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Operational Coordination in Intermodal Hinterland Transport as Support for Managing Operational Disruptions – An Information Processing Perspective

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ABSTRACT

Intermodal solutions, compared to the use of only road, in port hinterland transport involve numerous actors and activities that increase operational uncertainty. The purpose of this paper is to investigate the role of information, through an information processing perspective, for operational coordination in supporting operational disruption management in intermodal hinterland transport. A qualitative case study approach is adopted to obtain an in-depth understanding of operational coordination in a hinterland transport system. The results provide insights into how the actors use information processing for coordination to influence the mitigation of the impact from operational disruptions. The paper supports managers in improving disruption management by understand the processing of real-time information in the coordination for intermodal hinterland transport solutions. This paper provides input for operational disruptions using information for coordination on a day-to-day basis via an information processing perspective in contrast to the predominant coordination at a strategic level in the literature.

Keywords: *hinterland transport, operational coordination, disruption management, information processing perspective.*

1. INTRODUCTION

The road sector accounts for more than 75 % of the volumes transported to and from the hinterland (Eurostat, 2020). Due to the congested roads and inadequate rail connections, for many ports the weakest link in their transport chain is their hinterland access, causing delays and increasing the hinterland transport costs, which represents about 60% of the total transport costs (Behdani *et al.*, 2020). Therefore, functional port hinterland access is crucial for the efficiency of the whole intermodal transport chain (Roso *et al.*, 2009; Jeevan and Roso, 2019). In addition, road transport is mainly dependent on fossil fuels, which heavily contributes to the transport sector's greenhouse gas emissions (European Commission, 2017). A potential solution to lower the transport sector's emissions would be to shift freight transport from road to energy-efficient and high-capacity transport modes with lower environmental impacts, such as rail, inland waterways, and sea (European Commission, 2011; Roso, 2020). Intermodal solutions, which use more than one transport mode during the logistics activities and therefore support an increase in the use of modes other than road, have been extensively studied in the logistics literature from various perspectives (e.g., (Haralambides and Gujar, 2011; Bask *et al.*, 2014; Wiegmans *et al.*, 2020; Tadić *et al.*, 2019; Witte *et al.*, 2020)). Related to hinterland, as a part of an intermodal transport chain, dry ports as inland intermodal terminals enable lower environmental impact with a rail connection to the port, offering different logistics service and acting as the port's interface inland (Roso *et al.*, 2009; Khaslavskaya and Roso, 2020).

Intermodal transport includes various activities managed by numerous actors in the transport system (Monios and Bergqvist, 2015), resulting in an increased need for coordination. Coordination has been advanced as a way to increase efficiency in hinterland transport (van der Horst and De Langen, 2008), for example, through contractual arrangements between actors (Monios and Bergqvist, 2015). Gumuskaya *et al.* (2020) pointed towards a gap in hinterland transport literature regarding coordination at the operational level to impact the shift from road to intermodal hinterland transport. Operational coordination includes use of information as a coordination mechanism (de Langen and Douma, 2010; Gumuskaya *et al.*, 2020), which in turn, is an important part for a decision support systems (Wang and Yeh, 2014). Recent studies call for research on the mechanisms behind information sharing (Wiegmans *et al.*, 2018) and on coordination between multiple actors in hinterland transport (Hu *et al.*, 2019). To address the information aspect of operational coordination, this paper takes an information processing perspective by applying the Organisational Information Processing Theory (OIPT) (Galbraith, 1973; Galbraith, 1977).

Intermodal hinterland transport involves numerous actors and activities and as such has a high sensitivity for disruption (Fahimnia *et al.*, 2018), that is, deviations from the plan (Yu and Qi, 2014). Therefore, the management of disruptions in these logistics solutions plays a crucial role, even to the whole supply chain (Albertzeth *et al.*, 2020). The management of operational disruptions, e.g. congestion (Tang, 2006) or damaged freight at intermodal transhipment (Hudnurkar *et al.*, 2017), requires information for improved decisions (Meyer *et al.*, 2014; Hrušovský *et al.*, 2020). This information is important for both hinterland transport in connection with port activities (Li *et al.*, 2018) and the rail link of hinterland transport (Elbert and Walter, 2014). This is also related to coordination in hinterland transport, which, however, has been studied from a strategic and static perspective without considering how operational coordination sets conditions for information that could support the disruption management.

Therefore, the purpose of this paper is to investigate the role of information, through an information processing perspective, for operational coordination in supporting operational disruption management in intermodal hinterland transport.

2. COORDINATION OF HINTERLAND TRANSPORT

This section provides a review of relevant literature related to coordination in hinterland transport.

In hinterland transport research on coordination the perspective has been focussed in particular on coordination between organisations for strategic planning, as highlighted by Gumuskaya *et al.* (2020). To analyse coordination in hinterland transport, van der Horst and De Langen (2008) took an organisational perspective to come up with actions for enhanced coordination at a strategic level, e.g., incentive alignment, alliances between hinterland companies, and vertical integration of actors. Continuing with the same approach, van der Horst and van der Lugt (2011) investigated coordination mechanisms around the port from a transaction cost economics perspective. The authors looked at the mechanisms by following three problems related to coordination: lack of investments, under-utilisation of assets, and lack of operational coordination. Franc and Van der Horst (2010) studied coordination from the perspectives of transaction cost economics and resource-based view regarding arrangements of contracts with risk-bearing commitment, minority share investment, and subsidiaries for shipping lines and terminal operator companies to achieve integrated hinterland services. In line with these strategic approaches, Monios and Bergqvist (2015) examined the contractual aspects of shifting mode from road to intermodal hinterland transport. Similarly, van der Horst *et al.* (2019) investigated coordination via contractual relations for hinterland barge transport.

van der Horst and De Langen (2008) identified a need to conduct research on coordination in hinterland transport chains, and they also acknowledged the importance and need for operational coordination. Nevertheless, they did not focus on the operational aspects, instead, they focused on contractual relationships between the actors in the hinterland transport chain. Similarly, de Langen and Douma (2010) noted poor alignment of activities in different parts of the hinterland transport as a coordination problem, and they pointed towards usage of ICT, when this solution was in line with the different business models of the involved actors. van der Horst and van der Lugt (2011) found ICT mainly used in coordination to support what they denote as lack of operational coordination. Gumuskaya *et al.* (2020) claimed that academic research about coordination generally has a strategic perspective and does not include implementation at an operational level. Previously used frameworks based on transaction cost economics have been relevant in the analysis of contractual relationships between actors and willingness towards coordination in a hinterland transport chains, but these frameworks are not useful to analyse operational issues characterised by a dynamic environment, that is, to address what Gumuskaya *et al.* (2020) refer to as the actual coordination. The actual coordination is described as capturing the dynamic decisions made in the different planning processes in hinterland transport. Gumuskaya *et al.* (2020) highlight the importance of this aspect of coordination to support the dynamic nature of operational decisions such as those involved in addressing operational disruption. Considering the operational coordination of activities in hinterland transport, Gumuskaya *et al.* (2020) developed a three-layer framework in a hierarchical order: contracting processes, planning processes, and physical processes. The higher levels govern the lower, and the lower levels generate feedback for the higher levels. Considering the contribution to the hinterland literature made with the framework proposed by Gumuskaya *et al.* (2020), there is still a need for further extensions of their developed levels of planning processes and physical processes to manage the dynamic hinterland activities.

3. ORGANISATIONAL INFORMATION PROCESSING THEORY PERSPECTIVE ON COORDINATION

This section introduces the concept of coordination and the Organisational Information Processing Theory (OIPT) (Galbraith, 1973; Galbraith, 1977). It will be used to analyse the use of information to coordinate at an operational level.

The most common reason for need of coordination between organisations is *activity interdependence* (Thompson, 1967; Van De Ven *et al.*, 1976). Malone and Crowston (1994) define coordination as managing dependencies between activities. This is based on the fact that coordination is only necessary as long as activities (and included tasks) interact with each other. If no interdependencies exist, there is nothing to coordinate. Interdependencies can be categorised as follows (see the work of Thompson (1967)). Sequential interdependency arises when some activities cannot be started until others have been completed because output from one activity is input to the next. Pooled interdependency is the sharing or producing of a common resource. To adapt this resource to either activity A or B can have consequences for the other activity. They are indirectly dependent on each other, thereby creating a need for resource allocation or prioritisation of activities. Reciprocal interdependence occurs when each activity requires input from, and must change simultaneously with, other activities.

In order to manage different interdependencies, many different coordination mechanisms have been proposed, such as plan and rules (c.f. Thompson (1967); Sahin and Robinson (2002); Romano (2003)). Galbraith (1977) starts with these coordination mechanisms and acknowledges that they work well to coordinate interdependencies when uncertainty is low. Galbraith (1977) takes an information processing perspective and adds the consideration of information processed by an organisation and the required information for a task. The theory origin from thought in contingency theory and addresses the increase of uncertainty of tasks but highlights the information processing during task execution (Galbraith, 1973). The information processing perspective originated from a focus on internal organisational processes, but it has been extended to interorganisational supply chain settings (Hult *et al.*, 2004; Bode *et al.*, 2011). OIPT has been adopted in supply chain research with a main focus on information processing capacity as information integration between actors in a supply chain (Wong *et al.*, 2015), as well as supply chain analytics and supply uncertainty (Zhu *et al.*, 2018). Bode *et al.* (2011) investigated supply chain disruptions and how and why companies respond using both information processing and resource dependence perspectives. The information processing perspective has also been applied to collaboration in container shipping from a shipping company perspective (Lai *et al.*, 2020). Few of these articles have managed to capture the part of processing information related to a decrease of needed information. Bode *et al.* (2011) captured the creation of slack resources with their buffering role in supply chain disruptions, but they made no clear connections to the other mechanisms for this information strategy, as shown in **Figure 1**. Despite the multiple-actor setting in hinterland transport (Monios and Bergqvist, 2015) and the importance of information in managing disruptions (Li *et al.*, 2018; Wiegmans *et al.*, 2018), to the best of our knowledge, there are no articles that apply an information processing perspective to the hinterland setting. Additionally, the evidenced slow digitalisation of intermodal transport (Altuntaş Vural *et al.*, 2020) demonstrates the need for the information processing perspective used in this paper.

The OIPT highlights the fit between processed and required infomration when uncertainty increases. Galbraith defines uncertainty as “the difference between the amount of information required to perform the task and the amount of information already possessed by the organization” (Galbraith, 1973, p. 5). OIPT holds that when uncertainty increases beyond a certain point, the organisation will be overloaded by information that needs to be processed, as the fit between required and processed information is not sufficient. In these cases, possible solutions include decreasing the amount of information to be processed or increasing information processing capacity (Galbraith, 1977), as illustrated in **Figure 1**. To address the operational coordination gap in intermodal hinterland transport literature (c.f. Gumuskaya *et al.* (2020), this paper focus on the informational aspect of OIPT, highlighted in red in **Figure 1**.

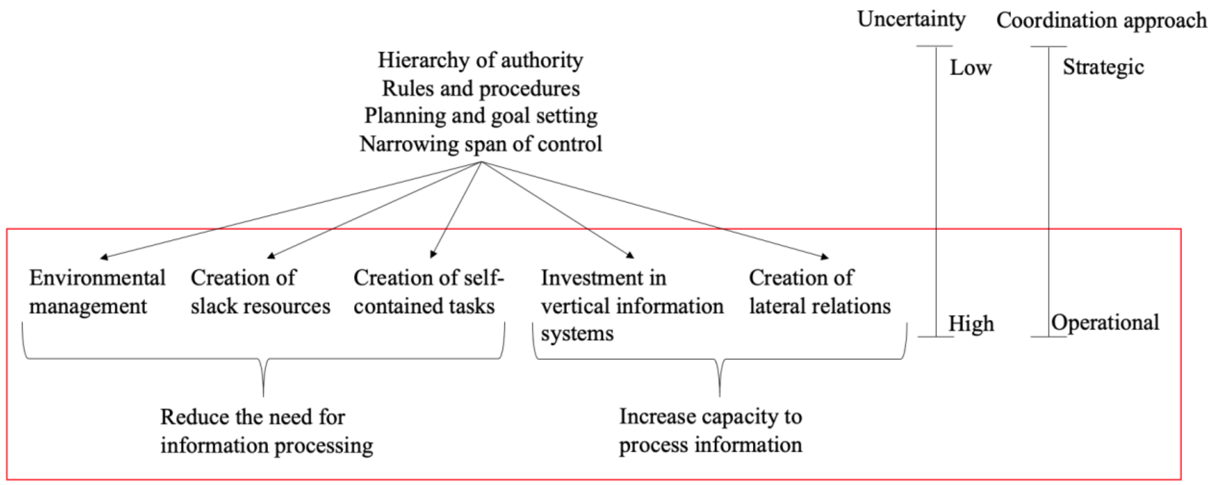

Figure 1 Overview on the information processing focus in this paper. Adopted from Galbraith (1977).

The informational aspect of coordination at the operational level increases the ability to frequently re-plan (Galbraith, 1977), in this paper referred to as decisions taken in operational disruption management (Yu and Qi, 2014). The information generated from the operational coordination can support operational disruption management via early detection and initiation (Sheffi, 2015; Wide, 2020). The OIPT proposes that the options, from an information processing perspective of coordination when uncertainty increases, are to either reduce the need for information processing or to increase the information processing capacity (Galbraith, 1973; Galbraith, 1977; Haussmann *et al.*, 2012). Galbraith (1973) expressed that if no active choice is made between these strategies, reduced performance through creation of slack resources will happen automatically. Moreover, it is not only an increase in processing capacity that is of importance, but also the fit between the capacity and information need (Tushman and Nadler, 1978; Galbraith, 1977). These two information processing approaches, suggested by Galbraith (1977) when uncertainty increases, are relevant in a setting of multiple actors and high uncertainty such as intermodal hinterland transport.

The one side for information processing part of the theory, the increase in information processing capacity (see **Figure 1**) includes investments in IT systems and creation of lateral relations (e.g., direct contact between people, forming of teams and new organisational roles). Both IT systems and lateral relations involve communicating and providing information to other involved actors but differ in the aspects of how the communication is facilitated. The IT systems concerns frequency of information flows, information scope and for decision makers to make sense out of the information to select a course of action (Galbraith, 1973). The lateral relations concerns making decisions where the information exists, by utilising direct contact, teams or integrative roles to take decisions (Galbraith, 1973). Higher uncertainty (in this paper, operational disruptions) induces the need for more frequent and timely updates of a plan, that is, more frequent and timely disruption management. Therefore, Galbraith (1977) argued that when uncertainty and exceptions increase, there will be a need for increased information processing capacity in terms of providing the decision maker with information about relevant factors. Information and communication technology (ICT) development is important for the management of operational disruptions in freight transport chains (Meyer *et al.*, 2014). The hinterland transport coordination literature has focused on information for the original plan, and the importance of ICT in coordination has been acknowledge. Li *et al.* (2018) focused on information regarding truck arrivals and port operations when disruptions occur in the hinterland transport that cause changes in the scheduled arrival times in the truck appointment system of a port. The mechanism of lateral relations employs lateral decision processes, that is, taking decisions where the information exists rather than providing information to a central decision maker. As Galbraith (1977) discussed OIPT from an organisational perspective, lateral relations exist across lines of authority within an organisation, which is in this paper is converted to be relations among actors in the hinterland transport chain. The lateral relations are intended to increase information processing capacity for decisions to be made on an as-needed basis, compared to those made in advance through previous coordination mechanisms, for example, plans and rules.

On the other side for information part of the theory, the reduction in the need for information processing (see **Figure 1**) is facilitated by environmental management, slack resources, and self-contained tasks (Galbraith, 1977). Notably, the mechanism of environmental management was not included in the first presentation of the theory (Galbraith, 1973) but added to developed version(Galbraith, 1977). These mechanisms aim to reduce the need for information when operations are executed. Environmental management revolves around changing or influencing not the organisation, but its environment, in order to reduce uncertainty. In the case of a hinterland transport chain, this is translated into changing the environment of the hinterland transport chain. Self-contained tasks are tasks not dependent on information from other actors, tasks, or resources. This includes making sure that all necessary resources and skills are available for a task and not having to share resources between units, for example, having the same resource for preparation both rail and road containers at a port. Slack resources provide excessive resources, such as buffers in scheduled time and/or resources that decouples the urgency of the interdependencies and therefore the urgency of the need for coordination. Galbraith (1977) expressed this as reducing the number of occurred disruptions by reducing the level of performance. In logistics, overcapacity has been viewed as a way to manage disruptions, which, in turn, generates longer logistics chains (Christopher and Lee, 2004). Christopher and Holweg (2017) highlighted that information is important for managing disruptions without buffers in cases where signals for a disruption can be found in the information. In this way, information can support both efficiency targets by lower buffers and disruption management targets of avoiding impacts.

Research on coordination in hinterland transport has mainly had a strategic focus, with scarce input to coordination made at the operational level. The operational coordination could provide insights to capture the dynamic hinterland activities and be connected to the dynamic re-plan of hinterland operations. For this purpose, the paper draws from OIPT including five proposed coordination mechanisms for operational coordination when uncertainty is high. The mechanisms either reduce the need for information processing or increase the information processing.

4. METHODOLOGY

A case study was adopted to capture the phenomenon of coordination for operations in a hinterland transport system. The case revolves around a material flow in containers originating from Asia via the Port of Gothenburg in Sweden to the shipper's central warehouse. The case fulfils the prerequisites of intermodal hinterland transport to study operational coordination of interdependencies by covering multiple actors involved in various operations of the freight between different modes. As previous research on this phenomenon is scarce, qualitative data collection was chosen to provide in-depth data (Flick, 2014; Ellram, 1996). The empirical data for this paper was collected at different companies involved in a hinterland transport, including intermodal transport and dry port setup. The case held the possibility of an in-depth study for the management of uncertainty in this hinterland setting. The qualitative data collection method of semi-structured interviews was chosen and included questions covering operational coordination while allowing opportunity for the interviewees to elaborate on their answers (Flick, 2014). The semi-structured interviews followed a guideline adapted to the used theory, where one part included a focus on the material flow, and the other part focused on the information shared between actors regarding material flows, resources availability, and operational disruptions.

The transport manager at the shipper was interviewed first to get an overview of the case. After this interview, the other involved actors in the hinterland transport system were mapped and interviewed as shown in **Table 1**. Thereafter, the transport manager at the shipper a follow-up interview was done to gain more insights into the disruption management. The selection process for the interviews was guided by both purposive selection (Maxwell, 2013) and snowballing selection (Bryman and Bell, 2011), where some interviewees were chosen based on their known expertise in the system and others through recommendations from other interviewees. The shipper, IT developer, freight forwarder, and port operator served the study with key information, and interviews were done with other actors to obtain a complete understanding of the case. All interviews, expect the first interview with the transport manager at the shipper that was done at the company, were performed via online meetings in the program Teams due to Covid-19 situation.

Table 1 Summary of performed semi-structured interviews.

Interview order	Role in hinterland chain (position)	Input to study
1	Shipper & dry port owner (transport manager)	Key informant
2	IT provider for dry port (CEO)	Key informant
3	Freight forwarder (sales manager)	Overview informant
4	Port authority (sales manager)	Overview informant
5	Freight forwarder (operative planner)	Key informant
6	Municipality for dry port (project leader)	Overview/background informant
7	Port operator (sales manager rail)	Overview informant
8	Port operator (operative planner)	Key informant
9	Follow up with shipper & dry port owner (transport manager)	Key informant

The gathered data was analysed regarding the coordination done in the operations performed in the studied hinterland transport system. To obtain an overview, the coordination at the studied hinterland transport chain was analysed through the interdependencies and connected coordination mechanisms discussed in the OIPT section. Thereafter, to understand the information connected to the operational coordination, the coordination was analysed through an OIPT lens of mechanisms to increase information processing capacity or decrease need of information. Additionally, from this perspective it was possible to gain an understanding of how the existing coordination mechanisms provide information that supports or does not support disruption management.

During the study, different strategies were applied to ensure research quality (Halldórsson and Aastrup, 2003). The interviews were recorded and transcribed to ensure that no information was lost and that the researchers could retrieve the data to assure the precision of the interpretations. All interviews were attended by at least two of the authors, which provided support in keeping to relevant questions and allowed varying viewpoints in the analysis whether or not the collected data diverged. If the views diverged or something was unclear, emails were used to follow up with the interviewees. During data collection, some of the actors initially planned for the interviews could not be interviewed. Interviews were not conducted with the dry port operator, rail operator, or road transport operator (between dry port and shipper) due to constraints from these actors. Nevertheless, the interviewed actors were able to provide input regarding their operations and coordination with the other actors. For example, the shipper is also the dry port owner and had good knowledge about the dry port operations. Additionally, the municipality was the previous owner of the dry port and also compensated for some of the input lacking from the missing actors.

5. FINDINGS

This section includes a description of the studied hinterland transport chain followed by an analysis of the operational coordination from the OIPT perspective.

The containers are mainly Full Container Load (FCL) and transported via train from the port to a dry port located between the port and the central warehouse, as illustrated in **Figure 2**. At the dry port, the containers are relocated, stored, and transported via road to the central warehouse. The central warehouse has around two weeks of demand covered for the shipper in this flow.

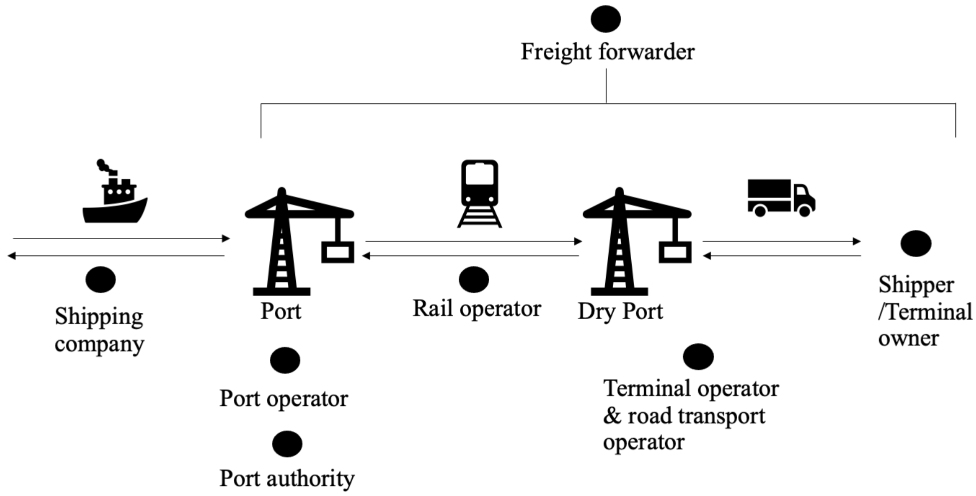

Figure 2 Overview of studied hinterland intermodal transport system.

The containers are either imported freight arriving at the port of Gothenburg from overseas or freight delivered to the port for export to overseas destinations. When the ship arrives at the port, an unloading plan is made by the port operator in the port IT system. The plan indicates when the containers will be unloaded for the yard and rail planning groups at the port operator. The yard plan indicates where the container should be placed in the port yard. When the container is booked for a train, it is planned to be moved from the yard to the rail terminal within the port.

The timeslots on the main rail for the trains serving the port are determined once a year by the Swedish transport administration. Additional timeslots for the trains are possible to obtain, but they require an additional request process. The freight forwarder books containers for the trains through the port's IT system and the trains have maximum capacity of 86 TEUs and are loaded/unloaded by cranes at the port rail terminal. When a train has left the port, the freight forwarder and the shipper can see in the port IT system which containers have been loaded on the train so that they can plan upcoming operations in the transport chain. After the train has left the port, the rail shift operator is responsible for transport from the port to the main rail tracks. Another rail shift operator has the same responsibility between the main rail tracks and the dry port. When the train leaves the port, the port operator sends a confirmation email to the freight forwarder, the dry port owner, and the rail shift operator (outside the port). The freight forwarder, in turn, provides an online document to the dry port operator and shipper regarding the containers loaded on the train. Additional information is given to the dry port operator by the freight forwarder regarding the time the containers should be delivered to the shipper and the time/date when the container should be back at the port.

After arrival at the dry port, the containers are unloaded from the train and placed in a yard by the terminal operator. Operations at the dry port trigger status events in an IT system to keep track of the progress of the containers, for example, unloaded from the train, stored in a certain place, or loaded onto a truck. The status events are logged in the system when the dry port operator performs an operation such as placing a container in the yard. The information from the system is accessed by the freight forwarder, dry port operator, and dry port owner to follow the progress of the containers. Thereafter, the distribution to the shipper is done via road by the road transport operator. In this case, the terminal operator and the road transport operator are the same company. The shipper ships around 10 000 TEUs/year via the rail hinterland setup and their freight is delivered to their central warehouse. Empty containers are either transported back via the same route to the port of Gothenburg or are transferred to an exporter at the dry port, who uses the empty containers for export freight. The containers filled with export freight are transported back to the port using the same route through the dry port as the import freight.

6. ANALYSIS OF OPERATIONAL COORDINATION FROM THE OIPT PERSPECTIVE

The studied hinterland transport chain is based on a series of sequentially interdependent activities, for example, the ship must arrive at the port before the containers can be unloaded and thereafter loaded onto the train for further transport. These interdependencies are mainly managed by plans, as suggested by Galbraith (1977), who based this on the work of Thompson (1967). Additionally, the pooled interdependencies for resources used in the hinterland transport chain were mainly managed by rules, which is in line with proposed strategies (Galbraith, 1977; Thompson, 1967). Examples of pooled resources in the studied hinterland transport chain are train tracks and loading/unloading equipment at port and dry port. The different interdependencies generate a need for coordination that from an information perspective can support disruption management at the operational level. For the coordination to support re-planning decisions when uncertainty increases and the rules and plans are not sufficient enough to avoid information overload, the information processing perspective is used. Therefore, the next section presents the analysis of coordination via information processing by increasing the capacity of information processing or decreasing the need for information processing.

6.1 Increasing the Capacity of Information Processing

Both the mechanisms of IT systems and lateral relations were used to increase the capacity for information processing when disruptions occurred. IT systems supported some of the information flows, but relations had to be created in the hinterland transport system to increase information processing capacity.

6.1.1 Increased Information Processing via IT Systems

The port IT system provides the port operator, freight forwarder, and shipper with a view of the progress of operations at the port. In a similar way, the IT system used for the dry port operations informs the dry port owner and shipper about the currents status of operations. The current status has to be compared to the planned status to know that a disruption has occurred, and this can delay the time at which the shipper or freight forwarder is informed about a disruption. This timepoint is crucial for quick and cost-efficient management of disruptions (Sheffi, 2015; Wide, 2020). The online documents used by the freight forwarder regarding what containers are transported by the train can be updated with new information to inform other actors about a disruption. The updated information in the online documents provides possibilities to compare current status of operations to planned status. These IT systems support detection when something is not going as planned for the actors performing the operations, such as the port operator and dry port operator. These actors are able to provide this information to other actors through the IT system, supporting coordination between their operations.

Nevertheless, for certain parts of the studied hinterland transport system, the current IT systems do not provide the needed information for task coordination as not enough information processing capacity is available. For example, if the dry port experiences a disruption, the freight forwarder and dry port owner can get information about delayed operations through the system, but the port operator is only informed about containers on the train when reported by the freight forwarder to their system. Therefore, if the train is delayed due to issues at the dry port, the port will not receive this update via their system. Additionally, possibilities were found to increase information processing capacity by investments in and adaptations of IT systems. As the software developer stated:

"It [the IT system] could have said exactly where it [the container] is positioned at the customer but they do not use it. The system could include now it is on the ship, now it has arrived at the port, now it is pre-worked at the port, now it is on the train, but it only shows when it is on the train and what position".

6.1.2 Increased Information Processing via Lateral Relations

Where the IT systems are not generating enough capacity to process information in the studied hinterland transport system, the lateral relations can address this issue. When a disruption occurs and the plans and rules are not sufficient to process information, lateral relation can be established. In these circumstances, the lateral relations occur when actors have to provide information to other actors in the hinterland transport who are not within their sphere of their day-to-day work (if the operations run as planned). These relations are mainly supported via emails and phone calls. A good example of this process is when disruptions occur in the operation of the dry port or road operations. Even though the freight forwarder is responsible to the shipper to deliver, the road transport operator does not provide any information about their operations to the freight forwarder if a container is delivered. First when a disruption occurs and increased information processing is needed, the road transport operator or dry port operator initiate contact with the freight forwarder. The freight forwarder found the dry port operator and the road transport operator were good at providing direct information when something occurred, in other words, they were good at increasing information processing. As the operative planner at the freight forwarder expressed it:

"Regarding disruptions, they are quite proactive, they inform quite quickly".

Additionally, some cases were found in which the ordinary information flow could provide support in case of a disruption, for example, if containers that were booked on the train are, for some reason, not loaded on the train, a notification is emailed from the port operator to the freight forwarder, the dry port operator, and the dry port owner. Another example of a lateral relation is the one that occurred between shipper and dry port operator when changes in demand compared to plan were present. In these cases, the shipper directly contacted the dry port operator to discuss increase of operation capacity. Interestingly, it was expressed that both phone and emails were used. Phone for quick communication, followed up by email as to what had been agreed upon.

Other parts of the transport chain were found less able to increase information processing when a disruption occurred. One important aspect of lateral relations is that the frames for decision making in the coordination is not as evident to the actors compared to coordination settings in which the operations run as planned. In this way, the point of providing decisions where the information is made available via lateral relations is lost, as the available information is different from case to case for the same disruption, and therefore it sometimes fails to reach the decision maker in a timely way. For example, a late arriving train at the port can be detected by the port operator through different ways. The port operator can receive information from the rail operator, the rail shift operator, the freight forwarder, or the dry port owner. There is also a webpage where information regarding the trains from the rail authority can be accessed and is used by the port operator to manually track the status of a train. When a train is late, the port operator is, in some cases, able to inform the rail shift operator so that they are aware that the late train needs fast handling once it arrives outside the port. This lack of understanding by the involved actors about who to inform (who needs information to make different decisions) limits the lateral relations to achieve increased information processing, mainly since the lateral relations involve few of the affected actors in certain parts of the hinterland chain. As an example, if a locomotive breaks down, the rail operator takes the lead in informing the others, but knowledge of how the information should reach each affected (unknown) actors is lacking. This, in turn, leads to the possibility that not all the actors are informed, even though the disruption will impact the operations for which they are responsible. The interview with the operative planner at the freight forwarder indicates that information is often provided by the port operator when a train arrives late, providing them with fewer possibilities to coordinate the sequential interdependencies in their plan of sequentially interdependent loading operations than if the information came directly from the rail operator. The late coordination provides re-plans after an impact has occurred (late train to port) rather than before the train arrives late to the port.

6.2 Decreasing the Need for Information Processing

In this case study, the use of slack resources was found to be the main mechanism in reducing the need for information when disruptions occur.

6.2.1 Decreased Need for Information Processing via Slack Resources

The case study shows how slack resources, buffers, are commonly used to decrease the need for information in the hinterland transport. The buffers were represented in forms of time buffers and resource buffers (i.e., personnel and equipment).

As the timeslot for a train at the port is longer than the handling time, the time buffer can be used to avoid disruption, even when a train is late. As the port operator interviewee expressed it:

"We [port operator] have our timeslots so that we have some margin, they are around three to four hours, so, often

if the train is one or two hours late, we can catch up [any delay]".

Another time buffer is the booking of containers on trains. The freight forwarder books the containers on a train when the shipper confirms the booking of containers at the port, adding extra time before train transport can be done. The port authority interviewee pointed towards a large risk in not having the buffers:

"We never plan a container, so to speak, directly from the ship to the train, because that is too much risk involved in that. We should always know the last unloading time from the ship before we should pick it up, so that there are always some margins".

This setup provided the freight forwarder with less risk of booking containers on a train that is not available due to late ships, and it also influenced the performance of the port operator. Additionally, the setup with buffers generates little need for coordination, or disruption management, when a ship is late as the containers are not booked for hinterland transport. This leads to inefficiency in the port operations, as the containers have to be taken from the ship to the yard before they are sent to the rail terminal. If the port operator knows when unloading the ship that the container should leave with the train, the route in the port for the container (and work for port operators) can be optimised:

"The majority of them [containers] are already in the yard [when booked on to train]. The ultimate would have been if they were booked on a train before they arrived at the port. Then we could have had the absolute best place in the yard."

The resource buffers of equipment were mainly connected to the port and its rail terminal operations. The six available tracks in the port provide the possibility to have three trains in the port at the same time. The port authority stated it as:

"We calculate that if we are using half of our capacity today, we expect to be able to double it".

These buffers concerned space for containers and stationary cranes used for loading and unloading of trains at the rail terminal. The port authority interviewee continued the reasoning for using buffers to avoid disruptions:

"Cranes can break down, that is why we at the rail terminal have two cranes, since we often have time to load a train with one crane if the other one is broken".

The port operator elaborated similarly, as the overcapacity of space in the rail terminal provides the opportunity to take another train than planned (as the planned train is late) even when the late train has been prepared by positioning containers at rail terminal. Connected to this buffer, the possibility of using road instead of train and scheduling for extra trains provided additional resources in cases of disruption. Interestingly, using extra resources such as a road transport for prioritised containers required using the lateral relation with the shipper for coordination. The overcapacity represented in the port area is further connected to the time delays in the hinterland transport. The port authority interviewee stressed this connection:

"Since we have such a large capacity at the rail terminal, we see that a lot of trains arrive late but leave on time. Since we have the buffer there, they [the trains] are handled in a good way so that one can catch up on delays [from arriving trains]".

Personnel resource buffers were found at the port as personnel can be shared between different parts of the port (e.g., unloading of ships and loading of trains), which provides flexibility if someone is sick as they can borrow someone from another area. Similar structures were found with the road transport operator, which was stated by the shipper to be flexible:

"The road transport operator has a high flexibility and can with short notice provide more truck drivers".

The use of overtime for operators and extra shifts on Saturdays resulted in less need for information in coordinating with other actors. Additionally, overtime for truck drivers and extra work at the dry port on Saturdays are used if not all containers are managed as planned.

6.2.2 Decreased Need for Information Processing via Environmental Management and Self-Contained Operations

The mechanisms of environmental management and self-contained operations to reduce the need for information processing were not evident in the studied hinterland transport to the same extent as slack resources. The fact that the shipper in the hinterland transport flow had bought the dry port is an example of environmental management as described by Galbraith (1977). This provides the shipper with control over the dry port (previously outside the shipper's environment) and its development without need for coordination with another actor.

7. DISCUSSION

The studied hinterland transport chain approached the information aspect of operational coordination by focusing on reducing the need for information rather than increasing information processing capacity. This focus is on opposition to proposals in the literature of hinterland transport to use ICT to support operational coordination (van der Horst and van der Lugt, 2011; Gumuskaya *et al.*, 2020). Similarly, as found by Gumuskaya *et al.* (2020), the re-planning decisions connected to hinterland operations influence the coordination, but as an extension, this paper examines how operational coordination is performed and support the disruption management with information. When the focus is placed on reducing the need for information processing, there is less information available for the disruption management. Most of the IT systems used focus on static monitoring of activities as they inform about static events, and they therefore lack the capacity to process information that can support the operational disruption management. This limits information for early detection of disruption, pointed out to be important for disruption management (Sheffi, 2015; Wide, 2020). The understanding of the underlining approach of reducing the need for information processing in the studied operational coordination supports insights into why usage of ICT and IT, tools proposed to support disruption management (Meyer *et al.*, 2014), are lacking.

By analysing the data from the studied hinterland transport chain through the OIPT lens, the framework in **Figure 3** was established. The framework provides improvement potential for operational coordination in supporting disruption management.

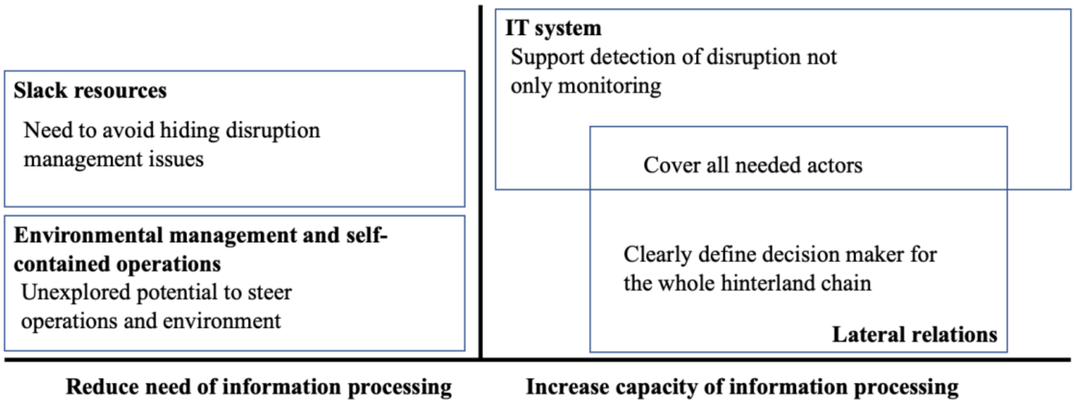

Figure 3 Framework with information perspective for operational coordination to support disruption management.

On the one side of the theoretical framework of increasing information processing capacity (right side in **Figure 3**), the IT systems used are not sufficient to provide all the actors with information for detecting disruptions and initiating the disruption management. The OIPT carries the limited assumption that investments in IT systems will provide possibilities to process more information. Even though OIPT originated in 1973 and 1977 (Galbraith, 1973; Galbraith, 1977) when IT systems were not so evolved as they are today, issues in the studied case show how investments in IT systems can be made to increase information processing, especially for continuously updated information instead of providing information statically after an activity has been performed. Similarly to Meyer *et al.* (2014), the IT systems in place support a static monitoring of the container flows, but they are not able to provide enough updates for on-going operations to support disruption management. In this way, the problem that all information in an IT system does not support the given coordination issue or link it to operational disruptions can be managed. Where the IT system is not supporting the information processing capacity of the case study, the other mechanism of relations steps into place. This mechanism works well for some parts of the hinterland chain where it is known by the involved actors whom to inform about disruptions, for example, between freight forwarder and road transport operator. Additionally, the perceived benefits of quick and secure communications with these relations can probably be obtained with a suitable IT system for coordination as well. However, in the parts of the hinterland transport chain where the number of the involved actors increases, for example, during arrival of a train at a port, not all actors are informed, and information regarding the same disruption is provided by different actors in each case. In this way, lateral relations are present at the studied hinterland transport chain, but they do not increase information processing capacity for the right actors. The lack of insight regarding which actors perform decision making in different parts of the hinterland chain limits the shared information to correct actors that could have increased information processing and supported the disruption management. Furthermore, the information from lateral relations did not always originate from the actor that first had the information, generating issues for early detection of disruptions. Neither of these mechanisms address all the involved actors, which limits the number of actors who receive information about a disruption.

On the other side of the theoretical framework of decreasing the need for information (left side of **Figure 3**), the case study represents a high use of buffers. This probably has to do with the lack of active use of any other strategy for information processing in the studied case, which according to Galbraith (1977); Galbraith (1973) will by default set to the mechanism of creating slack resources. These buffers implicate decoupling of interdependencies and less need for coordination when a disruption occurs. From a chain perspective, these buffers generate longer lead times, and since they do not focus on increase of information processing capacity, they could add issues for visibility of information within the chain as discussed by Christopher and Lee (2004). The studied hinterland transport chain includes flows of containers that are delivered to a central warehouse with high levels of buffers, which can be assumed to lead to a transport chain with lower buffers, but the buffers are evident in the hinterland transport chain the buffers as well. The costs of these buffers need to be compared to the costs of managing disruptions, the latter is only present in the case of a disruption (Christopher and Holweg, 2017). This paper provides an overview of the existing buffers, but it is not able to evaluate their costs (as coordination mechanism). Interestingly, different buffer types were identified, both fitting under the description of present and costly whether or not a disruption occurs (Christopher and Holweg, 2017), as the time buffers while the personnel buffers that are only used when needed. The personnel buffers, in comparison to time buffers, need coordination (costs). The actor carrying the costs for the buffers is different at different links of the hinterland transport chain. Efficient and reliable flow in the hinterland transport would be more dependent on coordination if buffers did not exist, especially coordination when disruptions occur. Additionally, the built-in buffers in the transport chain and at the shipper's central warehouse allow for a rail solution in the studied hinterland transport system. If the container flow would have been a just-in-time flow to the shipper, the dependencies would have been more visible and the need for other coordination mechanisms higher. Therefore, in including a rail solution in the hinterland transport without delays or other complications in the container flows, the management of disruptions through coordination would have been particularly important. Additionally, the two other mechanisms of decreasing the need of information (environmental management and self-contained tasks) were not found to be commonly used in the studied hinterland transport chain and they could provide supporting roles for the buffers in cases in which a hinterland transport chain strategy is to decrease the need for information.

In today's uncertain times, buffers are important assets to the hinterland transport chain in being able to deliver according to the promise. The issue with the described buffers in this case study is that the buffers do not only account for unexpected disruptions, e.g., Covid-19, but since information use is quite low (with the heavy focus on the strategy of decreasing information need), the disruptions that could have been expected become unexpected and covered by the buffers. Indeed, the used buffers do not mitigate disruptions of Covid-19 magnitude, but at least the first hit can be managed. The question is how much these buffers cost the hinterland transport chain before this kind of disruption occurs. The use of information could lower the costs of some buffers and mitigate inefficient performance due to disruptions that could be detected and managed with the support of information instead of buffers. With the strategy of decreasing the need for information, there is an accompanying lack of insight for predicting disruptions and making them expected and manageable without buffers. The division of buffers into those for unexpected disruptions and those for expected disruptions would require knowledge about what can be predicted and therefore expected. This study identified these buffers, but not the reason for them. The buffers could be in place to manage uncertainty in the hinterland system due to an active choice for decreasing the information need or they could be a consequence of no active choice for information processing as discussed by Galbraith (1973), or they could be intended for future expansion possibilities, for example, to handle future increase in demand. Nevertheless, it is important for a hinterland transport system to be aware of the strategies for information processing and make an active choice for to avoid unintentional buffers as an outcome.

The used perspective on information processing based on the OIPT (Galbraith, 1973; Galbraith, 1977) worked well as a lens to analyse the information aspect of the studied operational coordination. The OIPT perspective was useful to understand the different approaches to information processing in coordination, which generated an understanding of the information settings in the studied case that support (or do not support) disruption management. The original models have been developed and previously used in interorganisational settings, for example, supply chains (Zhu *et al.*, 2018; Wong *et al.*, 2015) and supply chain disruptions (Bode *et al.*, 2011). Differing from these papers, the current study includes the mechanisms proposed by Galbraith (1977) of creating slack resources, environmental management, creating self-contained tasks, investing in IT systems, and creating lateral relations, leading to certain issues in converting the organisational viewpoints in these mechanisms to the studied context of an interorganisational hinterland transport chain. As mentioned above, the current viewpoint on IT systems can be assumed to be different than that of the 1970s. However, even though investments have been made in IT systems since then, the findings indicate issues in increased information processing capacity. Maybe the slow development of digitalisation in the intermodal transport system indicated by Altuntaş Vural *et al.* (2020) is one factor explaining some aspects of this finding. Additionally, the lateral relations heavily involve a hierarchical organisational structure, which in a hinterland transport chain is not evident to be translated. The used assumption of this mechanism as the basis for relations between actors in the hinterland transport system provided a good explanation of information processing capacity being increased when disruptions occurred.

8. CONCLUSION

The purpose of this paper was to investigate the role of information, through an information processing perspective, for operational coordination in supporting operational disruption management in intermodal hinterland transport. The accomplishment of this purpose broadens hinterland transport coordination literature with the studied operational coordination focus and supply chain literature by using the information processing perspective in the hinterland transport context.

As previous hinterland transport literature has focused on coordination between actors at a strategic level, this paper adds to the hinterland operational coordination framework of Gumuskaya *et al.* (2020) through a description of the operational coordination in the studied hinterland transport chain and a detailed analysis through OIPT of information for operational disruptions. For operational coordination to support efficient hinterland transport flows, it needs to be extended with consideration of how the coordination supports management of disruptions. With the support of the OIPT, this paper proposes a framework for understanding how information from operational coordination can be improved to support disruption management. The proposed framework can support information for disruption management to improve hinterland flows via rail in order to support a shift from road hinterland transport. By analysing the coordination through an information processing perspective, it is possible to understand the connection of information between the performed coordination and management of disruptions. The identified strategy in the studied case of decreasing the need for information provides insight into why usage of ICT is lacking and presents issues regarding buffers that covers disruptions that information could have predicted. The decreased ability to predict disruptions through information due to use of the buffers indicates the need for a shift towards a more information-based operational coordination to support the disruption management if the transport chain wants to reduce the costs of buffers. Nevertheless, using information systems for coordination does not guarantee support for disruption management as the information about operations needs to be continuously updated for this purpose.

Even though this paper addressed multiple actors in a hinterland transport chain, future extensions to match operational coordination in other hinterland transport chain settings is needed. Furthermore, the issues of disruptions that can be predicted with information could be investigated in the hinterland transport settings. In this way, it would be possible to understand what disruptions that may be managed through information as opposed to buffers. Additionally, future research is needed on quantifying the costs of coordination, comparing the information approach to the buffer approach combined with potential costs for disruptions.

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REFERENCES

Albertzeth, G., Pujawan, I.N., Hilletofth, P. & Tjahjono, B. (2020), Mitigating transportation disruptions in a supply chain: A cost-effective strategy, *International Journal of Logistics Research and Applications* 23(2), pp. 139-158.

Altuntaş Vural, C., Roso, V., Halldórsson, Á., Ståhle, G. & Yaruta, M. (2020), Can digitalization mitigate barriers to intermodal transport? An exploratory study, *Research in Transportation Business & Management* 37, 100525.

Bask, A., Roso, V., Andersson, D. & Hämäläinen, E. (2014), Development of seaport–dry port dyads: Two cases from northern europe, *Journal of Transport Geography,* 39 (85-95).

Behdani, B., Wiegmans, B., Roso, V. & Haralambides, H. (2020), Port-hinterland transport and logistics: Emerging trends and frontier research, *Maritime Economics & Logistics,* 22 (1), pp. 1-25.

Bode, C., Wagner, S.M., Petersen, K.J. & Ellram, L.M. (2011), Understanding responses to supply chain disruptions: Insights from information processing and resource dependence perspectives, *Academy of Management Journal,* 54 (4), pp. 833-856.

Bryman, A. & Bell, E. (2011), *Business research methods, USA*, Oxford University Press.

Christopher, M. & Holweg, M. (2017), Supply chain 2.0 revisited: A framework for managing volatility-induced risk in the supply chain, *International Journal of Physical Distribution & Logistics Management,* 47 (1), pp. 2-17.

Christopher, M. & Lee, H. (2004), Mitigating supply chain risk through improved confidence, *International Journal of Physical Distribution & Logistics Management,* 34 (5), pp. 388-396.

De Langen, P. & Douma, A. (2010), Challenges for using ict to improve coordination in hinterland chains; an overview, *International Journal of Transport Economics / Rivista internazionale di economia dei trasporti,* 37 (3), pp. 261-279.

Elbert, R. & Walter, F. (2014), Information flow along the maritime transport chain - a simulation based approach to determine impacts of estimated time of arrival messages on the capacity utilization, Proceedings of the Winter Simulation Conference 2014, 7-10 Dec. 2014, pp. 1795-1806.

Ellram, L.M. (1996), The use of the case study method in logistics research, *Journal of Business Logistics,* 17 (2), pp. 93-138.

European Commission (2011), White paper roadmap to a single european transport area – towards a competitive and resource efficient transport system, *Brussels*

European Commission. 2017. *A european strategy for low-emission mobility* [Online]. European Commission (Ed.). Available: https://ec.europa.eu/clima/policies/transport_en [Accessed 13.06.2017 2017].

Eurostat. 2020. *Share of road in inland freight transport on the rise* [Online]. Available: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20200904-1 [Accessed 27 November 2020].

Fahimnia, B., Jabbarzadeh, A. & Sarkis, J. (2018), Greening versus resilience: A supply chain design perspective, *Transportation Research Part E: Logistics and Transportation Review,* 119, pp. 129-148.

Flick, U. (2014), *An introduction to qualitative research, London*, Sage publiations.

Franc, P. & Van Der Horst, M. (2010), Understanding hinterland service integration by shipping lines and terminal operators: A theoretical and empirical analysis, *Journal of Transport Geography,* 18 (4), pp. 557-566.

Galbraith, J. (1973), *Designing complex organisations, Reading, Massachusetts*, Addison-Wesley.

Galbraith, J.R. (1977), Organizing modes: An infomration processing model. *Organization design.* Reading, Massachusetts, Addison-Wesley.

Gumuskaya, V., Van Jaarsveld, W., Dijkman, R., Grefen, P. & Veenstra, A. (2020), A framework for modelling and analysing coordination challenges in hinterland transport systems, *Maritime Economics & Logistics,* 22 (1), pp. 124-145.

Halldórsson, Á. & Aastrup, J. (2003), Quality criteria for qualitative inquiries in logistics, *European Journal of Operational Research,* 144 (2), pp. 321-332.

Haralambides, H. & Gujar, G. (2011), The indian dry ports sector, pricing policies and opportunities for public-private partnerships, *Research in Transportation Economics,* 33 (1), pp. 51-58.

Haussmann, C., Yogesh, D.K., Venkitachalam, K. & Williams, M.D. (2012), A summary and review of galbraith's organizational information processing theory. *Information systems theory - explaining and predicting our digital society.* Springer.

Hrušovský, M., Demir, E., Jammernegg, W. & Van Woensel, T. (2020), Real-time disruption management approach for intermodal freight transportation, *Journal of Cleaner Production,* 280, 124826.

Hu, Q., Wiegmans, B., Corman, F. & Lodewijks, G. (2019), Critical literature review into planning of inter-terminal transport: In port areas and the hinterland, *Journal of Advanced Transportation,* 2019.

Hudnurkar, M., Deshpande, S., Rathod, U. & Jakhar, S. (2017), Supply chain risk classification schemes: A literature review, *Operations and Supply Chain Management: An International Journal,* 10 (4), pp. 182-199.

Hult, G.T.M., Ketchen Jr, D.J. & Slater, S.F. (2004), Information processing, knowledge development, and strategic supply chain performance, *Academy of Management Journal,* 47 (2), pp. 241-253.

Jeevan, J. & Roso, V. (2019), Exploring seaport - dry ports dyadic integration to meet the increase in container vessels size, *Journal of Shipping and Trade,* 4 (1), pp. 8.

Khaslavskaya, A. & Roso, V. (2020), Dry ports: Research outcomes, trends, and future implications, *Maritime Economics & Logistics,* 22, pp. 265 - 292.

Lai, P.-L., Su, D.-T., Tai, H.-H. & Yang, C.-C. (2020), The impact of collaborative decision-making on logistics service performance for container shipping services, *Maritime Business Review,* 5 (2), pp. 175-191.

Li, N., Chen, G., Govindan, K. & Jin, Z. (2018), Disruption management for truck appointment system at a container terminal: A green initiative, *Transportation Research Part D: Transport and Environment,* 6, pp. 261-273.

Malone, T.W. & Crowston, K. (1994), The interdisciplinary study of coordination, *ACM Comput. Surv.,* 26 (1), pp. 87–119.

Maxwell, J.A. (2013), *Qualitative research design: An interactive approach, London*, Sage publications.

Meyer, G.G., Buijs, P., Szirbik, N.B. & Wortmann , J.C.H. (2014), Intelligent products for enhancing the utilization of tracking technology in transportation, *International Journal of Operations & Production Mangement,* 34 (4), pp. 422-446.

Monios, J. & Bergqvist, R. (2015), Using a "virtual joint venture" to facilitate the adoption of intermodal transport, *Supply Chain Management: An International Journal,* 20 (5), pp. 534-548.

Romano, P. (2003), Co-ordination and integration mechanisms to manage logistics processes across supply networks, *Journal of Purchasing and Supply Management,* 9 (3), pp. 119-134.

Roso, V., Vural, C., Abrahamsson, A., Engström, M., Rogerson, S. And Santén, V., (2020), Drivers and barriers for inland waterway transportation, *Operations and Supply Chain Management: An International Journal,* 13 (4), pp. 406-417.

Roso, V., Woxenius, J. & Lumsden, K. (2009), The dry port concept: Connecting container seaports with the hinterland, *Journal of Transport Geography,* 17 (5), pp. 338-345.

Sahin, F. & Robinson, E.P. (2002), Flow coordination and information sharing in supply chains: Review, implications, and directions for future research, *Decision Sciences,* 33 (4), pp. 505-536.

Sheffi, Y. (2015), Preparing for disruptions through early detection, *MIT Sloan Management Review, Cambridge*

Tadić, S., Krstić, M., Roso, V. & Brnjac, N. (2019), Planning an intermodal terminal for the sustainable transport networks, *Sustainability,* 11 (15), 4102.

Tang, C.S. (2006), Robust strategies for mitigating supply chain disruptions, *International Journal of Logistics Research and Applications,* 9 (1), pp. 33-45.

Thompson, J. (1967), *Organizations in action, Chicago*, McGraw-Hill.

Tushman, M.L. & Nadler, D.A. (1978), Information processing as an integrating concept in organizational design, *Academy of Management Review,* 3 (3), pp. 613-624.

Van De Ven, A.H., Delbecq, A.L. & Koenig, R. (1976), Determinants of coordination modes within organizations, *American Sociological Review,* 41 (2), pp. 322-338.

Van Der Horst, M., Kort, M., Kuipers, B. & Geerlings, H. (2019), Coordination problems in container barging in the port of rotterdam: An institutional analysis, *Transportation Planning and Technology,* 42 (2), pp. 187-199.

Van Der Horst, M.R. & De Langen, P.W. (2008), Coordination in hinterland transport chains: A major challenge for the seaport community, *Maritime Economics & Logistics,* 10 (1), pp. 108-129.

Van Der Horst, M.R. & Van Der Lugt, L.M. (2011), Coordination mechanisms in improving hinterland accessibility: Empirical analysis in the port of rotterdam, *Maritime Policy & Management,* 38 (4), pp. 415-435.

Wang, T.-Y. & Yeh, D. (2009), An integrated forecasting dss architecture in supply chain management, *Operations and Supply Chain Management: An International Journal,* 2 (1), pp. 24-41.

Wide, P. (2020), Improving decisions support for operational disruption management in freight transport, *Research in Transportation Business & Management,* 37 No. 100540.

Wiegmans, B., Menger, I., Behdani, B. & Van Arem, B. (2018), Communication between deep sea container terminals and hinterland stakeholders: Information needs and the relevance of information exchange, *Maritime Economics & Logistics,* 20 (4), pp. 531-548.

Wiegmans, B., Witte, P. & Roso, V. (2020), Directional inland port development: Powerful strategies for inland ports beyond the inside-out/outside-in dichotomy, *Research in Transportation Business & Management,* 35 No. 100415.

Witte, P., Wiegmans, B., Roso, V. & Hall, P.V. (2020), Moving beyond land and water: Understanding the development and spatial organization of inland ports, *Journal of Transport Geography,* 84 No. 102676.

Wong, C.W.Y., Lai, K.-H., Cheng, T.C.E. & Lun, Y.H.V. (2015), The role of it-enabled collaborative decision making in inter-organizational information integration to improve customer service performance, *International Journal of Production Economics,* 159 No. 56-65.

Yu, G. & Qi, X. (2014), *Disruption management : Framework, models, and applications, Singapore, UNITED STATES*, World Scientific Publishing Co Pte Ltd.

Zhu, S., Song, J., Hazen, B.T., Lee, K. & Cegielski, C. (2018), How supply chain analytics enables operational supply chain transparency: An organizational information processing theory perspective, *International Journal of Physical Distribution & Logistics Management,* 48 (1), pp. 47-68.

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