelligence. For example, some have smarter implemented technology for bidirectional information exchange, whereas others have less, meaning that information moves only in one direction. Examples of access management services successfully implemented include advance notification and appointment services, in which turnaround times at terminals were reduced by 30% (Phan & Kim, 2015), and transaction and community services, which reduced turnaround times at terminals by 39% (Carlan et al., 2016).

1.4 Purpose and research questions

The goal of this research is to clarify how access management affects resource efficiency in road haulage in intermodal freight transportation. Accordingly, the purpose of the research is to improve access management at intermodal freight terminals from the perspective of road haulier operators. To that end, a problem-solving path defined by Booth et al. (Booth et al., 2008) is followed to study flows to and from terminals in order to partially solve the practical problems stated above (i.e., lack of communication and poor information exchange among actors involved, poor quality of real-time data, inefficient road haulier operations, and longer turnaround times at terminals). The path, as a practical problem, motivates a research question (RQ).

Road haulier operations in terminals and flows to and from intermodal freight terminals are investigated to elucidate the actors, activities, resources, processes, and information exchange involved in terms of how access is currently managed in those terminals from the perspective of road hauliers and to identify inefficiencies in the phenomenon under study. In this work, the perspective is that of road haulier operations since they are most involved in the problems identified (i.e., lack of communication and poor information exchange among actors involved, poor quality of real-time data, inefficient road haulier operations, and longer turnaround times in terminals). Although terminal operations such as loading and unloading are also involved in access management, the chief focus of the thesis is to clarify how access management affect resource efficiency for haulier operations in order to help transport operators of hauliers and terminals to increase their knowledge in response to the following question:

RQ1: How is access managed in intermodal freight terminals from the perspective of road haulier operations?

Information and differentiation and segmentation strategies for road hauliers and intermodal freight terminals are examined to gain insights into what information and strategies are required for an improved access management solution in order to help traffic planners and dispatchers to learn how they can improve their access management and, in turn, how improved access management affects resource efficiency in road haulage.

RQ2: What information and strategies are required for improving access management in intermodal freight terminals with the perspective of road haulier operations?

Increased information exchange among involved actors is scrutinised to elucidate potential operational effects (i.e., in terms of time) of improved access management in intermodal freight terminals from the perspective of road haulier operations. By elucidating effects means to investigate both advantages and disadvantages. This thesis will only consider the advantages of improved access management due to the main goal and purpose as previously described. Therefore, the potential operational benefits of improved access management are investigated.

RQ3: What are the potential operational benefits of improved access management in intermodal freight terminals from the perspective of road haulier operations?

1.5 Scope and delimitations

This research focuses on investigating how contemporary access is managed in intermodal freight terminals, how access management can be improved, and what potential operational benefits are achievable of improved access management. Importantly, the investigations are conducted to improve resource efficiency for road haulage only, not for other modes of transportation (e.g., rail, sea, and air). Moreover, only intermodal freight terminal operations in contact with road haulier operations (e.g., loading and unloading ITUs to and from trucks) are taken into account. All other operations connected to intermodal freight terminals are beyond the scope of this research.

In the three studies conducted in this work, two different road hauliers (i.e., one smaller and one larger), one railroad terminal, one seaport, and one IS system supplier were studied. The intermodal freight terminal ranks among the largest terminals in Sweden and handles rail and road freight transport. Meanwhile, the port is the largest in Scandinavia and operates transhipments among sea, rail, and road freight transport. Both road hauliers transport ITUs to the intermodal freight terminal and the port. The participants are further described in Section 2.3.

Figure 1 illustrates the theoretical scope and how the research is positioned among related literature. To improve access management in intermodal freight terminals, the definition of *access management* and how it can be improved are important, as are road haulier operations and terminals within intermodal freight transportation. To describe, analyse, and evaluate the phenomenon under study, the industrial network approach is used, since IS systems need to be studied to improve their access management and to investigate potential operational benefits of improved access management, as are differentiation and segmentation strategies that help to identify actors' access management and what actions are necessary to improve it.

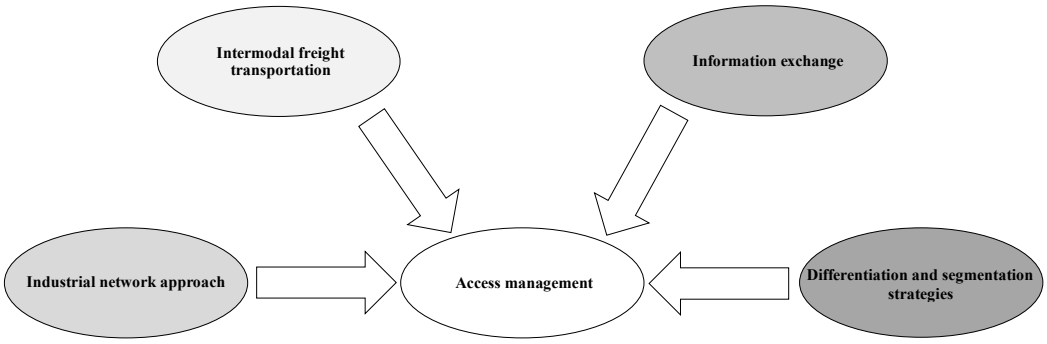

Figure 1 Position of the research among related literature

Figure 2 depicts the relationship between the theoretical scope and the RQs. The arrows indicate what body of knowledge is needed and how this body of knowledge can help finding answers to corresponding RQ. To solve RQ1, the theoretical domains intermodal freight transportation including road haulier operations and intermodal freight terminals are the main foundational to defining, describing, and investigating access management. Regarding RQ2, information exchange and differentiation and segmentation strategies are the two main foundations for solving RQ2. RQ3 is then solved by using the findings from both RQ1 and RQ2. The industrial network approach is used as theory for all RQs.

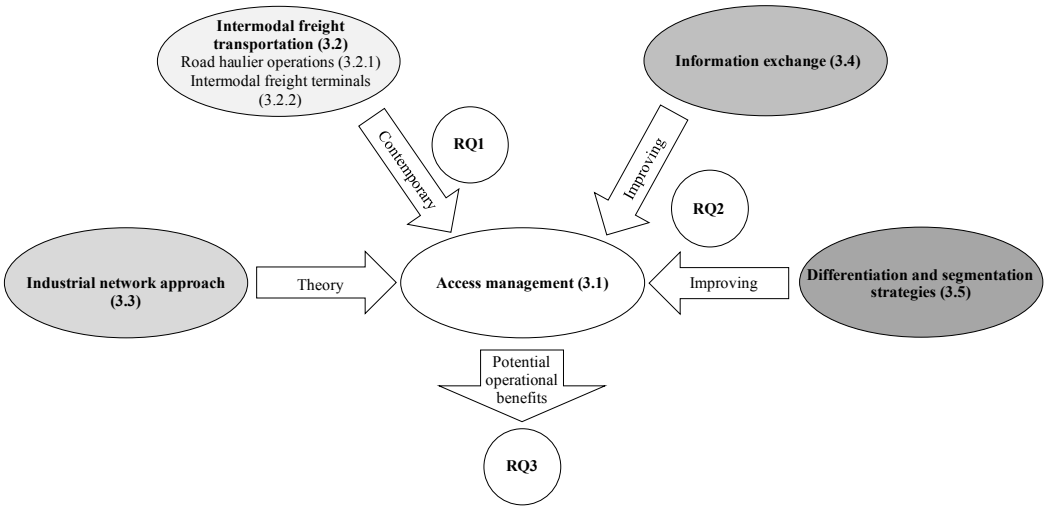

Figure 2 Relationship among RQs and the theoretical scope.

1.6 Structure of the thesis

Chapter 1 presents the background of the thesis, including the problem addressed, introduction of access management, the purpose and scope of the thesis, and its three RQs.

Chapter 2 describes the research design in terms of the research process, participants, and the parts of an interactive model of research design, including goals, the conceptual framework, RQs, methods, and validity.

To explain the frame of reference of the thesis, Chapter 3 is organised around five main topics as shown in Figure 1: access management; intermodal freight transportation; the industrial network approach; information exchange; and differentiation and segmentation strategies.

Chapter 4 briefly summarises the three appended papers for the reader's reference.

Chapter 5 presents results and analysis of the answers to the three RQs in relation to the three studies and three papers.

Chapter 6 contains a conclusive discussion.

Lastly, Chapter 7 presents conclusions, contributions and suggestions for further research.

2 Research design

This chapter describes the design that guide the research. Section 2.1 explains the motivation for conducting primarily qualitative research with a case study, after which Section 2.2 describes the research process. Section 2.3 details the participants in the research, and Section 2.4 presents the interactive model of research design. Section 2.5 explains the goals, Section 2.6 explains the conceptual framework, Section 2.7 describes the research questions, Section 2.8 details the methods with the studies in Section 2.9, and finally Section 2.10 details the validity of this research.

2.1 Introduction

Qualitative research is best for examining social relations (Flick, 2014), aspects of which—for example, sensitivity to context, changes in available participants, and relevance of the research—quantitative research cannot accommodate. Not only does qualitative research focus more on words than on the quantification of data (Bryman & Bell, 2011), but it also allows an inductive or abductive approach that can generate theory and capture the ways in which individuals interpret their social realities. Qualitative research focuses on situations, people, events, and how they influence each other, as well as affords deeper understandings of what they mean to participants in particular contexts and amid certain phenomena (Maxwell, 2013).

Table 1 Research design

(Bryman & Bell, 2011)	**(Yin, 2013)**	**(Flick, 2014)**	**Research design selected for this research**
Case study	Case study	Case study	Used as an approach common in business research to clarify certain real-world phenomena since the focus of the research is to describe and explain a particular phenomenon that is too complex for survey or experimental methods (Yin, 2013); multiple case studies are conducted since multiple organisations are studied and different aspects of the phenomenon investigated
Analysis of resources	Archival analysis	N/A	Partly conducted in Paper 1 since secondary data about information exchange in relation to access management are collected and analysed in a semi-structured manner
N/A	N/A	Snapshots	Partly used since the focus is contemporary behaviours as part of a phenomenon
Historical or longitudinal study	History	Retrospective or longitudinal study	Not applicable since the focus of the research is not to map variance during a longer period and because the phenomenon is studied only in a contemporary setting, mostly to capture its development; time measurements are nevertheless made during a 6-month period in order to reduce the risk of measuring abnormal situations
Multiple case studies	N/A	Comparative study	Not adopted due to the lack of comparative analysis of the case studies but of different aspects of the phenomenon instead
Surveys	Surveys	N/A	Not applicable since the research did not involve collecting quantitative data to identify different patterns of relationships, but to gain a deeper understanding of a phenomenon
Experimental	Experimental	N/A	Not applicable since no experiments in a true field are planned

Qualitative methods are ideal for the research that is conducted in this work, which examines access management in intermodal freight terminals from the perspective of road haulier operations in order to gain insights into how physical flows and

flows of information between hauliers and terminals are managed, all with the goal of increasing hauliers' resource efficiency. The research adopted a flexible approach in which the collection and analysis of data, the development and modification of analytical frameworks, and elaborations of RQs have been conducted more or less simultaneously in the three studies, all of which recommends qualitative methods (Maxwell, 2013).

To achieve the goal of the research, a concrete research design is important (Flick, 2014), as are the planning and construction of the design. Table 1 outlines different designs adopted from Bryman and Bell (2011), Yin (2013), and Flick (2014), and its fourth column lists the design choices made for the present research. The designs listed by Bryman and Bell (2011) and Yin (2013) encompass both qualitative and quantitative research strategies, whereas Flick (2014) lists only qualitative research designs. All things considered, the best method for the research is a case study, which will afford a deeper understanding of a contemporary real-life situation.

Figure 3 illustrates how the research questions, studies, and papers relate to each other. The three RQs (RQ1, RQ2, and RQ3) have been answered with three respective studies (Study 1, Study 2, and Study 3) that in turn have resulted in three corresponding papers (Paper 1, Paper 2, and Paper 3).

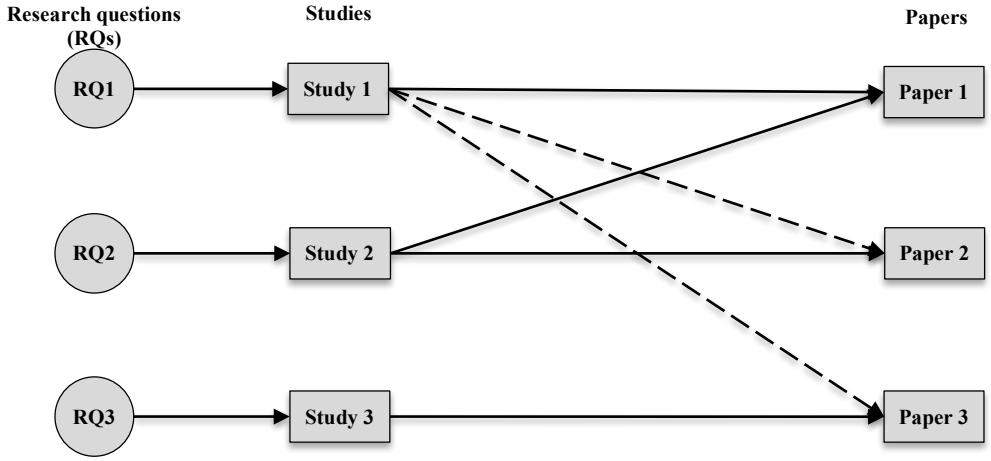

Figure 3 Relationships between the research questions, studies, and papers; solid lines indicate full deliverables, whereas dashed lines indicate partial deliverables

2.2 Research process

This research is part of the REACH project initiated on 1 September 2014 (VINNOVA, 2014). REACH's goal is to enable advanced, digital interaction in real-time among infrastructures, facilities, and vehicles in order to increase resource efficiency in intermodal freight transport systems through access management. The focus of REACH is on stakeholders in intermodal freight transport systems (e.g., hauliers and terminal operators) who with digital technology could achieve new environmental, security, and competitive benefits. REACH thus represents a collaboration of academia, industry, and society involving a university, six larger and three smaller organisations, and a public authority.

Likewise, all three studies (Study 1, Study 2, and Study 3) and all three papers (Paper 1, Paper 2, and Paper 3) were developed as part of REACH, per the schedule presented in Table 2. All studies were performed more or less simultaneously during a 2.5-year period. First, Study 1 sought to answer RQ1 by gaining insights into how access is managed in contemporary intermodal freight terminals, with results reported in Paper 1, which was finalised together with parts of Study 2. Second, Study 2 sought to investigate what information and differentiation and segmentation strategies are necessary to improve access management for participants. The differentiation and segmentation strategies also help participants to recognise that different information needs to be exchanged depending on whether the destination terminal is a railroad terminal or a seaport. Ultimately, Study 2 resulted in Paper 2. Third and lastly, Study 3 focused on the potential operational benefits of improved access management in intermodal freight terminals, with results reported in Paper 3.

Table 2 Research process

	2014		**2015**				**2016**				**2017**	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Study 1												
Study 2												
Study 3												
Papers											**Paper1**	**Paper2 Paper3**

2.3 Participants

Participants include two road hauliers, an intermodal freight terminal, a port, and an Information System Supplier (ISS). In Table 3, participants are described in terms of the industrial network approach—that is, actors, resources, and activities. The actors are named Road Haulier A (RHA), Road Haulier B (RHB), Terminal Operator C (TOC), Port Operator D (TOD), and Information System Supplier (ISS). The resources include the size of the organisations in terms of number of employees and number of pieces of major equipment used in performing the activities listed in the third column. The number of ITUs per week is the weekly volume of each actor.

Table 3 Participants

Actors	**Resources**	**Activities**
Road Haulier A (RHA)	9 employees, 31 vehicles	Road haulage, 650 ITUs/week
Road Haulier B (RHB)	182 employees, 50 vehicles	Road haulage, 300 ITUs/week
Terminal Operator C (TOC)	38 employees, 2 container cranes, 2 fork lifts	Transhipment, 750 ITUs/week
Port Operator D (POD)	438 employees, 8 container cranes, 2 railway cranes, 40 straddle carriers	Transhipment, 10,000 ITUs/week
Information system supplier (ISS)	33 employees, fleet management system	Consulting and development

The terminal operator (TOC) was selected because it is a major intermodal freight terminal in Sweden, while the two road hauliers, RHA and RHB, were selected based on recommendations from the terminal operator to find a smaller and a larger road haulier that both served the terminal operator. The terminal operator provided statistical data of all road hauliers that served the terminal operator in

order to avoid making measurements of nonparticipants. The trucks and truck drivers from the two road hauliers were chosen depending on equipment installed in the trucks, typical routes, driver language, driver behaviours, and driver training. The port operator was included in the study because the two road hauliers experience more significant problems with access management there. Lastly, the port operator was chosen because it is the largest port in Scandinavia and the ISS because it developed the fleet management system for both road hauliers.

2.4 An interactive model of qualitative research design

A qualitative research design consists of several key components (Maxwell, 2013; Flick, 2014): goals (e.g., personal, practical, research-oriented, generalisation-oriented), a theoretical or conceptual framework (i.e., body of knowledge), research questions (i.e., how, why, what, which, who, where), methods (e.g., triangulation, loose or tight design), resources (e.g., time, personnel, technical support, competencies, experience, activities, transcriptions), and validity (e.g., internal, external, reliability, objectivity).

The research design models of (Maxwell, 2013) and (Flick, 2014) differ in terms of how key components interact. In Flick's (2014) model, the research design unites a sequence of decisions regarding the key components and allows users to make decisions either prior to or while conducting the research process. In either case, the design aims to achieve the research goals and links all other corresponding key components. By contrast, Maxwell's (2013) model centres RQs, which serve as a hub for the other key components to interactively link throughout the research process.

The research in this work follows Maxwell's (2013) model due to its structure of key components and its interactive way of conceiving how RQs are modified in light of other key components during the research process. Figure 4 illustrates Maxwell's (2013) model in terms of the key components and corresponding views of the present research. The following subsections describe each key component and explain how the present research relates to Maxwell's (2013) model.

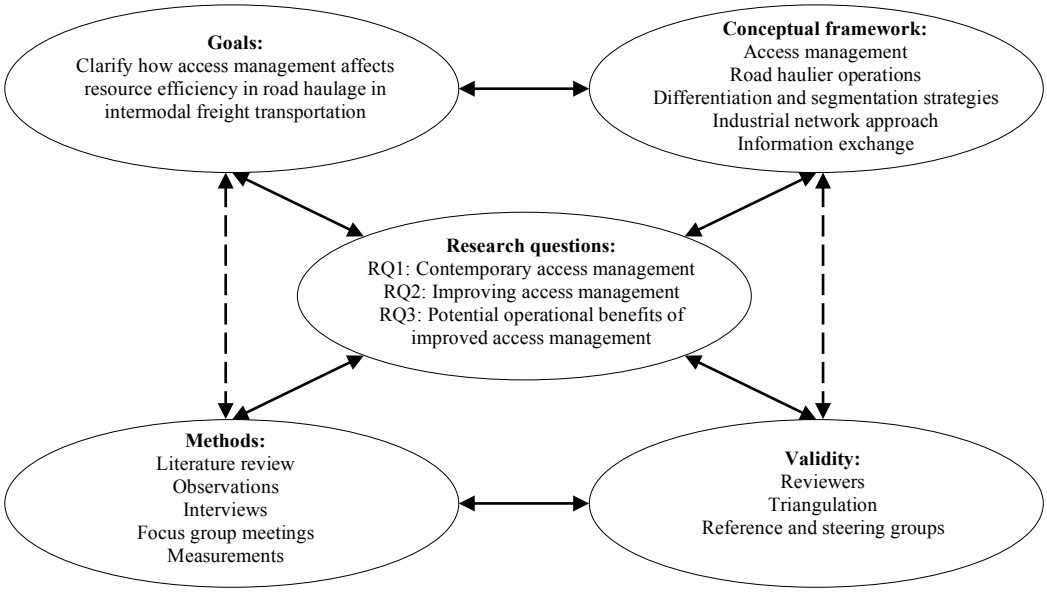

Figure 4 An interactive model of qualitative research design adopted from (Maxwell, 2013)

2.5 Goals

The goal of this research is to clarify how access management affects resource efficiency in road haulage in intermodal freight transportation. Accordingly, the purpose of the research is to improve access management at intermodal freight terminals from the perspective of road haulier operators. More specifically, personal goals include broadening academic skills and expanding knowledge of the phenomenon under study by interacting with stakeholders, while intellectual goals comprised gaining more profound insights into improving access management in intermodal freight terminals, road haulier operations, and information exchange within IS. Meanwhile, the practical goal is to enable digital interaction between hauliers and intermodal freight terminals in order to achieve the overall research goal. Goals regarding generalisation focus on achieving an analytical outcome depending upon both a detailed analysis of the current phenomenon under study and a before-and-after comparison of effects of a resource efficiency proposal's implementation and operation in real-life scenarios. Lastly, the presentation-related goals are based both on literature addressing the topic and empirical study.

2.6 Conceptual framework

Underlying research assumptions are often divided into deductive and inductive assumptions. (Bryman & Bell, 2011) distinguish deductive assumptions as theory testing (i.e., testing of hypotheses) and inductive assumptions as theory generating (i.e., developing theory from empirical data). A third type of assumption is abductive, which represents a combination of deductive and inductive assumptions. According to (Dubois & Gadde, 2002; Sternberg, 2011), the major differences between induction and abduction are twofold. First, abduction involves testing a developed theory against empirical data, whereas induction contributes to the generalisation of empirical findings. Second, in inductive research, the theory-building phase is distinct from empirical collection, whereas

in abductive research the two are developed simultaneously. Since the present research does not concern theory testing but building theories on prior theory or gained empirical data, an inductive approach is a better fit than a deductive one. However, since theory is continuously developed depending on empirical data acquired, this research uses an abductive approach.

Other important issues of scientific reasoning concern the ontology (i.e., nature of reality) and epistemology (i.e., nature of knowledge) of the research is conducted. On the one hand, ontology is described in terms such as *objectivism*—that is, a social phenomenon with meanings independent of social actors—and *constructivism*—a social phenomenon with meanings continually is accomplished by social actors and in a constant state of revision (Bryman & Bell, 2011). On the other, epistemological considerations involve *positivism*—that is, the idea that science needs to imitate natural science and be conducted objectively in a value-free way in order to generate acceptable knowledge—and *interpretivism*—that accepted knowledge requires contextual information about people and objects for social actions to have subjective meaning (Bryman & Bell, 2011). In light of those considerations, this research adopts the view that reality is developed upon tangible structures, but that due to the complexity of nature and to fully understand the world, assumptions (e.g., concepts) are necessary. The research also holds that knowledge is best gained from the interaction of objectivity and subjectivity—for example, that individuals can increase their knowledge and understanding via measurement. Altogether, the research represents realism with touches of nominalism and is more interpretivist than positivist according to Bryman and Bell's (Bryman & Bell, 2011) assumptions.

2.7 Research questions

The chief function of RQs is to direct what the phenomenon under study can reveal about realities (Maxwell, 2013). RQs are central in Maxwell's (2013) model, and unlike in other models, in which RQs should be formulated at the beginning of the research process and not changed thereafter, Maxwell's (2013) model encourages researchers to reformulate RQs throughout the research process in light of other key components. Whether general RQs, which usually belong to sample studies, or particular RQs, which usually belong to case studies, RQs should be neither too diffuse nor too general.

To develop RQs, (Maxwell, 2013) proposes numerous steps, each of which corresponds to a key component. The first step involves identifying new RQs according to a concept map that is developed in the conceptual framework. The concept map is used to identify aspects of literature on the topic of research that are not yet fully understood and raise questions about them. In the present research, Figure 1 acts as a broader concept map of five major topics that are studied. In light of Figure 1, Figure 2 is drawn to illustrate the relationships between the literature and RQs. The second step is to consider the research goals and formulate RQs so that those goals can be accomplished. Practical goals are excluded when formulating RQs, because RQs are guided by personal and intellectual goals in order to accomplish the practical ones. Accordingly, the personal and intellectual goals described in Section 2.5 were considered when formulating the RQs for this research. The third step focuses on the relationship between RQs and methods. It is important to choose appropriate methods, since

their chief task is to help to answer the RQs. Table 4 illustrates the fit among the RQs, the data necessary, and the chosen research methods.

Table 4 Fit among research questions, data needed, and research methods

Research question	Data needed	Research methods
RQ1	Perceptions of drivers, transport planners, and terminal operators Times for truck drivers' operations Conceptual overview	Participant observations and interviews Time measurements Literature review
RQ2	Perceptions of drivers, transport planners, terminal operators, and the commercial manager Conceptual overview	Semi-structured interviews and focus group meetings Literature review
RQ3	Times for truck drivers' operations and increased information exchange tests Perceptions of drivers, transport planners, and terminal operators Conceptual overview	Time measurements, increased information exchange tests Participant observations and interviews Literature review

The third and final step involves considering the validity of answers to the RQs by reflecting on how those answers could be inaccurate and what validity threats are possible. Section 2.10 further describes the criteria for validity for this research are considered when framing the RQs.

2.8 Methods

The goal of research methods is to collect data in order to answer the RQs (Maxwell, 2013). One method to form a more profound understanding of certain topics involves reviewing literature on those topics, and accordingly, a literature review on access management was conducted for this work. The three databases searched were Web of Science, Scopus, and ABI/Inform, which were culled for keywords and search strings such as 'transport*' AND ('freight' OR 'logistics') AND ('access management' OR 'arrival process*' OR 'appointment system' OR 'truck arrival' OR 'lorry arrival' OR 'slot allocation' OR 'truck scheduling' OR 'lorry scheduling'). Only peer-reviewed articles published during May 2000–August 2016 were selected for review. The hit rate for searches in the databases resulted in 20–287 articles. After having read the abstracts of all of the articles and taking the number of citations into account, 30 articles were selected for review.

The various methods available for collecting empirical data are either quantitative or qualitative (Maxwell, 2013). Quantitative methods include structured interviews (i.e., standardised interviews with the same questions for all interviewees), self-completion questionnaires (i.e., questionnaires in which respondents answer questions by themselves), structural observations (i.e., systematic observations of people's behaviours without any interviews or questionnaires), statistical testing, and content analysis such as examinations of mass media content (Bryman & Bell, 2011). By contrast, qualitative methods include unstructured interviewing (i.e., conversational interview in which interviewees are allowed to respond freely to spontaneous questions organised around a central topic), semi-structured interview (i.e., interviews guided by

certain questions and follow-up questions), focus groups (i.e., group interviews with questions on a particular topic), and participant observations (i.e., engagement in regular interactions of people's daily lives). The subsections that describe the studies conducted in this work also explain the choice of methods of data collection for those studies.

Triangulation involves a combination of qualitative methods or both qualitative and quantitative methods, or *mixed-methods* (Flick, 2014). Using mixed methods seeks to compensate for weaknesses and blind spots in order to make more generalizable conclusions (Bryman & Bell, 2011). For example, quantitative findings can be added to qualitative findings to obtain a more complete understanding of the research topics and RQs (Creswell, 2014). In that sense, qualitative findings can afford a better understanding of relations among quantitative variables.

From a practical perspective, mixed methods offer a complex, sophisticated approach (Creswell, 2014) that requires additional resources and time (Flick, 2014). Before performing mixed-methods research, the preconditions of the research with participants need to be investigated in terms of whether the research has the resources to accommodate the approach. Among drawbacks of the approach, certain methods can rely on various underlying presumptions (Hurmerinta-Peltomäki & Nummela, 2006) that are incompatible, which requires clarifying the specific features of each method before using them in tandem. That potential problem is addressed in the present research by taking theoretical considerations into account before conducting the two studies that involve mixed methods (i.e., Study 1 and Study 3).

2.9 Studies

This section describes the research methods used in Study 1: Contemporary access management, Study 2: Improving access management, and Study 3: Potential operational benefits of access management. Table 5 summarises the three studies in terms of RQs posed, methods used, and contributions made.

Table 5 Summary of all studies in terms of research questions (RQs), methods, and contributions

Study	RQs	Methods	Contribution
Study 1: Contemporary access management	RQ1	Literature review, participant observations, interviews, time measurements	New knowledge and understanding about how access is managed today in terms of how *access management* is defined, how the access process look like for participants, what actors, resources, activities and flows are involved; how information is exchanged among participants and what information attributes are existing in the system under study; and what inefficiencies of truck drivers' operations are present in the system under study.
Study 2: Improving access management	RQ2	Literature review, semi-structured interviews, focus group meetings	New knowledge and understanding about what information attributes are required to be exchanged among participants in order to improve their access management, and how

			differentiation and segmentation strategies can help managers at road hauliers and intermodal freight terminals to identify their level of access management and ways to improve it.
Study 3: Potential operational benefits of access management	RQ3	Literature review, participant observations, interviews, time measurements, increased information exchange tests	New knowledge and understanding about the potential operational benefits of using increased information exchange among participants in order to improve their access management.

To answer the RQs and, in turn, fulfil the overall goal of the research, the approach adopted for this research involves case studies (described in Section 2.1) with primarily qualitative but also quantitative strategies. Since there are multiple RQs, answering them benefit from using smaller case studies than a larger, all-encompassing case study. The goal of each study is to answer the corresponding RQ via appropriate methods, meaning that the RQ guides other components of the research design. Each study is developed in light of what methods need to be performed, what type of data is needed to be collected, and how the data is needed to be analysed in order to answer all or part of the RQ.

2.9.1 Study 1: Contemporary access management

Purpose
The purpose of this study was to answer RQ1 by gaining insights into the management of actors, activities, resources, and processes involved in intermodal freight terminals from the perspective of road haulier operations.

Approach
The approach of this study was both explorative—related literature was reviewed in order to define *access management* and learn about both access management and information exchange—and descriptive—characteristics of the phenomenon were described and measurements made to identify inefficiencies therein.

Data collection
A mixed-methods approach was used and a comprehensive literature review performed to clarify the state of the art of access management. In particular, to gain a clearer understanding of participants and an overview of their real-life situations, qualitative data collection methods such as participant observations and interviews were conducted while driving with truck drivers employed at the two road hauliers (RHA and RHB) along routes to and from the terminal operator (TOC) and the port operator (POD). Additionally, to investigate the workdays of the drivers and identify the inefficiencies of their operations, quantitative data collection methods such as time measurements were performed with the smartphone StarDriver developed by Prockl and Sternberg (Prockl & Sternberg, 2015). Measurements with StarDriver were made by five students, each of whom accompanied a different truck driver for 1 working week (Monday–Friday). During the time measurements of total 199 hours, five different truck drivers were interviewed and observations were made from the cockpit of the trucks.

Data analysis
The industrial network approach was used to analyse related literature, observations, and interviews by parsing the phenomenon under study into different actors, resources, and activities. The truck driver activity framework developed by Sternberg et al. (Sternberg et al., 2014) was used to analyse the results from the time measurements made with StarDriver.

Contribution
Study 1 contributed with new knowledge and understanding (1) to Paper 1, Paper 2, and Paper 3 about how access is managed today in terms of how *access management* is defined, how the access process look like for participants, what actors, resources, activities and flows are involved, (2) to Paper 1 about how information is exchanged among participants and what information attributes are existing in the system under study, and (3) to Paper 3 about what inefficiencies of truck drivers' operations are present in the system under study.

2.9.2 Study 2: Improving access management

Purpose
The purpose of Study 2 was to answer RQ2 by investigating what information attributes and differentiation and segmentation strategies are necessary to improve the access management of participants.

Approach
Study 2 followed an explorative approach that provided insights into what information attributes and differentiation and segmentation strategies. The strategies are influenced by different customer services that include logistics services (access management services), delivery services (delivery time, delivery reliability, delivery precision, delivery flexibility) and information exchange (frequency, direction, modality, information attributes).

Data collection
Study 2 consisted of a comprehensive literature review, semi-structured interviews, and focus group meetings. The literature review addressed information attributes (i.e., to investigate which can be exchanged between road hauliers and intermodal freight terminals), access management (i.e., its definition and current access management services in order to improve it), and differentiation and segmentation strategies (i.e., that can differentiate customer services (access management services, delivery services, information exchange) according to type of intermodal freight terminal). Seven semi-structured interviews with participants were conducted to investigate how they handle information exchange, what information attributes are required to improve their access management, and how differentiation and segmentation strategies need to be adopted by the actors in order to improve their access management. Interviewees were truck drivers and transport planners, dispatchers and planning managers, and a commercial manager. Five focus group meetings were conducted with representatives of all actors in order to identify the information attributes needed to improve the access management of participants and investigate how information flows need to be segmented by the terminal operator (TOC) and the

port operator (POD) as well as by import and export flows of ITUs toward improving their access management.

Data Analysis
The information attribute framework was defined and developed based on the literature reviewed and the industrial network approach in order to sort and analyse the identified information attributes by classifying them into static, historical, and dynamic categories with respect to the sources that produce them. Semi-structured interviews were analysed by sorting out the results in terms of actors, resources, and activities in light of the industrial network approach. Data gained from semi-structured interviews and focus group meetings were analysed in light of the differentiation and segmentation strategies developed in the study.

Contribution
Study 2 contributed with new knowledge and understanding (1) to Paper 1 about what information attributes are required to be exchanged among participants in order to improve their access management, and (2) to Paper 2 about how differentiation and segmentation strategies can help managers at road hauliers and intermodal freight terminals to identify their level of access management and ways to improve it.

2.9.3 Study 3: Potential operational benefits of improved access management

Purpose
The purpose of Study 3 was to answer RQ3 by investigating the information attribute framework and differentiation and segmentation strategies developed in Study 2 in order to answer RQ1 and RQ2 and to study results of prior research by using different forms of Information Communication Technology (ICT).

Approach
Study 3 was mostly descriptive since its chief task was to identify potential operational benefits of improved access management by conducting time measurements and tests to increase the information exchange between the participants. However, Study 3 also followed an explorative approach by seeking insights into access management in terms of the potential operational benefits of identified access management services and different forms of ICT.

Data collection
A review of literature on the potential operational benefits of identified access management services and different forms of ICT was performed. Mixed methods were used to gain insights into the results from qualitative data collection (i.e., five participant observations and five interviews) and from quantitative data collection (i.e., times of five truck drivers' operations collected with StarDriver). Increased information exchange among participants was tested in real-life scenarios with a smartphone app, called the REACH app, designed and implemented as part of the information exchange framework based on the information attribute framework and the differentiation and segmentation strategies gained from Study 2. Figure 5 presents the time measurements in Study 1 and increased information exchange tests with corresponding time measurements collected from Study 3. In the latter study, truck drivers´ operations

of five different truck drivers were measured for 505 hours. During these hours, students were accompanied and interviewed the five truck drivers.

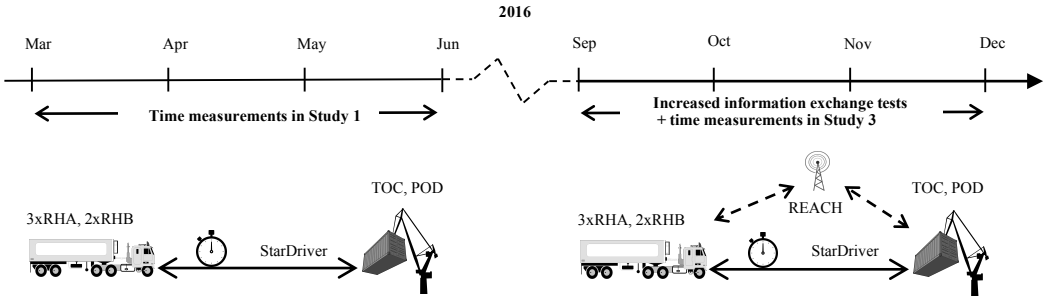

Figure 5 Quantitative data collections in Study 1 and Study 3

Data analysis
Results from StarDriver were analysed by using the truck driver activity framework developed by Sternberg et al. (Sternberg et al., 2014), as well as analysed to results from prior research regarding potential operational benefits of access management services. Results from the REACH app were analysed by comparing those gained when the app was activated to those gained when the app was not activated.

Contribution
Study 3 contributed with new knowledge and understanding to Paper 3 about the potential operational benefits of using increased information exchange among participants in order to improve their access management.

2.10 Validity

(Guba & Lincoln, 1989) identify four conventional quality criteria: internal validity, reliability, external validity, and objectivity. Parallel to those criteria are alternative ones developed in order to better accommodate qualitative research: credibility, transferability, dependability, and confirmability (Guba & Lincoln, 1989). Table 6 describes the criteria in general and how they relate to the present research.

Table 6 Criteria in general and related to the research

Criteria	In general	Related to the research
Credibility (i.e., internal validity)	Credibility determines the fit between respondents' constructions of reality and those of researchers (Halldórsson & Aastrup, 2003). Credibility improves in-depth understandings and meanings of phenomena studied.	The selection of drivers, transport planners, trucks, and terminals was grounded on interviews and statistics available from participants to ensure that data collected excluded nonparticipants. Visits to participants were made to accompany different truck drivers from Road Haulier A and Road Haulier B to gain insights into the studied phenomenon.
Transferability (i.e., external validity)	Transferability focuses on the possibility of making general claims about the world. Transferability precludes making true generalisations since sampling is not randomised. On the contrary, transferability means to apply knowledge gained outside the context of the phenomenon studied. Recipients of transferrable findings include actors (e.g., stakeholders,	Access management for participants involved data collection for all actors in order to develop frameworks and strategies also based on results from prior research and developed to make them transferable to other settings (e.g., other intermodal terminals and road hauliers). All three papers (i.e., Paper 1, Paper 2, Paper 3) were subjected to double blind reviews with critical comments and were presented and

	users, reference groups), peer reviewers (e.g., reviewers, editors), and the body of knowledge in what is dubbed *analytical generalisation* (Yin, 2013).	defended at different international research conferences.
Dependability (i.e., reliability)	Dependability indicates how stable data are over time (Guba & Lincoln, 1989) and seeks to track variance by documenting processes and methods.	Every conversation and interview with participants was recorded, and photographs and videos were taken during observations. The designs, methods, processes, and their rationales are well documented.
Confirmability (i.e., objectivity)	Confirmability gauges how well findings are based on data and needs to be traced to sources. Since interpretations and recommendations are a part of qualitative research, researchers need to show that they can be traced to sources (Halldórsson & Aastrup, 2003). To ensure the confirmability of results, an external audit of the process can be performed.	The REACH project entailed both a reference group and a steering group; the first acted operationally in the project and included partners in the development and measurements, whereas the steering group was not active in the research process but offered a wider perspective and discussed the effects of the research. Each group met twice annually to review findings and discuss prior and future research actions to ensure that the findings were confirmable and that the research was interesting and on point.

3 Frame of reference

This chapter presents the frame of reference of the thesis, as well as relevant background information about haulier operations in intermodal freight terminals and flows to and from terminals, all in order to identify and explain how hauliers' contemporary access is managed in intermodal freight terminals in terms of the actors, activities, resources, and processes involved. The chapter also describes the body of knowledge on access management and differentiation and segmentation strategies in order to potentially improve access management for the actors involved.

3.1 Access management

Earlier in this work, the causal of access management is introduced. This section focuses especially on digital real-times access management services, which exert the greatest influence on improving access management for actors involved, as further described in Section 3.5. From the literature, five existing access management services used in the transport industry are identified as shown in Table 7, all of which operate in different ways and with various levels of advanced technology implemented and information exchange, with one common goal to improve the access management for actors involved.

Table 7 Existing access management services

Service	Description	Potential operational benefits
Web services	Webpages to gain better information about weather information (e.g., www.klart.se, www.yr.no), traffic and road conditions (e.g., www.trafiken.nu, http://api.trafikinfo.trafikverket.se/API/Model), and queueing status in intermodal freight terminals (e.g., https://tos.portgot.se/truckservicetime/)	Promotes cost-effectiveness, helps users to quickly gain information, and provides navigational guidance, traffic information, road conditions, and queuing status in intermodal freight terminals
Automated gate services	Automatic inspections of intermodal transport units (ITUs) when entering terminals; automatic information provision to truck drivers to minimise unnecessary stops (Choi et al., 2006)	Can reduce the total average wait time for truck drivers in terminals by up to 83% (Dekker et al., 2013)
Advanced notification and appointment services	Arrival procedures of trucks to terminals; operations to send arrival notifications from trucks to terminals in response to certain events (e.g., delivery failures of ITUs, delays, geofencing triggering locations); booking procedures to optimise truck arrivals by distributing them evenly (Giuliano & O'Brien, 2007)	Reduce turnaround time by up to 30% (Phan & Kim, 2015)
Transaction and community services	Planning activities; resource allocation to transport management services, route-planning services, and fleet telematics services (Buijs & Wortmann, 2014); information exchange regarding documents and status information via electronic data interchange; electronic handling of import and export of containerised information, customs declarations (Baron & Mathieu, 2013)	Improves visibility, can reduce turnaround times by up to 39% and affect the profitability of the entire port community (Carlan et al., 2016), and makes transactions safer, more accurate, and more effective (Macharis et al., 2008)
Priority services	Customised services developed for specific hauliers that need priority access for different reasons such as urgency and liability due to dangerous goods (Zhao & Goodchild, 2013); priority access if trucks fulfil certain requirements regarding environmental, safety, security, creditworthiness, and agreement records (Boile & Sdoukopoulos, 2014)	Can reduce communication costs per ITU trip or shipment by an average of 2 h (Boile & Sdoukopoulos, 2014)

Table 7 also provides potential operational benefits of corresponding access management services, all of which are foundational to the different analytical frameworks developed in the research and used to analyse its empirical findings.

3.2 Intermodal freight transportation

In supply chains, freight transportation is a key component to ensuring the efficient movement of goods (Crainic, 2003). In 2014, 49% of the total amount of freight transportation in EU countries was attributed to road transport, 31.8% to sea transport, 11.7% to rail, and the remaining 7.5% to inland waterways and oil pipelines (European Commission, 2016). Moreover, further increasing the amount of rail and water transportation is necessary to meet new EU goals regarding the reduction of greenhouse gases (European Commission, 2011).

A transportation system can be described in three different layers (Wandel et al., 1992): material flow, transport operation, and transport infrastructure. Figure 6 illustrates the three-layer model, in which the marked area represents the focus of this research in light of its overall goal and purpose. The first layer describes the material flow by using links and nodes, whereas the second layer models transport operations and corresponding activities generated by transportation service companies. A result from transport operations is the flow of loads and vehicles among nodes. Lastly, transport infrastructure refers to the physical infrastructure and its management.

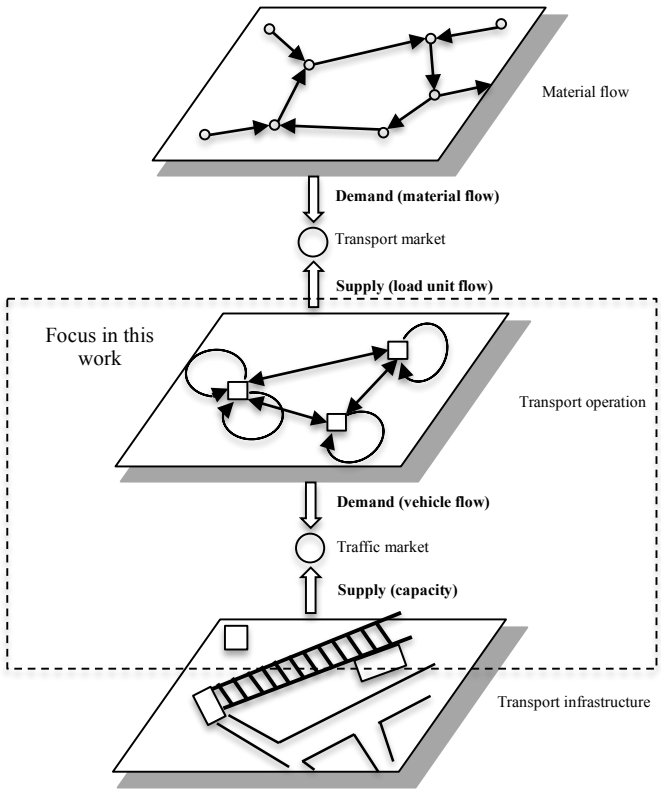

Figure 6 A three-layer model of transport (Wandel et al., 1992)

Figure 6 shows how each layer of the transportation system depends on each other in terms of demand and supply. For example, vehicle flow creates demand that is supplied by transport infrastructure in terms of capacity, which in turn creates a traffic market. For this research, a piece of the transport infrastructure is selected

because infrastructure is an important resource for producing information and because improved access management could enable the allocation of a piece of the infrastructure (e.g., a fast lane) in order to achieve priority access. In other words, the present research does not investigate the need for new infrastructure, but to use and allocate existing infrastructure in a more efficient manner.

There are different flows in logistics: material flow, resource flow, information flow, and monetary flow (Lumsden, 2006). Material flow is created through the movement of goods, which in turn creates a resource flow since goods must be connected to some form of load unit (e.g., trucks, container, pallets). Resource flow is always bidirectional because resources are not consumed in the system. Information flow occurs both horizontally and vertically; horizontal information flow creates the need for its vertical counterpart because producers and consumers of goods need to exchange information regarding requirements, specifications of function, and times, thereby forming a bidirectional horizontal information flow. That flow in turn creates the need for information about goods, the status of resources, and the physical location, all of which is important for planning and controlling goods in a bidirectional vertical information flow. Lastly, monetary flow is controlled among the seller, buyer, and conveyor of goods with the help of information from the other flows. Figure 7 shows the various flows.

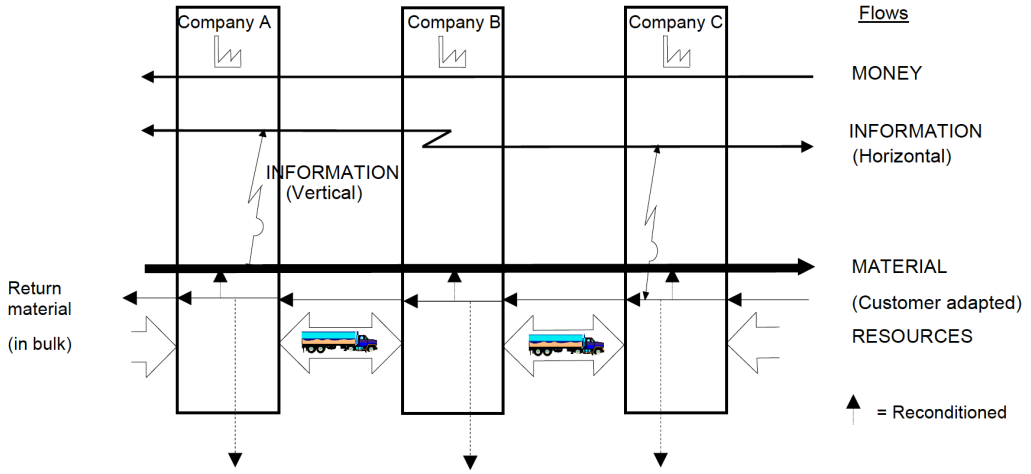

Figure 7 Flows in logistics (Lumsden, 2006)

Given the overall goal and purpose of this research, only resource flow and horizontal information flow are considered, the latter since improved access management relies on enhanced information exchange among actors from different organisations. By contrast, resource flow is selected since improved access management can potentially make the utilisation of resources of road hauliers more efficient. All other flows are excluded since they are not affected by improved access management and are therefore beyond the scope of this research.

Intermodal freight transport, or intermodal transport, is a key element in the transportation industry (Lowe, 2005; Rodrigue et al., 2006). The definition of *intermodal transport* varies in the literature, from having a more general scope to more specific one (Bontekoning et al., 2004). In this research, *intermodal transport* is defined according to the United Nations and Economic Commission

for Europe (The United Nations Economic Commission for Europe, 2001) as 'the movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transportation without handling the goods themselves in changing modes'. According to (Lowe, 2005), the objectives of intermodal transportation are to accomplish a more sustainable delivery of goods by using modal shifts among road, rail, sea, and air transport.

3.2.1 Road haulier operations

In Sweden, total road haulier transport hovers around 35–40 billion tonne km and encompasses roughly 70% of all freight transport by rail, sea, and air (European Commission, 2016). Road haulier transport is characterised by six factors (Lumsden, 2006): small scale quantities (i.e., smaller than other modes for the advantage of easily adopting a single customer), flexibility (i.e., can be easily redirected during ongoing transport), safety (i.e., safer for goods, for comfort, and against theft and loss), reliability (i.e., the combination of a vehicle and an accompanying driver), service (i.e., can locally solve the transportation buyer's problems), and adaptability (i.e., can solve low-level economic problems). Among forms of intermodal freight transport, road haulage is the activity in which ITUs are transported on roads (Woxenius, 1998) and is considered as both pre- and post-haulage (Woxenius & Bärthel, 2008). The major challenges of road haulage are to achieve high resource use with low costs and to deliver transport quality demanded by customers (Behrends et al., 2011). As mentioned in Section 1.1, there are eight primary road haulier operations in focus in this work (Sternberg et al., 2014): breaks (i.e., drivers are required to take regulated breaks every 4 or 5 h), driving (i.e., between hauliers and intermodal freight terminals), handling (i.e., separate from loading and unloading and concerns dealing with equipment and containers), administration (i.e., document handling or information retrieval, such as walking outside the truck to announce the arrival of ITUs or making phone calls to a transport planner), loading (i.e., loading containers onto a truck), servicing (i.e., fuelling or servicing a truck), unloading (i.e., unloading a container from a truck), and waiting (i.e., due to bottlenecks at terminals while, for example, loading or unloading ITUs onto or from trucks).

3.2.2 Intermodal freight terminals

Intermodal freight terminals involve two different groups of actors: terminal owners and terminal operators (Wiegmans et al., 1999). Terminal owners can be private, public, or both, and their chief role is to facilitate central terminal services such as the provision of the terminal and office space (Wiegmans et al., 1999). By contrast, the chief role of terminal operators is to provide terminal services requested by customers for the best possible price (Wiegmans et al., 1999); those terminal services include the handling, sorting, grouping, and transhipment of ITUs (Crainic & Kim, 2007). In this research, only transhipment receives focus since it is part of identified access management services; *transhipment* is the movement of ITUs from one transportation mode to another (Bontekoning et al., 2004).

As mentioned earlier in this work, there are four different types of intermodal freight terminals (Lowe, 2005; Roso et al., 2009): railroad terminals, seaports, inland waterway terminals, and airports. Only railroad terminals and seaports receive focus in this work since they represent two participants; the selection

criteria of those two types of terminals are described in Section 2.3. Railroad terminals provide transhipment between smaller freight flows (e.g., road) to larger ones (e.g., rail and inland waterways), and seaports offer transhipment between vessel transports and land-based transports (e.g. railways or trucks) (Lumsden, 2006).

3.3 Industrial network approach

Businesses can be sorted into two categories: business in practice and business in theory (Håkansson, 2009). Business in practice encompasses interactions with others for an ordinary or extraordinary phenomenon, whereas business in theory describes only independent companies driven by competitors and that operate as individuals. The interaction process can take many different of forms in the business landscape; some have long histories, whereas others involve more spontaneous contact (Håkansson, 2009). In either case, those interactions form different business relationships that interconnect companies in business networks (Snehota & Hakansson, 1995).

The industrial network approach describes a system by denoting relevant actors, resources, and activities (Gadde et al., 2003), as mentioned in Section 1.3 and further described by Håkansson (Håkansson, 1987):

- Actors aim to increase the control of a network and are people or organisations within the network;
- Resources are commonly heterogeneous, physical and human, dependent on connections to other resources, and owned by actors (Håkansson & Snehota, 1989; 2006); and
- Activities are based on specific resources, are actions performed by actors and are grouped in two categories: transformation activities performed by single actors and transaction activities performed between actors. When a joint activity is performed by two actors, the combined resource efficiency of the actors can be improved (Frazier et al., 1988).

The industrial network approach is used in earlier research to describe and analyse logistics systems such as intermodal freight transport (Woxenius, 1998; Stefansson & Lumsden, 2009; Sternberg et al., 2013a). The advantage of the approach and why it suits the present research is that it handles the exchange of products and services between two organisations and addresses how they organise the flow of goods and information. The approach can also help to identify sources that collect or produce information attributes due to its comprehensive description of relationships between different organisations in the network.

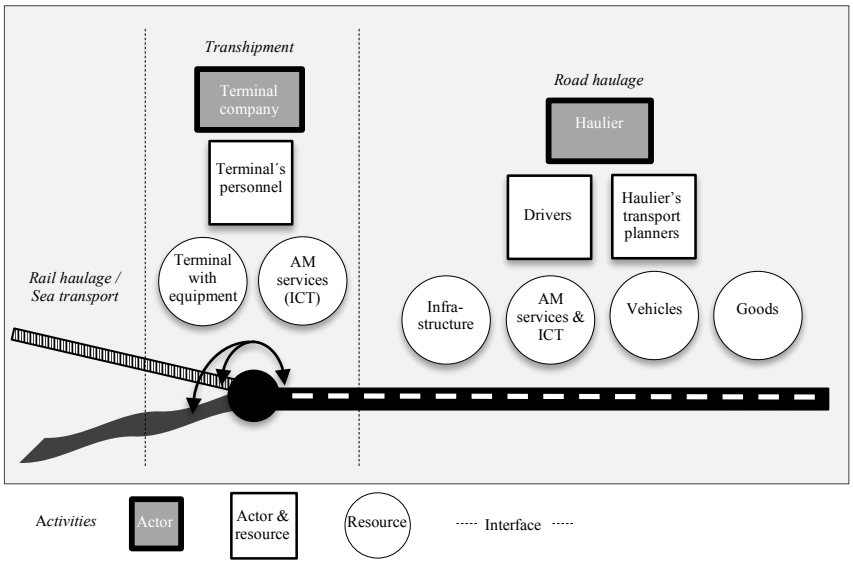

Figure 8 The system under study in terms of actors, resources and activities

Figure 8 shows the actors, resources, and activities of interest in this work; only actors and resources belonging to the activities of road haulage and transhipment are presented, since rail haulage and sea transport are beyond the scope of this research. Terminal personnel, drivers, and haulier transport planners are defined as both actors and resources (i.e., white boxes in Figure 8) since they can be seen as both employees (i.e., actors) and producers of information (i.e., resources).

3.4 Information exchange

There are four different facets that define information exchange among actors (Mohr & Nevin, 1990): frequency, direction, modality, and content. First, frequency relates to the frequency of transport that concerns information flows and describes how often information needs to be exchanged among actors in order to be used effectively. For example, such information flows might be triggered when hauliers plan a new route to pick up or deliver ITUs to terminals. Second, direction describes how information is exchanged; it can either be bidirectional (i.e., information flow in two directions) or unidirectional (i.e., information flow in one direction). Direction also characterises whether the information flow is inter-organisational or intra-organisational. In this research, only inter-organisational directions receive focus, as discussed in Section 3.2. Third, modality refers to the medium used for information flow; it can be analogue (e.g., over the telephone) or digital (e.g., video chat, email, social media). In this research, the focus falls to digital media and transmission in real-time. Fourth, content is the actual transmitted message, which in this work is structured according to the object-orientation paradigm (Booch, 1991). Consequently, content is presented as information attributes and is further categorised into static (i.e., present before or at the beginning of transport and does not change thereafter), historical (i.e., captured during transport and used for making predictions for future transport), and dynamic (i.e., which change over time and can be useful when making decisions in real-time).

3.5 Differentiation and segmentation strategies

To meet the needs and requirements of customers, differentiation and segmentation strategies are used in prior research in logistics and transportation to make supply chains more effective and efficient (Farahani et al., 2011; Hofmann et al., 2012). Therefore, differentiation and segmentation strategies are used in this work due to that customers (e.g. road hauliers) require different services to potentially improve their access management at intermodal terminals.

Differentiation strategies focus on advertising and acquiring services or products for an organisation for different customer segments (Smith, 1956). The strategies can help organisations to offer a flexible range of services or products in order to meet the specific requirements of various customers (Clemons & Weber, 1994; Hofmann et al., 2012). Services and products can also be differentiated by their characteristics (e.g., sizes, key features, and complexity) to make them unique (Dickson & Ginter, 1987; Magrath, 1988). Although services cannot be stored and are intangible activities produced and consumed in real-time, products are concrete physical objects produced before they are consumed (Grönroos, 1990; Looy, 1998; Normann, 2000) In this research, services can be represented as customer services and products as transported ITUs. Customer services are influenced by logistics services, delivery services, and information exchange (Lumsden, 2006; Jonsson, 2008) Logistics services are services that can provide customers value and in this work they are referred to the identified access management services, and delivery services are influenced by delivery time, delivery reliability, delivery precision, and delivery flexibility, and information exchange is described according to Section 3.4 (see Paper 2 for further details about customer services). Both customer services and transported ITUs are important for access management; however, since services bear the greatest impact on improving access management, only customer services are considered in this work. The differentiation of customer services can be an important competitive advantage (Looy, 1998) for the better the customer services that improve access management at a terminal, the greater the chance that customers can transport ITUs through that terminal.

Segmentation strategies focus on dividing markets or populations with similar characteristics into segments. Like differentiation strategies, segmentation strategies are developed with respect to the requirements of customers (Smith, 1956), and as long as the strategies are well developed, additional segments can be identified. Segmentation strategies both can enable and require differentiation strategies (Dickson & Ginter, 1987; Clemons & Weber, 1994) for each segment to be successful. As a result, segmentation strategies can help to split markets into comparable segments in order to gain more precise, rational adjustments of services or products in order to fulfil specific requirements of customers. The strategies might help to improve the access management for actors involved by dividing the terminals into segments in order to identify the various differentiation strategies for customer services at each terminal.

3.6 Reference model based on relevant literature

Figure 9 illustrates a reference model to describe the system under study.

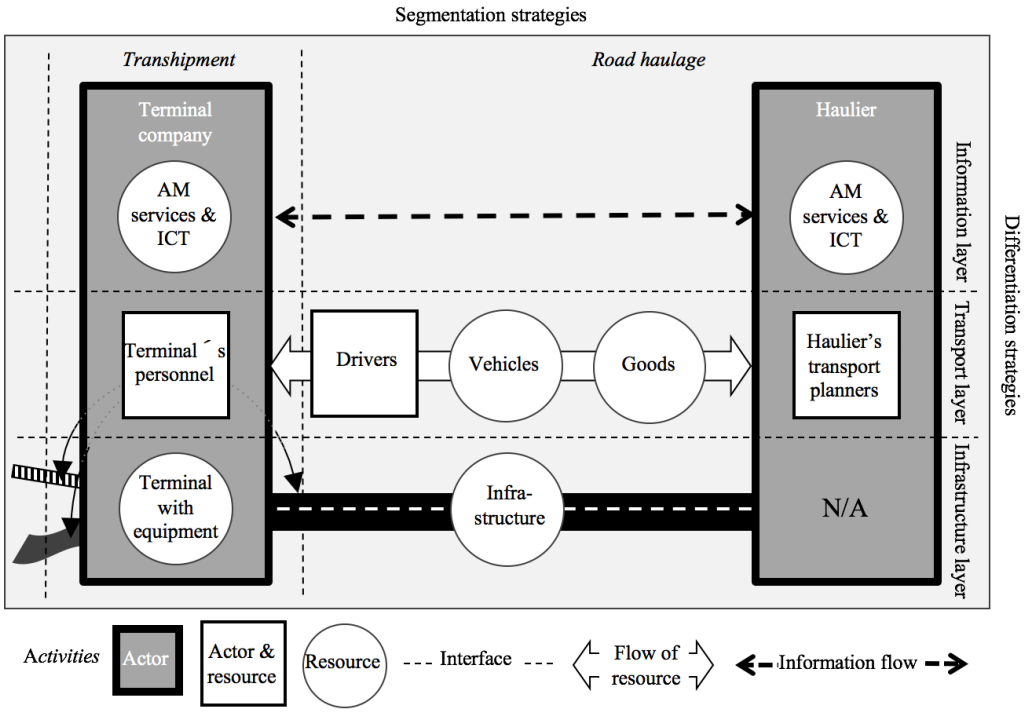

Figure 9 Reference model based on the industrial network approach and synthesised from models regarding transportation layers (Wandel et al., 1992) and transportation flows (Lumsden, 2006).

The model is sorting the actors, resources, and activities taken from Figure 8 into the transportation layers defined by Wandel (Wandel et al., 1992) and adding the transportation flows defined by Lumsden (Lumsden, 2006). Additionally, the model only considers the actors, resources, activities, transport layers, and information flows in focus in this work, as previously explained in Sections 3.3 and 3.4. For example, no vertical information flows are considered due to how information exchange is presented for this research, although differentiation and segmentation strategies are considered. On the one hand, the segmentation strategies are written on top of the model since they distinguish segments as railroad terminals or seaports; on the other, the differentiation strategies are marked on the side of the model since they both distinguish and consider the information exchange characteristics of the different access management strategies.

4 Summary of papers

This chapter summarises the three appended papers (i.e., Paper 1, Paper 2, and Paper 3), an overview of which appears in Table 8 in terms of the purposes, RQs, and contributions of each paper. The three papers are the result of the three studies: Study 1, Study 2, and Study 3.

Table 8 Summary of the three papers (i.e., Paper 1, Paper 2, and Paper 3) in terms of their purposes, research questions (RQs), and contributions

Paper	Purpose	RQs	Contribution
Paper 1	To identify the existing and required information attributes that need to be exchanged between the studied intermodal freight terminals and hauliers to improve their access management	RQ1, RQ2	Definition of access management; development of the information attribute framework to sort and analyse information attributes; presentation of information exchange and how it relates to this research; compilation of existing and additional information attributes (e.g. actual pickup times of ITUs, the occupancy rate and queuing status at the terminal (TOC) and the port (POD), and weighing status of ITUs) that need to be exchanged to improve the access management for participants
Paper 2	To identify contemporary and to develop potential future differentiation and segmentation strategies to facilitate an evaluation of the improvement of access management	RQ2, RQ1	Development of the differentiation and segmentation framework to identify existing and to develop future differentiation and segmentation strategies by which participants can improve their access management; these strategies are based on customer services (access management services, delivery services and information exchange) for participants
Paper 3	To identify the potential efficiency benefits for road hauliers when accessing intermodal freight terminals	RQ3	Time measurements showing that wait and administration times are chief areas of inefficiency for the two road hauliers (RHA and RHB); development of information exchange framework to increase the interaction between participants; smartphone app, which however did not reduce wait and administration times because participants did not react well to new real-time information received from the app

4.1 Paper 1

Purpose

The purpose of Paper 1 is to identify the existing and required information attributes that need to be exchanged between the studied intermodal freight terminals and hauliers to improve their access management.

Research questions (RQs)

Paper 1 addresses RQ1 by defining *access management* and describe its general characteristics, and RQ2 by identifying which information attributes need to be exchanged among actors involved and how in order to potentially improve access management for participants.

Contribution

Paper 1 revealed deficiencies in the information exchange among participants in a comprehensive compilation of identified information attributes presented and analysed with the information attribute framework developed. The information

that participants need to exchange to improve their access management are the actual pickup times of ITUs, the occupancy rate and queuing status at the studied terminal and port. Paper 1 also contributes new knowledge regarding the management of freight transport systems, intermodal transport systems, and information systems.

4.2 Paper 2

Purpose
The purpose of Paper 2 is to identify contemporary and to develop potential future differentiation and segmentation strategies to facilitate an evaluation of the improvement of access management.

RQs
Paper 2 addresses RQ2 by presenting different customer services (access management services, delivery services, information exchange) in current operation in the transportation industry worldwide and by developing differentiation and segmentation strategies to improve access management in intermodal freight terminals from the perspective of road haulier operations. As a secondary endeavour, Paper 2 also addresses RQ1 by defining *access management* and describing access management for road hauliers in terms of the industrial network approach, including its actors, resources, and activities.

Contribution
Paper 2 contributes with an analytical framework for developing and analysing differentiation and segmentation strategies that can improve the access management for participants by analysing customer services, rating them by suggested level of classification, and identifying customers' needs for products and services offered in different segments. It also contributes new knowledge with the developed analytical framework to help to identify and analyse differentiation and segmentation strategies in the fields of management of freight transport systems, intermodal transport systems, and IS. From a managerial standpoint, Paper 2 contributes strategies that can support hauliers and intermodal freight terminal operators to distinguish their access management operations and provide customer services to improve their access management in alignment with existing or future access management strategies.

4.3 Paper 3

Purpose
The purpose of Paper 3 is to identify the potential efficiency benefits for road hauliers when accessing intermodal freight terminals. To that end, the practical goal is to investigate what inefficiencies are present and how they can be reduced by improving access management in intermodal freight terminals from the perspective of road haulier operations.

RQs
Paper 3 answers RQ3 by reviewing literature on potential operational benefits of resource efficiency regarding access management services, ICT technologies and time measurements made with StarDriver and information exchange tests with the REACH app. Paper 3 also partly answers RQ1 by showing how time

measurements made in Study 1 clarified knowledge of access management among road hauliers.

Contribution

Above all, Paper 3 documents the implementation and testing of the REACH app. The app is based on the analytical framework developed in this work and implemented in order to increase the information exchange among participants and, in turn, improve their access management by reducing major inefficiencies in the areas of wait and administration times, which were identified to comprise 32% of a typical truck driver's workday. The impact of increased information exchange among participants did not reduce those inefficiencies, primarily because the two road hauliers (RHA and RHB) did not react well to the new information that they received from the app. On the one hand, adopting the new technology proved to be a major obstacle for the conservative mind-set common in intermodal freight transportation, as other research points out (Marchet et al., 2012).

5 Results and analysis

This chapter provides answers to the RQs. Section 5.1 presents answers to RQ1 by defining *access management*, describing and analysing access management for road hauliers in terms of the industrial network approach by using the reference model in Figure 9, explaining how information exchange operates, and identifying existing inefficiencies in the system under study. Next, Section 5.2 presents answers to RQ2 by identifying the information attributes required and differentiation and segmentation strategies that are based on customer services (access management services, delivery services, information exchange) available to participants. Lastly, Section 5.3 presents answers to RQ3 by investigating the potential operational benefits of access management services in terms of empirical measurements and in light of secondary sources with other results on the topic.

Each RQ motivated a different study, as described in Chapter 2 and shown in Figure 10. The figure also illustrates an overview of deliverables from the three studies (Study 1, Study 2, and Study 3) included in the three papers (Paper 1, Paper 2, and Paper 3).

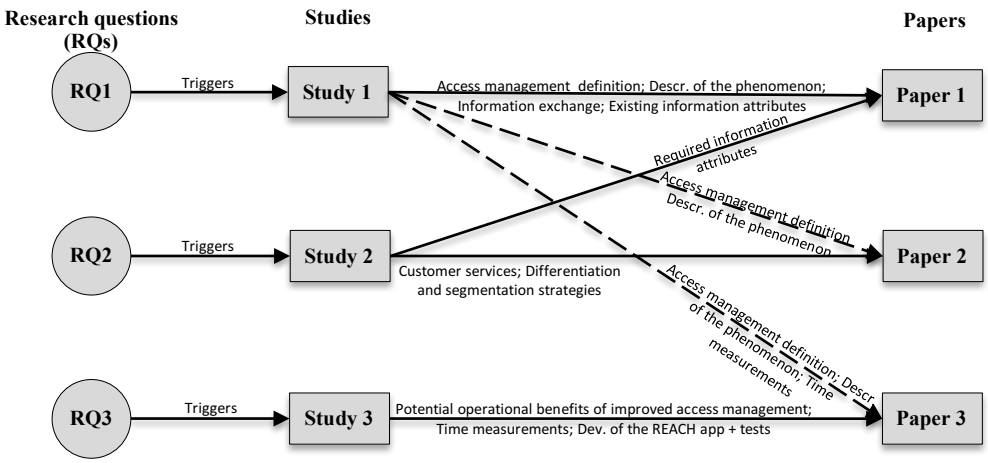

Figure 10 The relationship between the research questions, studies, and papers, including the deliverables of each entity; a solid line indicates a complete deliverable, whereas a dashed line indicates a partial deliverable

A corresponding overview of the relationship between the papers, RQs and frame of reference is illustrated in Figure 11. This figures shows what body of knowledge is foundations for each paper. For example, Paper 1 is mainly built upon the foundation of information exchange with focus on information attributes.

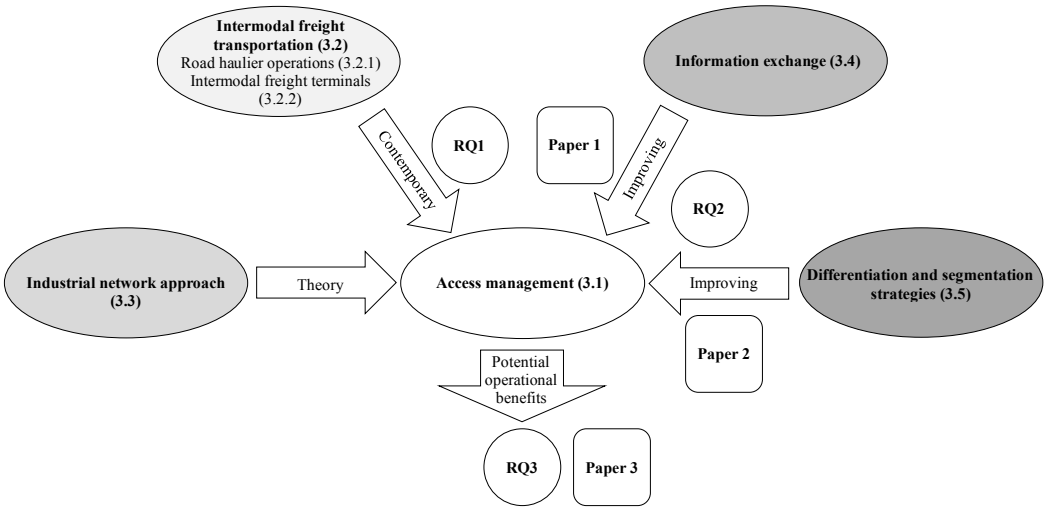

Figure 11 The relationships between the papers, research questions and frame of reference

5.1 RQ1 - How is access managed in intermodal freight terminals from the perspective of road haulier operations?

Although Paper 1 primarily answers RQ1, Paper 2 and Paper 3 also respond to the question. Answering RQ1 involves several steps in addition to the definition of *access management*: (1) the access process, (2) involved actors, resources, activities and flows, (3) information exchange among participants, and (4) time measurements of drivers´ operations.

5.1.1 Access processes

Figure 12 shows the access processes and illustrates the different stops that both the two road hauliers (RHA and RHB) need to make to access the terminal operator (TOC) and the port operator (POD) and, once there, load or unload Intermodal Transport Units (ITUs). As Figure 12 also shows, loading and unloading ITUs at the terminal operator involved fewer stops than those processes at the port operator. In fact, only the final three stops are similar for both places. The port operator requires more stops since it handles both import flows and export flows (i.e., international transport of ITUs).

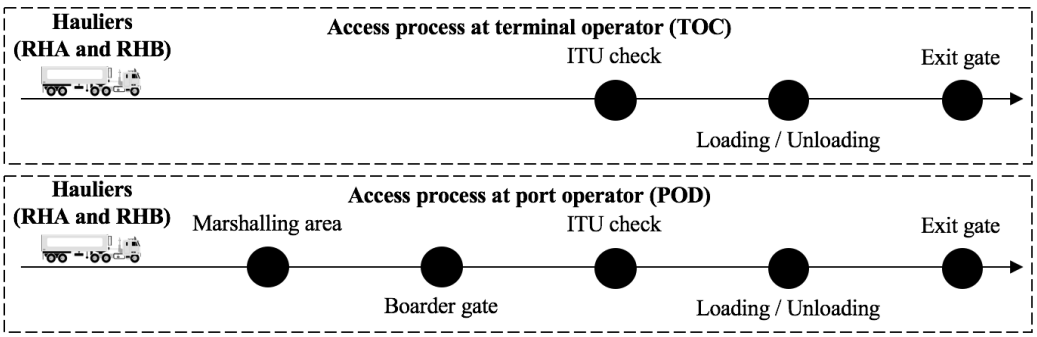

Figure 12 Access processes at the terminal (TOC) and the port (POD)

The different stops are the marshalling area (i.e., where trucks need to take a queueing ticket and wait to be served), the boarder gate (i.e., where truck drivers need to show their credentials to enter the port operator), and the ITU check (i.e.,

where ITUs are checked for their condition and seal numbers). Other stops include the announcement of the ITU planned for pickup or delivery, the loading and unloading of ITUs, and the exit gate where ITUs are picked up at the terminal operator or the port operator need to be registered before trucks may exit the terminal. The description of the access process (as shown in Figure 12) is the first step in answering RQ1.

5.1.2 Actors, resources, activities, and flows involved

Adopted from the reference model shown in Section 3.6, Figure 13 illustrates the different actors, resources, activities, and flows of resources and information involved when the two road hauliers (RHA and RHB) access the terminal operator (TOC) and the port operator (POD).

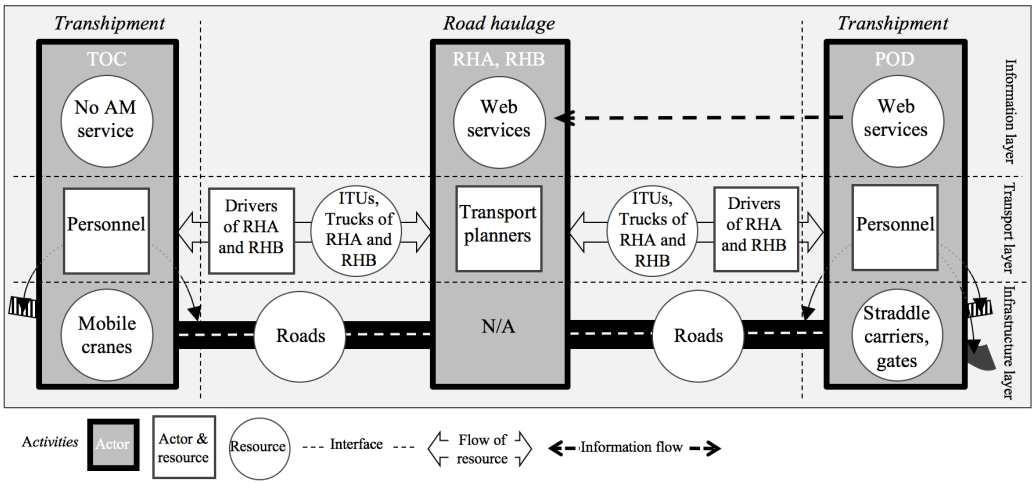

Figure 13 The access of two road hauliers (RHA and RHB) to the terminal (TOC) and port (POD)

Most of the actors, resources, and activities are similar for both the terminal and port operators. However, the access management resources of services and terminal with equipment differ, and whereas the terminal operator provides transhipment between road and rail only, the port operator conducts transhipments among road, rail, and sea. The terminal operator does not use any access management services, meaning that it does not manage access to the terminal. Accordingly, although it is possible to access the terminal and trucks may pick up or deliver ITUs, there is no management in order to improve access. The port operator uses web services, meaning that it can provide hauliers information regarding certain ITUs via the IT system. Both road hauliers also use web services; they not only access the IT system of the port operator, but also use different webpages to learn about status of roads, weather, and congestion at the port. The description and analysis of the involved actors, resources, activities and flows as shown in Figure 13 above are the second step in answering RQ1.

5.1.3 Information exchange among participants

Answering RQ1 also involved clarifying how information can be exchanged among participants, since information exchange is a cornerstone of how access is managed. In the case of the terminal operator (TOC), no information exchange between the two road hauliers (RHA and RHB) and the terminal operator exist; however, on rare occasions, transport planners at the road hauliers phone the

terminal operator for information about a certain ITU or the arrival time of a specific train. In the case of the port operator (POD), information flows from the port operator to the two road hauliers via the port operator's information systems, which allow the hauliers to gain information about the status of a certain ITU planned for pickup. The differences of the information flows between the terminal and port could stem from the fact that the terminal and port operators use different access management services. The consequence of no or poor information exchange is that management of access is prevented to be improved due to the fact that enhanced information exchange among actors is necessary for improving access management. For example, earlier research identifies that improving the poor quality of real-time data and information exchange between actors (Acciaro & Wilmsmeier, 2015) can increase resource efficiency in intermodal freight transportation (Cepolina & Ghiara, 2013). This clarification on how information is exchanged among the participants is the third step in answering RQ1.

5.1.4 Time measurements of drivers´ operations

Answering RQ1 also involved identifying inefficient road haulier operations by conducting time measurements of drivers' operations. Those measurements resulted in that almost 51.7% of the time, the vehicle was not moving, and truck drivers were busy with operations other than driving. The two primary operations that cause trucks to stand still are administration and waiting, which together account for 32.2% of stop time. That result clearly confirms results from prior studies about problems with congestion (Zhao & Goodchild, 2010; Borgman et al., 2011) and long turnaround times for trucks in intermodal freight terminals (Lubulwa et al., 2011; Islam et al., 2013). The time measurements of drivers´ operations is the fourth and final step in answering RQ1.

5.2 RQ2 – What information and strategies are required for improving access management in intermodal freight terminals from the perspective of road haulier operations?

Paper 1 and Paper 2 responded to RQ2 by improving the access management for participants. Answering RQ2 involved two different steps: identification of required information, and development of differentiation and segmentation strategies that are based on customer services (access management services, delivery services and information exchange).

5.2.1 Required information

Table 9 presents the required information attributes, some of which are discussed in Section 5.1. The first column represents producers of information (actors, resources and activities) and the other three columns represent categories of information attributes (static, historical, and dynamic). Cells bearing 'None' indicate that no required information attributes were identified. Although most information attributes listed in the table are self-explanatory, the rest refer to definitions of information attributes presented in the appendices of Paper 1. According to the empirical findings, the most important required information attributes for participants are notifications about certain ITUs regarding actual pickup time, terminal loading point, terminal unloading point, occupancy rate, and queuing status. If the road hauliers could receive those attributes, then their

transport planners could plan to use their trucks accordingly. When making those types of operations more efficient, congestion at the port could be reduced.

Table 9 Required information attributes from Paper 1

Source	**Categories**		
1. Actors	**A. Static**	**B. Historical**	**C. Dynamic (real-time)**
1.1 Haulier	None	*Earlier interactions*	None
1.2 Terminal company	None	*Coating history*	None
2. Resources	**A. Static**	**B. Historical**	**C. Dynamic (real-time)**
2.1 Terminal with equipment	*Estimated departure time, equipment information, customs clearance status, discharge status, advanced notification number, release status, queuing status, visit code*	*Occupancy rate, queuing status, traffic history*	*Actual departure time, availability, occupancy rate, queuing status*
2.2 Drivers	None	None	None
2.3 Vehicles	*Number of intermodal transport units (ITUs)*	None	None
2.4 Haulier transport planners	*Booking information, estimated pickup time*	*Estimated pickup time, time of delivery*	*Actual pickup time, actual time of delivery*
2.5 Terminal personnel	*Estimated delivery time, estimated pickup time, preliminary pickup location, time of delivery*	*Deviation information, estimated pickup time, time of delivery*	*Actual pickup time, actual time of delivery, deviation information*
2.6 Goods	*Goods priority information, ITU identification, type of ITU, weight*	*Goods priority information*	*Goods priority information*
2.7 Infrastructure	None	None	None
3. Activities	**A. Static**	**B. Historical**	**C. Dynamic (real-time)**
3.1 Road haulage	*Estimated time of arrival (ETA), sequence, shipment identification, weight of shipment*	*Deviation information, ETA*	*Deviation information, ETA, terminal loading point*
3.2 Transhipment	*Sequence, shipment identification, transportation costs, weight of shipment*	*Arrival time of ITU, deviation information, pickup location*	*Deviation information, handling of ITU*

At the same time, the overview of required information attributes could help personnel at terminals and transport planners at hauliers to improve their access management. However, that possibility does not mean that all information attributes must be used and transmitted to improve access management, for it depends on what access management service is available and to what actors would like to gain access. In that sense, Table 9 should be used as a guideline, not a prescription, to help personnel at terminals and transport planners of hauliers to improve their information exchange and, in turn, access management, both toward making transportation operations more efficient.

Most identified information attributes are also identified in prior research (Woxenius, 1998; Andersson, 2005; Lumsden, 2006; Crainic & Kim, 2007; Stefansson & Russell, 2008; Sternberg, 2008; Wang & Hu, 2016) and secondary sources (The United Nations Economic Commission for Europe, 2001; Trafikanalys, 2014; Dynafleet, 2015; PBS, 2015). The identification of the required information attributes is the first step in answering RQ2.

5.2.2 Differentiation and segmentation strategies

Differentiation and segmentation strategies are developed to improve access management for participants. Table 10 illustrates the developed strategies by using the structure of the differentiation and segmentation framework.

Table 10 Differentiation and segmentation strategies from Paper 2

Differentiation and segmentation strategies			Segmentation strategies					
			Contemporary		Future			
			Terminal and port		Terminal and port			
Differentiation strategies	Road Haulier A and Road Haulier B	**Access management service**	No access management service (Level 0)	Web services (Level 1)	Automated gate services (Level 2)	Advanced notification and appointment services (Level 3)	Transaction and community services (Level 4)	Priority services (Level 5)
		Delivery time	None	None	No estimations applicable	Deviation information, ETA	Deviation information, ETA	Deviation information, ETA
		Delivery reliability	Manual quality check of ITUs and seals	Manual quality check of ITUs and seals	Automatic digital quality check of ITUs and seals	Deviation information	Deviation information	Deviation information
		Delivery precision	None	None	None	Timeslots	Real-time agreements	Real-time agreements
		Delivery flexibility	None	None	None	Rebooking of time slots	Real-time flexibility	Real-time flexibility
		Frequency	Rare	Before loading and unloading	Before loading and unloading	Before loading and unloading	Before, during, and after loading and unloading	Before, during, and after loading and unloading
		Direction	Bi-directional	Uni-directional	Uni-directional	Uni-directional	Bi-directional	Bi-directional
		Modality	Telephone	Web browsers	Web browser or IT system	Web browser or IT system	Digital via IT systems	Digital (e.g., via IT systems, smartphones, tablets)
		Information attributes	Ad hoc information	ITU status, queuing status	Driver ID, ITU ID, shipment ID, vehicle ID	ETA, ITU ID	**Import flows**: ITU ID, ITU status, queuing status **Export flows**: ITU ID, queuing status, weighing status	**Import flows**: Goods priority information, ITU ID, ITU status, queuing status **Export flows**: Goods priority information, ITU ID, queuing status, weighing status

Note. ETA: Estimated time of arrival, ID: Identification, IT: Information technology, ITU: Intermodal transport unit

The table shows that the two road hauliers (RHA and RHB) have different requirements regarding customer services (i.e., access management services, delivery services (delivery time, delivery reliability, delivery precision, delivery flexibility), frequency, direction, modality, and information attributes) for different segments (i.e., terminal operator C and port operator D). The five access

management services described in Section 3.1 (i.e., web services, automated gate services, advanced notification and appointment services, transaction and community services, and priority services) operate at different levels with different degrees of resource efficiency. The lower level (e.g., Level 0) poses the least degree of resource efficiency, whereas the higher level poses the greatest degree. The table also shows both contemporary and future differentiation and segmentation strategies for participants. For example, the future segmentation strategies of the port operator in the last column reveal that the hauliers would appreciate more priority services that can meet certain requirements for delivery time (e.g., deviation information, estimated pickup time, and estimated time of delivery) in a bidirectional information flow using smartphones or tablets to transmit specific information attributes (i.e., goods priority information, ITU identification, ITU status, and queuing status) for import flows.

In summary, Table 10 contributes new knowledge for practitioners by providing a good overview for managers to realise their level of access management and how they can improve it, as well as for scholars, since it is a useful tool for analysing different access management levels when investigating other hauliers and terminals. However, since a higher level of access management service involves more advanced technology, such access management services could pose disadvantages since different actors might differ in their willingness to adopt such technology, as identified in prior research (Marchet et al., 2012; Evangelista & Sweeney, 2014; Harris et al., 2015). The development of the differentiation and segmentation strategies is the second and last step in answering RQ2.

5.3 RQ3 - What are the potential operational benefits of improved access management in intermodal freight terminals from the perspective of road haulier operations?

Answering RQ3 involved investigations into the potential operational benefits of improved access management for participants through empirical studies that entailed increased information exchange tests using the REACH app. These tests demonstrated that it had more or less no impact upon deceasing the inefficiencies of waiting and administration that were identified when answering RQ3. Interviews with truck drivers and transport planners from both road hauliers involved in the tests revealed two major reasons why the REACH app did not have any impact. On the one hand, a closer look at the log files showed that the REACH app was not activated as much as planned. According to truck drivers who used the app, it was too complicated to use another smartphone in addition to their work phone and personal phones. Such complexity discouraged truck drivers from using the app, especially during stressful circumstances. On the other hand, when the app was used, neither the truck drivers nor transport planners reacted to the new information (e.g., information attributes ITU status and congestion status) exchanged. According to the transport planners, the new information was helpful because it allowed them to inform customers about delays. However, the truck drivers only became more confused and did not know how to react to the new information. Thus, regardless of the new information, the drivers drove to the terminal and the port as planned, even if they knew about congestions in either location. Problems with adapting to new technologies are also identified in prior research (Marchet et al., 2012; Evangelista & Sweeney, 2014; Harris et al., 2015). If the truck drivers and transport planners are willing to

use and adopt different ICT technologies, then the inefficiencies of waiting and administration could be reduced by 30% and 100%, respectively (Sternberg et al., 2014). Moreover, by using and adopting the access management services, waiting and administration inefficiencies could be reduced even more. Indeed, prior research shows that advanced notification and appointment services can reduce turnaround times by approximately 30% (Phan & Kim, 2015), and by 38% by adopting and using transaction and community services (Carlan et al., 2016). RQ3 is answered through the empirical tests where the potential operational benefits of increased information exchanged is investigated and through the identification of potential operational benefits based on relevant literature regarding access management services.

5.4 Summary

Table 11 shows a summary of the results of each RQ with related literature reviewed, empirical evidence gathered, and papers.

Table 11 A summary of the results of each research question (RQ)

RQ	Literature	Empirical evidence	Papers	Results
RQ1	Identifies themes of access management, including road haulier operations, intermodal freight terminals, industrial network approach, and information exchange	Observations while accompanying truck drivers, interviews with the drivers, and time measurements expand current knowledge of how contemporary access is managed for road hauliers	Paper 1, Paper 2, Paper 3	*Access management* is defined; a reference model that describes and analysis access management for road hauliers is developed; descriptions of how access in managed in the terminal (TOC) and the port (POD) for the two road hauliers (RHA and RHB) are presented; the information exchange and how it relates to this research is presented; existing information attributes are identified; and time measurements are conducted that described the operations of drivers of the two hauliers and identified the two chief areas of inefficiency: waiting and administration
RQ2	Involves a literature review on improving access management with themes such as access management services, road haulier operations, intermodal freight terminals, industrial network approach, information attributes, and differentiation and segmentation strategies	Semi-structured interviews and focus group meetings with truck drivers, transport planners, dispatchers, planning managers, and commercial managers to gain necessary foundational knowledge	Paper 1, Paper 2	Description of access management services is presented; the information attribute framework is developed to sort and analyse existing and required information attributes; identification of a set of required information attributes to improve access management for participants; the differentiation and segmentation framework is created to develop differentiation and segmentation strategies based on customer services (access management services, delivery services, information exchange) for participants
RQ3	Involves a literature review on potential operational benefits of improved access management in terms of access management services, road	Observations at terminals and while driving with truck drivers, interviews with drivers and transport planners, time measurements of drivers' operations, and increased information exchange tests confirm and expand	Paper 3	The REACH app was implemented based on the information exchange framework developed in Study 3 and presented in Paper 3; an increased information exchange was tested by using the REACH app but resulted in no impacts on identified inefficiencies due to insufficient use of the REACH app and resistance among truck drivers and transport planners to adopt new technology; access

	haulier operations, intermodal freight terminals, information exchange, and information attributes	knowledge gained from the literature review		management services and different ICT technologies demonstrate the potential to reduce waiting and administration by more than 30%.

6 Discussion

This chapter discusses the results of the research.

6.1 Contemporary access management

The term *access management* is prevalent in information systems research, but not explicitly defined in freight transport. And, there is no scientific definition of the term encompasses a broader view of the entire process of how actors access different resources for various activities toward achieving improved resource efficiency. Prior research is fragmented when it comes to capturing the entire process; studies variously focus on regular security systems with access control functionalities (Marchet et al., 2009; Marchet et al., 2012; Andersson & Sternberg, 2013; Urciuoli et al., 2013), different real-time digital services for improving the access of trucks arriving to terminals via more automatic gate access (Dekker et al., 2013), the issuance of advanced notifications (Stefansson & Lumsden, 2009), the booking of timeslots (Shiri & Huynh, 2016), or the provision of priority lanes (i.e., green lanes) in terminals for unloading and loading Intermodal Transport Units (ITUs) (Sternberg et al., 2012; Boile & Sdoukopoulos, 2014). In response, this work contributes a definition of *access management*—the management of the process of actors accessing resources for specific activities in transportation systems—that derives from the industrial network approach and addresses all of those functionalities and services, as explained in Section 1.3. It should be noted that this work used only the industrial network approach that highlights actors, resources, and activities and did not include the connections among them, to gain insight into access management in intermodal freight transport.

Access management is dependent on information exchange. Regarding the part of this work that addresses information exchange, the results show that information exchange among participants, particularly in terms of existing information attributes, is poor. At times, such dismal exchange causes truck drivers at the two road hauliers (RHA and RHB) to return from the terminal operator (TOC) or the port operator (POD) empty because ITUs planned for pickup is not ready for some reasons. Problems associated with running empty trucks are raised in prior research (McKinnon & Ge, 2006), which shows that increased collaboration among actors can reduce those problems (Islam & Olsen, 2014).

Through empirical time measurements of truck driver activities, this work identifies that wait and administration times are two major areas of inefficiencies, which represent 32% of a typical workday. The identification of those inefficiencies clearly confirms results from prior studies regarding problems with congestion (Giuliano & O'Brien, 2007; Zhao & Goodchild, 2010; Borgman et al., 2011) and long turnaround times, including both wait and administration times, for trucks in terminals (Lubulwa et al., 2011; Islam et al., 2013).

6.2 Improving access management

Two different approaches are identified to improve the access management of participants. The first approach is to reduce the identified inefficiencies (wait and administration) by increasing the identified poor information exchange among participants. An enhanced information exchange where information can be

delivered at the right time, reliable and of high quality, is important to increase resource efficiency among involved actors as stated in previous research (Buijs & Wortmann, 2014; SteadieSeifi et al., 2014). A set of required information attributes (i.e. estimated time of arrival, status information about congestions, and ITUs to be picked up or delivered) are identified to be exchanged every time one of the participants needed more information due to certain reasons. Most of the identified information attributes are also identified in prior research (Woxenius, 1998; Andersson, 2005; Lumsden, 2006; Crainic & Kim, 2007; Stefansson & Russell, 2008; Sternberg, 2008; Wang & Hu, 2016) or other secondary resources (The United Nations Economic Commission for Europe, 2001; Trafikanalys, 2014; Dynafleet, 2015; PBS, 2015).

The second approach is to differentiate identified access management service (i.e. web services, automated gate services, advanced notification and appointment services, transaction and community services, and priority services) that all focus on improving access management for involved actors in order to help participants to identify their level of access management and ways to improve it. Additionally, the information exchange among participants need to be segmented by terminal and port operators as well as by export and import flows of ITUs. Earlier research shows that differentiation and segmentation strategies are import to make supply chains more efficient and effective (Farahani et al., 2011; Hofmann et al., 2012).

6.3 Potential operational benefits of improved access management

The results from the increased information exchange tests shows, surprisingly, no potential operational benefits in improving access management for participants (the identified inefficiencies, wait and administration, are not reduced), primarily because neither truck drivers nor transport planners at the two road hauliers (RHA and RHB) reacted well to the information that they received. On the one hand, the adoption of new technology proved to be a major barrier to the conservative mind-set common in intermodal freight transportation, as addressed in prior research (Marchet et al., 2012; Evangelista & Sweeney, 2014; Harris et al., 2015). On the other, earlier research indicates that more and better communication prerequisites have the potential to decrease inefficiencies (Sternberg et al., 2012; Buijs & Wortmann, 2014). For example, the chief identified inefficiency in RQ1 (i.e., wait times) could be decreased by 83% with automated gate services (Dekker et al., 2013) and by 30% with different ICT technologies (Sternberg et al., 2014), all of which could moreover completely eliminate administration times, as identified in RQ1 (Sternberg et al., 2014). Furthermore, turnaround times, including both wait and administration times, could be reduced by 30% and 38% with advanced notification and appointment services (Phan & Kim, 2015) and transaction and community services (Carlan et al., 2016), respectively.

7 Conclusions, contributions and future research

This chapter presents the conclusions of the thesis, its contributions to the industry and the field of logistics and IS, and directions for future research.

7.1 Conclusions

The goal of this research is to clarify how access management affects resource efficiency in road haulage in intermodal freight transportation. Accordingly, the purpose of the research is to improve access management at intermodal freight terminals from the perspective of road haulier operators. To fulfil that goal and purpose, several subtopics are investigated—namely, how contemporary access is managed, how access management can be improved, and what operational benefits are possible with improved access management.

The first topic is to define *access management*, given the lack of its definition in research on transportation. Ultimately, this work defines ***access management*** as the management of the process of actors accessing resources for specific activities in transportation systems. For that first step, investigations were conducted via literature reviews, observations, and interviews, which resulted in descriptions of how access is managed for **participants** (two road hauliers, one terminal, and one port) in terms of their **access processes** (necessary stops for the two road hauliers when accessing the terminal or the port), other involved **resources** (i.e., drivers, Intermodal Transport Units (ITUs), trucks, mobile cranes, straddle carriers, other personnel) and **activities** (road haulage and transhipments). Moreover, time measurements of truck drivers´ operations were conducted and resulted in **two major inefficiencies: waiting time and administration** tasks that represent about 32% of a normal workday. Finally, **poor or no information is exchanged** among participants that negatively affects the access management.

To enhance the poor information exchange, the second topic about **improving access management** resulted in that different **required information attributes** (i.e. estimated time of arrival, status information about congestions, and ITUs to be picked up or delivered) need to be exchanged among participants in order to improve their access management. Moreover, identified access management services (which all operate at different levels to improve access management) need to be **differentiated** to help managers at road hauliers and intermodal freight terminals in order to identify their level of access management and ways to improve it, and that the information exchange needs to be **segmented** by terminal operators and port operators as well as by import and export flows of ITUs.

The third topic entails investigations to achieve **potential operational benefits** of improved access management by conducting literature reviews, empirical tests of increased information exchange among the mentioned actors, time measurements, interviews, and observations. On the one hand, the **increased information exchange tests did not, surprisingly, affect the inefficiencies** due to that participants did not react upon the new information they received, and because they were not willing to adopt to new technology. On the other hand, **prior research shows** that if involved actors are willing to adopt and use identified access management services (i.e. web services, automated gate services, advanced notification and appointment services, transaction and community services, and

priority services), **the identified inefficiencies (wait and administration) could potentially be reduced by more than 30%**.

A major limitation of the research is that it focuses only the collaboration of road hauliers and terminal operators, thereby ignoring other actors in the supply chain, including shippers, receivers, logistics service providers, and logistics service intermediaries. Moreover, the research's focus on land-based interactions affected the sampling of participants, resources, activities, and types of information attributes. At the same time, measurements were made only regarding one activity (i.e., road haulage) in intermodal freight transportation. Lastly, only horizontal information exchange between organisations is considered, which meant the exclusion of all vertical information exchange within organisations. As such, communication between truck drivers and transport planners and between dispatchers and straddle carrier drivers were not considered.

7.2 Contributions

This work contributes to new knowledge by developing analytical frameworks (including a reference model, an information attribute framework, a differentiation and segmentation framework, and an information exchange framework). For industry, the frameworks offer transport planners at road hauliers and dispatchers at terminals with a clearer understanding of their access management and how they could improve it by using a more advanced access management service. For logistics and IS, those frameworks aid in clarifying access management and identifying and analysing how information should be exchanged, what information attributes are available and required, and how customer services (access management services, delivery services, information exchange) can be differentiated and segmented depending on which terminal is to be accessed, all in order to improve access management for the actors involved. The contributions of this work are further described in Chapter 4. Table 12 summarises the contributions and further distinguishes their implications for industry, logistics, and IS.

Table 12 Contributions of this work

Topic	Industry	Logistics and information systems
Contemporary access management	The findings contribute to the intermodal freight industry and are important for transport planners at hauliers and personnel at terminals since it might improve their information exchange and access management.	*Access management* is defined and an information attribute framework is developed to sort and analyse information attributes with respect to source (i.e., actors, resources, and activities) that produce information and the time perspective categories (i.e., static, historical and dynamic).
Improving access management	The differentiation and segmentation strategies can support hauliers and terminal operators to distinguish their access management operations and provide customer services to improve their access management and align them with existing or future access management strategies.	A differentiation and segmentation framework is developed to identify and analyse differentiation and segmentation strategies gained from interviews and focus group meetings with participants. The strategies can be used to analyse different customer services in terms of their access management services and corresponding levels of delivery services and how their information exchange is operated, as well as to rate their access management based on the degree of service.
Potential operation benefits with improved	New knowledge is provided for managers regarding the potential operational benefits of resource efficiency by using and adopting different access management	An information exchange framework is developed that shows how information should be exchanged depending on the type of terminal and whether intermodal transport units are to be exported or imported. Additionally, a smartphone app REACH

access management	services based on information and communication technology.	based on the information exchange framework was implemented to measure the impacts of increased information exchange among participants.

7.3 Future research

Widening the perspective

Since this research focuses on improving access management in intermodal freight terminals from the perspective of haulier operations, future research should widen that scope to include the perspective of terminals in order to increase the possibilities of improving access management for more actors from other transportation modes such as rail and sea. Of course, that approach will require further development of the definition of *access management*. Previous studies reveal major deficiencies in current access management in railroad terminal and seaports, at which only individual processes are in focus. A wider perspective that includes the views of actors from other previously mentioned transportation modes could therefore be interesting. Example of actors in those modes are terminal operators, hauliers, train operators, freight forwarders, and agencies. A wider perspective should also include the different logistical requirements that actors have for each other, including mobility-related requirements (i.e., further development of the identified required information attributes), technological requirements (i.e., further development of information attributes, differentiation and segmentation, and information exchange frameworks, as well as the REACH app, to be compatible with other transportation modes). Regarding technological requirements, future research should involve the collection of more empirical data from intermodal freight terminals and include more information sources, as described in the information attribute framework, to improve the information attributes, differentiation and segmentation, and information exchange frameworks. The differentiation and segmentation strategies should be further developed so that customers who access a terminal only once a year have different requirements from those who access the terminal regularly.

Improving seamless digital information exchange

Better information is needed regarding the status of freight trains, the status of ITUs, and ETAs at intermodal freight terminals. Specific freight-related requirements regarding the weighing of containers and the advanced notification of incoming shipments to ports (i.e., export flows) should be also taken into account. As a result, digital information exchange can offer actors the opportunity to work more effectively when loading and unloading ITUs in ports. Moreover, future research should concentrate on clarifying the potential of seamless digital information exchange among all mentioned modes of transportation (i.e., road, rail, and sea) in order to improve the access management of actors in those modes. For example, with seamless increased information exchange, transport planners from different modes of transportation can more easily communicate with each other in order to make better joint decisions in real time since the information will be timely and of high quality. The idea behind seamless information exchange is that any actor should be able to interact with any system to improve the management, planning, and synchronisation of the supply chain. Lastly, seamless information exchange among the mentioned modes of transportation should then lead to more efficient, more sustainable, and safer intermodal freight transportation.

Improving generalisability
By taking a wider perspective, longer wait times according to time measurements presented in Section 5.1 and previous research described in Section 1.2, and the number of empty runs in intermodal freight terminals might be reduced through seamless digital information exchange. Future research should involve extending the results to and applying the developed frameworks and strategies in other intermodal freight terminals. By that approach, the frameworks and strategies can be further developed and generalised both nationally and internationally.

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