

# **STANDARDIZATION AND INTEGRATION OF INFORMATION FLOW ALONG THE MARITIME TRANSPORT CHAIN – ANALYSIS OF THE PORT OF HAMBURG AND ITS HINTERLAND TRANSPORTATION BY RAIL USING BUSINESS PROCESS MODELING NOTATION**

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*Ralf Elbert, Technische Universität Darmstadt, Hochschulstr. 1, 64289 Darmstadt, Germany, [elbert@bwl.tu-darmstadt.de](mailto:elbert@bwl.tu-darmstadt.de)*

*Holger Pontow, Technische Universität Darmstadt, Hochschulstr. 1, 64289 Darmstadt, Germany, [pontow@bwl.tu-darmstadt.de](mailto:pontow@bwl.tu-darmstadt.de)*

## **ABSTRACT**

Container flows in the hinterland of maritime transport chains are implemented using co-ordinated logistics processes, which are dependent upon information exchanges between various actors. To be effective and efficient, these logistics processes require a seamless information flow between these actors. However, this does not always occur with hinterland transportation by rail, as is shown by Almotairi et al. (2011). Timely and accurate information, however, allows for coordination of each actor's processes and can, thus, increase customer value. Furthermore these pieces of information support an efficient hinterland access accompanied by a better utilization of existing infrastructure. Using a case study of incoming container flows via the port of Hamburg, this investigation models business processes and information flows on a scale of involved activities, events, and IT systems using business process modeling notation (BPMN). Next, we analyze the documented business processes and information flows with respect to standardization and integration. Additionally, we identify important junctures in the transport chain where a standardized and integrated information flow can improve the efficiency of the utilization of existing infrastructure. Thus, in the context of standardization and integration, this investigation analyzes, how information is exchanged in the hinterland between a deep sea carrier (DSC), terminal operator (TO), railway operator (RO), and railway company (RC). In terms of standardization, it was observed that more than half (60%) of the identified communication interfaces are standardized between the DSC and

the TO. On the other hand, only about every third communication interface is standardized in the analyzed transport chain. This leads to numerous extra manual activities and results in an unreliable information flow (e.g. commissioning of railway operator), which is providing clear evidence that the existing infrastructure can be used more efficiently.

*Keywords: Hinterland transportation by rail, information and communication technology (ICT), business process modeling notation (BPMN), standardization, integration, information flow*

## **INTRODUCTION**

Since the 1980s and despite the 2009 financial crisis and its impact on the flow of goods, maritime container transport has grown rapidly worldwide (Zondag et al., 2010; UNCTAD, 2011). This development was accompanied by an increase in vessel capacity (ISL, 2011). Both trends affect not only deep sea carriers and terminal operators but also hinterland transportation, which represents on-carriage transport in the context of incoming container flows in maritime transport chains.

Because hinterland transportation—especially hinterland transportation by rail (Turner, Windle and Dresner, 2004)—is seen as a key factor in the success of ports and their connected transport chains (Van der Horst and De Langen, 2008; Van der Horst and Van der Lugt, 2011), this investigation focuses on container flows actuated by the actors deep sea carrier (DSC), terminal operator (TO), railway operator (RO), and railway company (RC).

The increase in the number of containers transported by seaway in combination with the steady enlargement of container vessels has an enormous impact on existing infrastructure. As a result, bottlenecks in current port infrastructure arise in terms of cargo storage capacity as well as sea- and landsite access (Cullinane and Wilmsmeier, 2011). To overcome this challenge, Roso, Woxenius and Lumsden (2009) presented solutions. That included the enlargement of physical infrastructure, the improvement of labor organization, and the assignment of new technologies or information systems. However, Cullinane and Wilmsmeier (2011), De Souza, Beresford and Pettit (2003), and Henesey (2006) showed that infrastructure enlargement is cost-intensive, longsome, and not always realizable due to space shortages (especially in Europe's urbanized port areas). Even though the other possible solutions have been regarded extensively in research (improvement of labor organization (Notteboom, 2010; Cetin and Cerit, 2010; Paixão and Marlow, 2003; Dowd and Leschine, 1990), assignment of new technologies (Chao and Lin, 2011; Cetin and Cerit, 2010; Ballis, Goliias and Abakoumkin, 1997)), only a few investigations have dealt with information flows and business processes in hinterland transportation by rail (Almotairi et al., 2011; Henesey, 2006). This is remarkable for two reasons. First, efficient hinterland transportation by rail is important for handling increasing number of containers (Wilmsmeier, Bergqvist and Cullinane, 2011; Turner, Windle and Dresner, 2004). Second, Panayides and Song (2008) and Jarrell (1998) showed the positive effects that an improved information flow has on chains within logistics, especially if associated business processes are simultaneously considered (Al-Mashari and Zairi, 1999; Davenport and Short, 1990).

The present investigation contributes to closing this gap in research by analyzing how information is exchanged between a DSC, TO, RO, and RC in hinterland transportation by

rail. To achieve this objective, three interrelated research questions (RQs) are answered through an embedded single-case study for the port of Hamburg and the related actors in hinterland transportation by rail. The following are the research questions:

RQ 1: On which junctures of the business processes of the considered actors is the information flow standardized and integrated?

RQ 2: Why is the information flow standardized or integrated on particular junctures and not on other junctures?

RQ 3: Which junctures in the transport chain have potential for improving efficiency of utilization of existing infrastructure through a standardized and integrated information flow?

This paper is organized as follows. First, relevant literature in the context of information flows in supply chains, transport networks, and, especially, maritime transport chains is explored. On this basis, we establish literature-based propositions, which appear to be reasons for standardization and integration in terms of information flow. In the following section, the case of the port of Hamburg and the associated hinterland is introduced. Data collection, including the use of the business process modeling methodology is presented in the ensuing section. The analysis of the modeled business processes and information flows allows us to answer the three interrelated research questions and to provide the results of this paper. The conclusions of the article are presented in the last section.

## **STANDARDIZATION AND INTEGRATION OF INFORMATION FLOW AND THEIR IMPORTANCE FOR HINTERLAND TRANSPORTATION BY RAIL**

Compared with other investigations that emphasize the importance of information flows for supply chains (Bowersox, Closs and Cooper, 2002; Flynn, Huo and Zhao, 2010; Lee, Padmanabhan and Whang 1997) and transport chains (Loebbecke and Powell, 1998; Stock and Lambert, 2001), only a few are primarily concerned with the more specific topic of information flows within hinterland transportation by rail, despite the fact that this is of high importance (Van der Horst and De Langen, 2008; Van der Horst and Van der Lugt, 2011; Song and Panayides, 2008).

Jürgens et al. (2011), whose investigation can be perceived as a pilot for the present case study, examine the information flow and conclude that a faster, more accurate and more transparent information flow<sup>1</sup> leads to improved efficiency of how existing infrastructure is utilized. Moreover, the importance of a standardized and integrated information flow for an efficient and effective container flow is highlighted. But, due to the objective of their investigation, Jürgens et al. (2011) did not pursue this aspect.

The article by Almotairi et al. (2011) analyzes how information and information technology is used to support hinterland transportation by rail in Sweden. In this investigation, the importance of the relationship between the flow of goods and information flows is emphasized by tabular summarizations of the key business processes on the one hand, and by describing

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<sup>1</sup> The article of Jürgens et al. (2011) is about data flow, but because data are abstract representations of information, the terms "data flow" and "information flow" considered synonymous for the remainder of this article.

verbal and by a table a typical information flow on the other. In context of integration and standardization of information flows, Almotairi et al. (2011) use a classification according to Heinrich and Simchi-Levi (2005). This classification divides the IT systems of various actors into “disconnected”, “internal integration” and “intra-company integration and limited external integration” up to “multi-enterprise integration”, depending on their degree of integration. A communication by standardized EDI messages is only provided in the last two stages.

Thereby, this classification scheme is consistent with Hasselbring (2000) and Bharadwaj, Bharadwaj and Bendoly (2007). Hasselbring (2000) states that standards are based on previous-gained knowledge and the experiences of (integrated) information flows. Furthermore, a central element of (EDI) standards is to keep a pre-decided syntax and semantics within the scope of the information to be exchanged (Hasselbring, 2000). In contrast to this is the integration of information flows. Here the central element is the consolidation of information from different information sources (especially IT systems) (Evgeniou, 2002; Jürgens et al., 2011). To precisely distinguish between standardized and integrated information flows, we provide the following differentiation: integrated information flows connect different sources of information and provide an uninterrupted information flow depending on the degree of integration (Evgeniou, 2002; Baharadwaj, Bharadwaj and Bendoly, 2007). The structure of the exchanged messages in this field is not specified by an official standards body, such as the United Nations Economic Commission for Europe, and therefore could be agreed bilaterally by the actors involved. In contrast, standardized information flows rely on messages whose structure is predetermined by an official standards body (ISO/IEC, 2004; French, 1981).

Although Almotairi et al. (2011) came to the conclusion that, based on pressure from customers and the desire to reduce administrative tasks, actors should aim to force integration and standardization processes, the Swedish system is currently only in transition from the “disconnected” stage to the “internal integration” stage. This is astonishing, because the positive aspects of an integrated information exchange, such as increased accuracy of exchanged information, improved speed of information exchanges, reduced manual data entry effort, reduced costs for information exchanges, and the additional benefit achieved by standardized information exchange, namely the simple involvement of new communication partners (an interface specification does not have to be negotiated with every new partner), that were already mentioned many years ago by Scala and McGrath (1993), Carr (2004), Iskandar, Kurokawa and LeBlanc (2001), and Strader, Lin and Shaw (1998).

This specific point is considered in this investigation. As such, we analyze the container flow and the related information flow in the case of the port of Hamburg and its actors involved in hinterland transportation by rail to acquire insight into which junctures of the business processes of the considered actors the information flow is standardized and integrated (RQ 1).

Regarding the standardization of information flows, it has to be considered that a high level of management commitment is required to be successful. Furthermore, due to high initial capital expense, a high volume of unchanging information exchanges is needed to realize economic benefits from implementing standardized interfaces (Scala and McGrath, 1993; Stefansson, 2002). For this reason, this article questions why the information flow is standardized or integrated on particular junctures and not on other junctures (RQ 2). The described drivers and barriers, in combination with past research on the topic of standardization and integration (Scala and McGrath, 1993), allows for a first possible and worth to investigate proposition.

**Proposition 1:** Standardized communication interfaces in hinterland transportation by rail can always be found at a high number of unchanging information exchanges.

Furthermore, Angeles et al. (2001) show that, for international intermodal transport chains, a standardized information flow is of outstanding importance to connect various actors involved in the transport. For this reason, the following proposition is additionally investigated:

**Proposition 2:** Standardized communication interfaces can be found in hinterland transportation by rail especially in context with international operating actors.

An investigation of these propositions is followed by the persecution of the third research question, which requires an answer to the question on which junctures in the transport chain a standardized and integrated information flow can improve efficiency of how existing infrastructure is utilized.

## **DATA/METHODOLOGY**

Due to the objective of how information is exchanged between actors involved in hinterland transportation by rail and the possibilities of data triangulation connected to the research method of case studies, we conduct a case study (Yin, 2009).

There are three main reasons for using the port of Hamburg and its associated actors for an analysis of business processes and information flows: First, the port of Hamburg belongs to those ports that are historically based in urbanized areas. Therefore, its infrastructure is not expendable at will due to shortages in space. The consequence is that efficient infrastructure utilization is of outstanding importance, an aspect that can be achieved by seamless information flow. Second, due to its high handling rate, the port of Hamburg is an important location factor for German and European economies. Third, Elbert and Walter (2010) previously showed that information transfer is subject to the problem of bounded rationality in the context of hinterland transportation by rail. This has the consequence that information flows are not modified due to the uncertain rentability of such investments. Therefore, it is important to identify important junctures in the transport chain where a standardized and integrated information flow can improve the efficiency of how existing infrastructure is utilized, because actors like DSC, TO, RO, and RC acquire first insights about the rentability of investments in information flow standardization and integration efforts.

In addition, by the selection of the considered actors it is possible to gain insight into detailed business processes and information flows for the first time. In this respect, the present case study complies with the revelatory case by Yin (2009), and provides the reason for implementing an embedded single-case study.

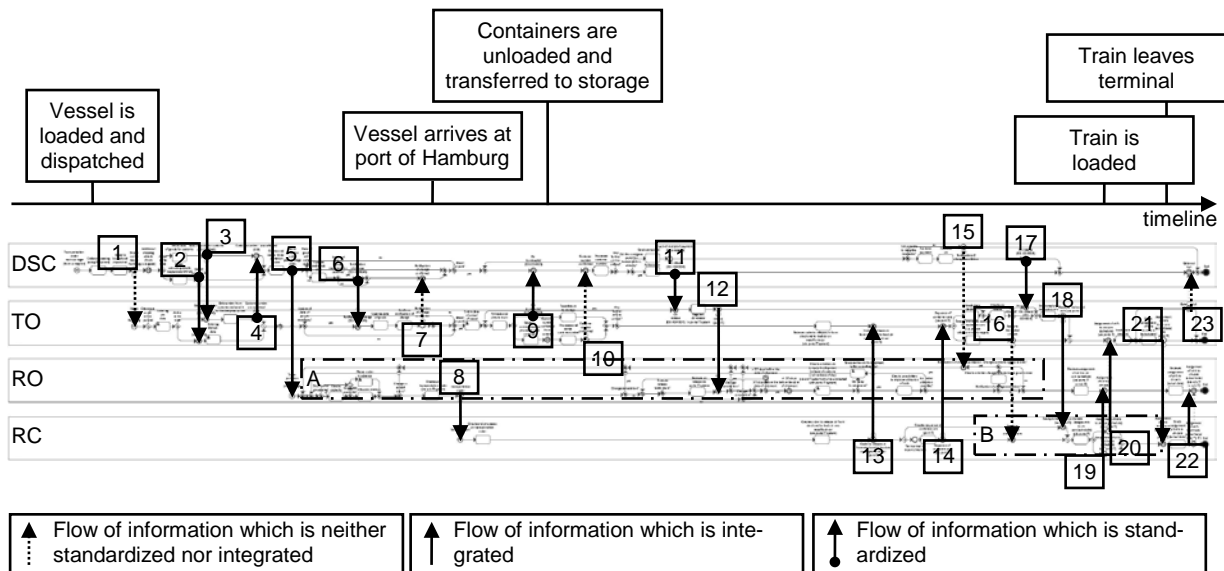
In order to limit the scope of our work this case study considers incoming container flows in carrier's haulage. The reasons for this limitation are, that especially in the case of incoming containers, high rates of rebooking exist (Jürgens et al., 2011) and that the carrier's haulage has a positive influence on the modal-split. Therefore, the share of railroad traffic in the context of the carrier's haulage is, in general, greater than in the merchant's haulage (Notteboom, 2008).

In order to provide an easy to understand overview on business processes and information flows and in order to represent activities, events and IT systems in context of their

surrounding elements the choice of the modeling principle was in favor of diagram-based models (modeling language: BPMN).

## RESULTS

**RQ 1: On which junctures of the business processes of the considered actors is the information flow standardized and integrated?**



| Arrow nr. | Description                              | Arrow nr. | Description                                      |
|-----------|--|-----------|--|
| 1)        | Vessel is on the way to Hamburg          | 13)       | Order to load ctr. on specific ctr. wagon        |
| 2)        | Details for unloading of vessel (BAPLIE) | 14)       | Sequence of ctr. wagons                          |
| 3)        | Data of goods for customs (CUSCAR)       | 15)       | Notification of change/cancelation               |
| 4)        | Customs number–unconfirmed               | 16)       | Ready-to-be-loaded ctr. wagons                   |
| 5)        | Commissioning–on-carriage                | 17)       | Ctr. release (COREOR)                            |
| 6)        | Notification of change (CUSCAR)          | 18)       | Ready-to-be-loaded ctrs. (containers)            |
| 7)        | Notification of change confirmed         | 19)       | Assignment of ctrs. to ctr. wagons (schedule)    |
| 8)        | Container (ctr.) transportation order    | 20)       | Assignment of ctrs. to ctr. wagons (schedule)    |
| 9)        | Ctr. is unloaded (COARRI)                | 21)       | Assignment of ctrs. to ctr. wagons (actual data) |
| 10)       | Customs number–confirmed                 | 22)       | Assignment of ctrs. to ctr. wagons (actual data) |
| 11)       | Ctr. release (COREOR)                    | 23)       | Gate out full                                    |
| 12)       | Ctr. release                             |           |  |

Figure 1–Overview of the modeled business processes and information flows

Figure 1 gives an overview of the modeled business processes of loading the vessel in the port of departure, the arrival of the vessel at the port of Hamburg, the unloading of the vessel, and the storage of containers through the TO, up to the point at which the loaded train leaves the terminal towards the hinterland.

The swimlanes typical for the BPMN are arranged below the timeline. Each actor (DSC, TO, RO, and RC) has its own swimlane. Within these swimlanes, the individual activities and

events were modeled on a detailed and actor-specific level. These activities and events are necessary for the process steps presented above the timeline.

During these activities and events, not less than 22 different messages are communicated, which can take place at 23 different times. These are indicated by the vertical arrows between the swimlanes. The difference between messages and the various times of communication is due to the release container message (COREOR). This is transmitted by the DSC typically shortly after the unloading of the container from the vessel or shortly before the train leaves the terminal (arrow no. 11 and 17).<sup>2</sup>

It is notable that, especially before the vessel arrives at the port of Hamburg, an active exchange of information between the DSC and TO via standardized interfaces occurs (arrows 2-4 and 6). In the hinterland, after unloading and transferring the container to storage, communication between the TO, RO, and RC is enhanced by integrated information flows (arrows 12-14 and 18-22). This means that 28.57% of information flows are neither integrated nor standardized and that 71.43% of information flows are standardized before the arrival of the vessel (arrows 1-7). After the arrival of vessels, only 13.33% of information flows are standardized, but 60% are integrated. The remaining 26.67% are neither standardized nor integrated. Therefore, it can be concluded that the degree of standardization of information flows before a vessel's arrival is much higher than after. Subsequently, the higher degree of integration is remarkable.

Considering the absolute frequency in the context of the analysis of standardized interfaces, it is striking that, in the considered case study, only the DSC and TO send messages using standardized interfaces, which represents about one-third (31.82%) of the total exchanged messages. With regard to the proportion of standardized messages that are exchanged between DSC and TO, this means that more than half (60%) of the messages are exchanged via standardized interfaces.

The TO, acting as a hub of information (17 of 22 messages or 77.27% are associated with this actor), sends the highest proportion of neither standardized nor integrated messages (44.44%). Incoming messages, which are neither standardized nor integrated, are carried out through this actor only in 12.5% of cases, which is, in proportion, the lowest value.

## **RQ 2: Why is the information flow standardized or integrated on particular junctures and not on other junctures?**

Based on the results of the junctures on which the flow of information is standardized and integrated, we now investigate why this is the case. The first proposition is:

**Proposition 1:** Standardized communication interfaces in hinterland transportation by rail can always be found at a high number of unchanging information exchanges.

This proposition is confirmed by the fact that, in the communication before the arrival of the vessel at the port of Hamburg, all messages are standardized, except for the piece of

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<sup>2</sup> For quantitative evaluation, only the last message (arrow no. 17) is taken into account for further analysis so as not to distort the evaluation. This decision was taken after consultation with the experts on super-user level of the actors, because late incoming container releases for further planning are particularly critical and, therefore, a more detailed analysis of the impact appears particularly worthwhile.

information that the vessel is on the way to the port of Hamburg (message 1) and the confirmation of a change (message 7). Once the vessel with containers has arrived at port, only the message that the container was unloaded (message 9) and the message of the container's release (message 17) are standardized. However, with the exception of messages 10, 15, 16, and 23, all remaining messages are integrated. Due to the relationship mentioned in the section title "Standardization and integration of information flow and their importance for hinterland transportation by rail", it is not unlikely that integrated interfaces will result in standardized interfaces, in future. Therefore, in summarization, it can be noted that, no link seems to exist between the quantity of unchanging message exchanges and standardization.

**Proposition 2:** Standardized communication interfaces can be found in hinterland transportation by rail especially in context with international operating actors.

Although nowadays none of the actors considered in this case study exclusively operates on national markets only (De Souza, Beresford and Pettit, 2003; Debie and Gouvernal, 2006), the business model of the DSC is primarily aligned to international transports. Although rail-related actors (RO and RC) also operate in other countries, their degrees of internationalization are far less pronounced, not at least due to the different regulatory systems and technologies in foreign countries (Ghijsen, Semeijn and Van der Linden, 2007).

Along with the high degree of the DSC's internationalization comes the high degree of internationalization of the TO. This is because the DSC connects many ports worldwide and because vessels from various countries (various DSCs) arrive and leave terminals. Due to these facts, it seems that the identified positive characteristics of standardization have a particularly strong influence and eliminate the negative characteristics. This can be concluded from both the share of standardized interfaces between the DSC and the TO (60%) and the existing committees that provide international EDI standards for communications between DSCs and TOs (for example see UNECE, 2000).

For actors with a lower degree of internationalization—namely the RO and RC—standardization of information flows seems to have a lower importance because there is only one standardized message in their communications.

### **RQ 3: Which junctures in the transport chain have potential for improving efficiency of utilization of existing infrastructure through a standardized and integrated flow of information?**

To identify potential ways to improve how existing infrastructure is utilized, the methods applied in the context of business process management can be used. As Hunt (1996) shows, business processes can be accomplished more efficiently by avoiding repeated execution of the same activities. Such activities are shown as loops within BPMN diagrams.

As rectangle A in Figure 1 illustrates, the largest loop is located on the RO's side. Most activities of the RO are carried out within this loop. The reasons for this loop are twofold, according to expert interviews of super-users from DSC and RO.

First, there is a problem at the time of the RO's commissioning. This problem exists because the DSC places container transportation orders without having transfer orders present for the corresponding relations in the hinterland. The DSC uses this reservation strategy in order to have enough hinterland transportation capacities. This is especially important for the DSC in



economically tough times, when rail-transport capacity is scarce. The consideration of these reservations in the RO's transportation planning causes unnecessary effort and avoidable costs, especially since some activities are manually performed. In terms of how existing infrastructure is utilized in the hinterland, this aspect is particularly evident when cancellations arrive at the RO too late. Such cancellations make it impossible for the RO to dispose other containers for the respective relation, so that transport capacity remains unused.

Another problem, which leads to unused capacities for the RO are unreliable or incomplete orders that the DSC sends to the RO at the time of commissioning (message 5). This requires that numerous correction loops must be passed through the RO during the planning process. Interviews have shown that these corrections represent the regular rather than the special case. Therefore, about ten correction loops are necessary per order. Particularly noteworthy is that notification of changes/cancellations is neither standardized nor integrated (message 15), excluding automated information processing.

In addition to the reservations, this fact leads, especially in short-term adjustments of hinterland destinations and changes in the scheduling of individual containers, to an information processing that is too slow. The result—that no other container can be scheduled properly in time for the relation that is affected by the change—causes some container wagons to have to leave the terminal without containers. In this respect, the standardization and integration of message 15 could help automate the disposition of single containers to relations. Thus, shorter processing times, which improve the efficiency of how existing infrastructure is utilized and lower costs for the RO, can be realized.

Rectangle B in Figure 1 highlights the messages and activities that follow the message of the sequence of container wagons (message 14). In this message, the RC informs the TO about the sequence of container wagons in the terminal, which is important for subsequent loading of containers. Subsequently to this message the ready-to-be-loaded container wagons (message 16) are declared by TO. This message, which is neither standardized nor integrated contains essentially all container wagons that are ready-to-be-loaded after checking their quality. One reason why container wagons are not identified as ready-to-be-loaded is that they are damaged. Based on the ready-to-be-loaded container wagons, the assignment of containers to container wagons (schedule) is made. This process is also very critical in terms of time, because loading can be done only by the TO, after the assignment of container to container wagons is scheduled. The belated communication of the assignment of containers to container wagons (schedule) is one reason why individual containers no longer reach trains, essentially because the TO has insufficient time to get all scheduled containers from storage and load them on the train. In this context, a standardization and integration of message 16 could promote an automated creation of assignment of containers to container wagons and, as a consequence, save time that could be used for loading containers on the train. Also, this standardization and integration aspect could be used for improving how existing infrastructure is utilized.

## **CONCLUSIONS**

Based on the determination of the relevance of a seamless flow of information for an efficient and effective utilization of infrastructure in hinterland transportation by rail, the objective of this investigation was to determine how information in the hinterland between the actors

DSC, TO, RO, and RC are exchanged. Due to the few investigations existing in this field of research, focus was placed on the standardization and integration of information flows. To achieve the objective, three interrelated research questions were answered by an embedded single-case study at the port of Hamburg. This allowed us to combine different sources of data within diagram-based business process modeling (modeling language: BPMN). With respect to the first research question, subsequent analysis of the BPMN diagram demonstrated that, before the arrival of the vessel at the port of Hamburg, standardized information flows occur 71.43% of the time. Thereafter, only 13.33% of information flows are standardized, but more than half of the interfaces are integrated (60%). It was also found that only the DSC and the TO send standardized messages, with the consequence that more than half of the messages between these two actors (60%) are standardized. However, only about every third message in the considered transport chain is standardized (31.82%). RQ 2 was answered by a proposition-based investigation. It was found that the quantity of unchanged information exchanges alone is not a reason for standardized interfaces. However, the proposition that standardized communication interfaces can be found especially in context of international operating actors was confirmed. To answer RQ 3, it was shown which junctures in the transport chain have potential for improving efficiency of how existing infrastructure is utilized through a standardized and integrated flow of information. This is especially the case when the DSC notifies the RO of short-term changes of order data. It can be assumed that a standardized and integrated information flow increases the possibilities of automated container disposition for the RO. In case of cancelations of single containers for a given transport relation by the DSC this would allow the RO to quickly schedule other containers providing clear evidence that the existing infrastructure can be used more efficiently. The same applies to the so far neither standardized nor integrated message of “ready-to-be-loaded container wagons” that can inhibit subsequent information flows, which, at the critical time of container loading, can cause containers to be unable to be loaded in a timely manner. This link can also cause the available infrastructure to not be used efficiently and effectively. Because of the recognized link between standardized and integrated information and efficiency in our investigation, two cost reduction potentials exist for the considered actors, in particular, that could be incentives for more coordination of interfaces: the available capacity can be used more efficiently and effectively and the quantity of manual activities can be reduced for involved actors. Furthermore, our results enlarge the scope for government action in these times of increasing vessel capacity. Obviously, it is possible for government to improve the efficiency of how existing infrastructure is utilized by fostering standardization of information flow. This additional alternative will be of great importance if, due to shortages of space in some urbanized port areas, ports and their connecting infrastructure are not permitted to expand.

Further research could examine whether our results are transferable to other ports and how governance structures should be designed to enable individual actors to achieve an integrated and standardized information flow. Moreover, the intrinsic motivation of the actors involved in hinterland transportation by rail to further design information flows could be examined. This would give insight into whether further standardization is driven primarily by the actors or whether incentive systems must be externally created (e.g. by the government).

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