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Managing digital transformation in response to supply chain disruptions: improving firm performance of service providers in ports

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Abstract.

The latest developments in big data analytics technologies provide numerous possibilities for managers in ports in enhancing their supply chain resilience strategy to continue firm performance. Due to disruptive circumstances in the maritime environment, supply chain resilience and big data analytics have become an important research topic. Supply chain resilience strategies are in the early stages of development in the maritime industry and appear to become essential in achieving firm performance. The aim of this research is to investigate at what extent big data analytics can be used to respond to supply chain disruptions in improving the firm performance of service providers in ports. First, this study proposes a hypothetical model where big data analytics in three contexts: strategic, resource, and capability. Moreover, the mediating role that supply chain resilience plays between big data analytics and firm performance is examined. This study discusses strategic insights by conducting interviews with high-tier managers working in the maritime industry. The findings provide evidence that big data analytics strengthens supply chain resilience and firm performance in ports.

Keywords: Big Data Analytics, Supply Chain Resilience, Supply Chain Disruptions, Firm Performance, Strategic Insights

1.   Introduction

Due to innovative digital technologies, service providers in ports are constantly overwhelmed by the amount of generated data. In addition, big data analytics (BDA) has become more challenging nowadays: around 80-95% of data generated worldwide contains unstructured patterns and is almost impossible to analyse using statistical programming methods (Syed, Gillela, & Venugopal, 2013). As the amount of data is increasing, BDA is receiving considerable attention from practitioners and scholars (Waller & Fawcett, 2013; Maheshwari, Gautam, & Jaggi, 2021). The BDA capability could be used to evaluate decisions and predict future patterns after managers learn how to integrate data (McAfee & Brynjolfsson, 2012). However, the maritime industry is one of the oldest and most traditional industries that still relies on intuition rather than databased decisions (Munim, Dushenko, Jimenez, Shakil, & Imset, 2020). Previous studies applied to different industries have shown that firm performance can be improved, and innovation efforts could be fast-forwarded when firms learn to exploit data (Ritter & Pedersen, 2020).

Efforts of managers in ports to set up BDA strategies are already in progress, but in preliminary stages (Ichimura et al., 2022). Previous literature states that BDA is relevant to supply chain resilience and firm performance outcomes (Dalenogare et al., 2018; Ritter & Pedersen, 2020; Gupta et al., 2020). Moreover, better performance when using data leads to a better competitive position in the supply chain (McAfee & Brynjolfsson, 2012; Ichimura et al., 2022). In fact, the maritime industry is a data-rich environment that may enhance disruption response (Ivanov & Dolgui, 2019). To date, there is still little empirical evidence that creates an understanding of factors that contribute to the successful use of BDA in supply chain resilience strategies and hence improve perceived firm performance. This study will close the literature gap concerning the relation between BDA, supply chain resilience, and firm performance in ports by addressing the question: *To what extent can big data analytics be used to respond to supply chain disruptions in improving firm performance of service providers in ports*? Therefore, this study contributes to the extant literature and managers in ports investigating the overlapping of BDA, supply chain resilience, and firm performance, while providing a further direction of research in this field.

1   Literature Review

Despite the growing usage of BDA and the emergence of supply chain disruptions, research on the impact on supply chain resilience is still in its early stages. Addressing this gap in the literature is essential, as the emergence of supply chain technologies shifts to new ways of working (Ivanov & Dolgui, 2019; Zouari et al., 2021). Therefore, BDA, supply chain resilience, and firm performance are defined before establishing their relationship to completely comprehend the literature. Literature from the last ten years is used to investigate the above-mentioned link. To ensure that the right literature is selected, search keywords are guided by the research objectives and Boolean operators are included in database searches.

1.1   Big data analytics in ports

The research of Waller & Fawcett (2013) pointed out different opportunities for BDA if this is applied to supply chain management and research. BDA applies to relevant SCM problems using quantitative and qualitative techniques. It improves supply chain design and competitiveness by estimating past and future patterns. The research also states that there is

more available data because it is increasingly captured in more detail. However, this research is conducted in 2013, but recent research stated that this is still relevant to current BDA use in supply chain management (Aryal et al., 2020; Gupta et al., 2020; Maheshwari et al., 2021). Among researchers and scholars, there is no consensus on one definition of the term "Big data analytics" (Akter et al., 2016; Richey et al., 2016; Fosso Wamba et al., 2017; Aryal et al., 2020). Zheng et al. (2021) examined the applications of industry 4.0 technologies in supply chain management. Therefore, this study adopted the definition of BDA from the aforementioned authors. This study defines BDA as the collection and analysis of large amounts of generated data in operations, using a series of statistical techniques to filter and report actionable insights. Furthermore, most of the literature has recognised the following general characteristics of big data in the context of supply chain management: volume, variety, velocity, veracity and value (Ghasemaghaei, 2021; Richey et al., 2016; Aryal et al., 2020; Maheshwari et al., 2021). *Volume* refers to the amount of data generated in the supply chain. Second, *veracity* concerns to the extent which generated data are truthful and reliable. Third, *velocity* refers to the speed of processing and generating data. Fourth, data appears structured or (semi-) unstructured from internal or external sources. As a reference, internal data is readily available data retrieved from own channels, and external data is retrieved from customers or supply chain partners, this is called the *variety* of data. Last, *Value* includes the extraction of economic benefits from data. "Business analytics", "Data science, "Supply chain analytics", and "Data mining" are henceforth considered synonyms of BDA.

As stated in the introduction, the unit of analysis in this study is "service providers in ports". However, the literature is relatively silent regarding what service providers at what supply chain tiers are included in ports, but Pu & Lam (2021), Port of Rotterdam (n.d.), and North Sea Port (n.d.) divided this into the following sectors: terminal operators, ship operators, shipbuilding and maintenance, warehousing and logistics, energy and recycling, maritime technology providers, and maritime governmental organisations. Terminal operators are considered the central body of data generation in the maritime land operations supply chain compared to the other sectors (Pu & Lam, 2021). Accordingly, the unit of analysis consists of all service providers directly involved in the port land operations supply chain.

Following the trend of using BDA in ports, data-driven innovative technologies and new business models are being developed, although there are differences in BDA adoption in maritime firms (Munim et al., 2020). However, the research of Ichimura et al. (2022) argued that developing a BDA strategy is currently among the biggest interests of service providers in ports. This transformation is reshaping ports, providing new opportunities to improve firm performance (Heilig & Voß, 2017). Additionally, BDA-enhanced maritime operations can contribute to the strategic, resource and capability aspects of maritime firms (Sanchez-Gonzalez et al. 2022). Although studies on the synthesis of BDA application to service providers in ports are rare, there is evidence that it is of increasing importance in maritime operations and technologies (Yang et al., 2019). Figure 1 depicts a general overview according to Heilig & Voß (2017) of how data is generated by enabling technologies and stored by information systems at service providers in ports (Pu & Lam, 2021; Port of Rotterdam, n.d.; North Sea Port, n.d.).

Figure 1: Information systems and enabling technologies to overview the unit of analysis.
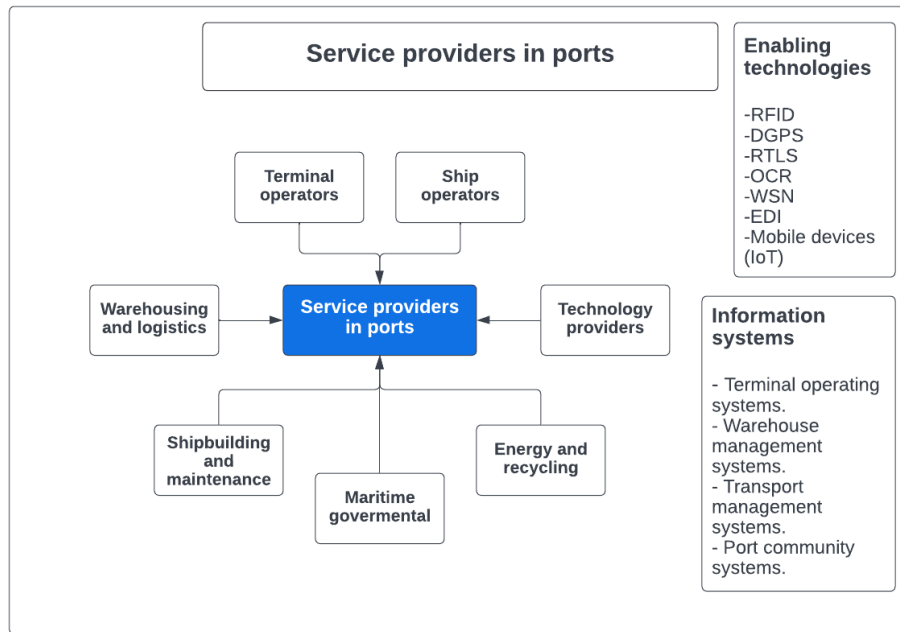
The information systems are in general terminal operating systems, warehouse management systems, transport management systems, and port community systems, the technologies enabling to generate the data are shown on the right. In general, this research aims to focus on the analytics of the generated data by the enabling technologies, stored in information systems. According to Heilig & Voß (2017), the enabling technologies forming the central body of data generation in ports consist of RFID (radio frequency identification), DGPS (differential global positioning systems), RTLS (real-time location systems), OCR (optical character recognition), WSN (wireless sensor networks), EDI (electronic data interchange), and mobile devices. In addition, port integration into the global supply network through data sharing has evolved significantly. Besides the enabling technologies and BDA mentioned in the above paragraph, Zarzuelo et al. (2020) mentioned additional advanced systems which use big data to facilitate intelligent ports for the future. These tools include the internet of things, cloud computing, blockchain, artificial intelligence, machine learning, and autonomous vehicles.

1.2 Big data analytics and firm performance in different contexts

To investigate the link between BDA and firm performance, Chen et al. (2015) use a TOE (technological, organisational, and environmental) framework which is used to investigate how BDA adoption affects value creation in organisational or supply chain management from these perspectives. Aydiner et al. (2019) divide BDA into descriptive, predictive, and prescriptive. Inspired by these frameworks, BDA is highlighted in a contextual approach which makes this study more specific: a Strategic context, a Resource context, and a Capability context. Previous research has already used contextual approaches, as described in Table 1.

Table 1: Firm performance measures in different contexts

Previous literature on BDA in different contexts applied to firm performance.			
Authors	**Context**	**Industry**	**Applications**
Troilo et al. (2016)	Strategic	Sports	BDA adoption has a significant effect on the manager's perception of firm performance. Financial and market performance are significant facilitators of firm performance.
Hallikas et al. (2021)	Strategic	Procurement	BDA adoption and strategy alignment have a significant effect on supply chain performance and supply chain performance on firm performance.
Suoniemi et al. (2020)	Resource	Manufacturing	This study reveals that BDA resources primarily improve firm performance.
Ashrafi et al. (2019)	Resource	Various	Information quality and innovation quality affect agility. Furthermore, it concludes that agility affects firm performance positively.
Akter et al. (2016)	Capability	Marketing	BDA management capability, talent capability, and technology capability have a significant effect on firm performance.
Gupta et al. (2020)	Capability	Technology	Managerial decision-making capability and technical skills capabilities positively influence firm performance in terms of operational performance, market performance, and financial performance.

1.3   The mediating role of supply chain resilience

Previous research pointed to a future research direction concerning the effects of BDA on supply chain resilience (Ivanov & Dolgui, 2019; Zheng et al., 2020; Bag et al., 2021). According to Ralston & Blackhurst (2020), BDA may lead to increased supply chain resilience due to capability improvement and the development of new skills. Moreover, the research of Tortorella et al. (2022) claims that BDA improves supply chain resiliency because of predicting consumer behaviour, inventory management, and relationship management. Applying this to service providers in ports, previous literature indicated that risk resilience in maritime supply chains is linked to BDA and firm performance (Dubey et al., 2021; Iftikhar et al., 2022). The key benefit that maritime firms gain from implementing BDA for the purpose to be more resilient, is the ability to conduct complex calculations, do pattern analyses, and maintain sound relationships with suppliers and customers (Zheng et al., 2020; Iftikhar et al., 2022).

Service providers in ports are influences by global trade and economic developments. Therefore, unprecedented demand increases or low commodity price levels have a negative impact on maritime transportation. Maritime disruptions cause problems in transportation processes, resulting in delays and financial losses for maritime firms. As a result, improving BDA and resilience capabilities helps maritime firms in mitigating the effects of disruptions while still allowing them to perform core business tasks. Therefore, researching to what extent BDA can lead to better supply chain resilience and firm performance of service providers in ports can be an essential contribution to the extant literature (Ivanov & Dolgui, 2019; Golan et al., 2020; Akpinar & Özer-Çaylan, 2022).

Strategic context: The strategic context contains BDA adoption, strategic planning, and strategic alignment. Previous research suggests that the strategy and use of the available data drive or restrict the development of BDA capabilities. Akter et al. (2016) emphasized not only

the importance of BDA adoption but also a strong alignment between the BDA strategy and the overall firm strategy to achieve improved performance. Hallikas et al. (2021) confirm this by arguing that aligning the BDA strategy with the firm strategy positively influences the supply chain and firm performance.

Resource context: The resource context contains the availability, accuracy, and integration of data with actors in the end-to-end supply chain. The burst of data volume provides opportunities for BDA in ports to respond to supply chain disruptions (Munim et al., 2020). Dubey et al. (2021) indicated positive effects of having access to data on supply chain resilience. As stated before, there are several advanced systems where the available data is stored, and technologies enabling to generate data such as RFID and OCR (Heilig & Voß, 2017). Data consists of structured and unstructured data, where unstructured data is almost impossible to analyse without advanced technologies. Structured data is seen as readily available (accurate) data to analyse (Syed et al., 2013; Ashrafi et al., 2019; Maheshwari et al., 2021). However, the share of unstructured data is significantly higher than structured data. As a result, more complex data is generated, which creates more complex analytics in supply chains (Iftikhar et al., 2022). Aydiner et al. (2019) argued that data integration with other firms in the supply chain increases a firm's capacity to recognise and exploit possibilities and knowledge for efficiently handling operational processes. The extent to which a supply chain is interconnected and integrated with the supply chains of partner firms is referred to as supply chain integration (Cohen et al., 2022).

Capability context: According to recently published literature, there is a challenging role played by BDA for directors and supply chain decision-makers that need to appropriately understand trade-offs (McAfee & Brynjolfsson, 2012; Nooraie & Parast, 2016; Merendino, et al., 2018; Golan et al., 2020). Supply chain managers in ports are currently facing challenges from high customer expectations, intense competition, and supply chain disruptions. Previous disruptions have learned that a future implication of supply chain design is to effectively invest in capabilities to be more responsive to supply chain disruptions. The current post-COVID business climate requires managers in ports to make the most effective decisions possible (Panwar et al., 2022). Maritime firms must constantly search for dangers and possibilities in such a turbulent market and make decisions fast based on available data (Jeble et al., 2017; Zouari et al., 2021).

Supply Chain Resilience and Firm Performance: The literature discussed several ways to measure firm performance: supply chain performance, financial performance, and operational performance. Literature applied to various industries confirmed a significant positive effect of BDA on firm performance in terms of operational, financial, and supply chain performance.

2 Methodology

Closing the literature gap as described in the literature review, this research is both theories- and application-orientated, meaning that literature and interviews will be used as research methodologies that are aimed at assessing the mediation of supply chain resilience.
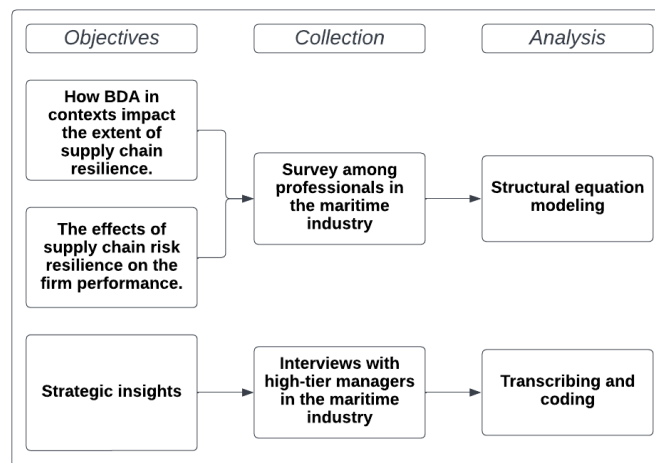
2.1 Data Collection Strategy

Interviews were undertaken with managers high in the hierarchy employed in ports. The ultimate goals of these interviews are to discuss (1) their knowledge about this topic, (2)

possibilities for survey distribution, and (3) strategic insights about current and desired supply chain resilience strategies. Strategic insights could be generated when identifying gaps between the respondents' current state and the desired state of supply chain resilience. The concept of semi-structured interviews is chosen, because current and desired states of supply chain resilience can be pursued with flexibility (Cohen et al., 2022). Nakano & Matsuyama (2022) conducted survey research and used five interviews. Aydiner et al. (2019) conducted mixed-method research using interviews for validating their survey questions. In this study, five interviews were undertaken, following a recommendation of Flynn et al. (2017), and the research of Nakano & Matsuyama (2022). Last, the open question in the survey suggested by Wieland et al. (2016), makes the strategic insights comparable. The interview questions are included in Appendix A.

2.2   Data Analysis Strategy

To uncover themes and sub-themes, the interviews are analysed by QDA Miner software, where all answers of the respondents are coded using open, axial, and selective coding (Modgil, Gupta, Stekelorum, & Laguir, 2022). The first step is dividing the interview into open codes: (1) current view on supply chain resilience, (2) BDA and supply chain resilience, (3) strategic insights, (4) survey distribution and further research directions. This division is also used in Appendix A. To conclude, Figure 2 depicts the objectives linked to the data collection and analysis strategies in this study.

Figure 2: Data collection and analysis strategy summarised

2.3   Validity and Reliability

As described in the data collection strategy, five practitioners well-versed in BDA and supply chain resilience are interviewed. Their current view and desired view on this topic are provided. With this method, data triangulation is facilitated among the analyses. In general, data triangulation is a research method that uses more than two methods to collect data, implying to minimize a common method bias. In general, as many other supply chain researches do, this research measures relationships from the perspectives of several functional areas within a (maritime) firm, which complicates asking about the opinions of an individual (Flynn et al., 2017). Therefore, multiple sources are needed to collect data for this complex question. This enhances both the validity and reliability of the analyses of BDA and supply chain resilience and leads to actionable strategic insights (Kumar et al., 2022).

3 Results

3.1 Relevant findings from the literature

The literature review revealed nine constructs when measuring the relationship between BDA and the firm performance of service providers in ports, presented in Table 2. In total, 31 studies were found investigating a relationship between firm performance using a literature review or structural equation modelling. Most of the constructs showed significant results on firm performance. However, as described in the literature review, Aydiner et al. (2019) and Suoniemi et al. (2020) showed no direct significant results when investigating this relationship in a resource-based view with a survey. In contrast, results were indicating that there is an indirect relationship between BDA and firm performance in terms of higher customer loyalty and lowering various costs.

Table 2: Literature review findings linked to constructs

Literature review findings of constructs			
Number	**Construct**	**Total**	**Significance**
1.	Adoption	6	**Significant:** (Troilo et al., 2016), (Ramanathan et al., 2017), (Ashrafi et al., 2019). **Insignificant:** (Aydiner et al., 2019), (Suoniemi et al., 2020).
2.	Supply chain resilience	6	**Significant:** (Iftikhar et al., 2022), (Singh & Singh, 2019) (Dubey et al., 2021), (Ivanov & Dolgui, 2019) (Yang & Hsu, 2018), (Bag et al., 2021).
3.	Strategic planning	4	**Significant:** (Akter et al., 2016), (Ramanathan et al., 2017), (Kumar et al., 2022), (Ichimura et al., 2022).
4.	Strategic Alignment	4	**Significant:** (McAfee & Brynjolfsson, 2012), (Akter et al., 2016), (Ritter & Pedersen, 2020), (Hallikas et al., 2021),
5.	Availability	3	**Significant:** (Suoniemi et al., 2020)**,** (Akter et al., 2016), (Aydiner et al., 2019).
6.	Decision-making	3	**Significant:** (Gupta et al., 2020), (Jeble et al., 2017), (Merendino et al., 2018).
7.	Integration	2	**Significant:** (Woo et al., 2013), (Cohen et al., 2022).
8.	Innovation	2	**Significant:** (Bahrami et al., 2022), (Sabahi & Parast, 2020).
9.	Accuracy	1	**Significant:** (Syed et al., 2013).

3.2 Interview Analysis

As established in the methodology, five interviews were conducted with practitioners well-known in the maritime industry. The interview participants all have a background in diverse maritime sectors. Table 3 provides a description of the interview participants.

Table 3: Description of interviews

Description of interview participants			
No.	**Industry**	**Position**	**Participants**
R1	Cold chain logistics	Managing director	One

R2	Shipbuilding & ship maintenance industry	Supply manager	Two
R3	Port operations consultancy	Operations & supply chain manager	One
R4	Maritime technology provider	Co-founder/ Executive	One
R5	Inland waterways	Project leader digital transformation of an inland port	One

3.2.1 Interview Labelling

The open codes split is provided in Table 2, where the interview is split into four parts; (1) current view on supply chain resilience, (2) BDA and supply chain resilience, (3) strategic insights, and (4) further research directions. In a nutshell, the open codes are divided into axial codes that are further analysing the four open codes. The axial codes are the categories of the open codes. Furthermore, the axial codes are merged into broader codes using selective coding (Cohen et al., 2022). In Table 4, the selective codes are merged in an explanation.

Table 4: Explanation of selective codes

Open code: Current view on supply chain resilience	
Categories	**Explanation selective codes**
Disruptions in the maritime industry	The disruptions that are mostly mentioned include the consequences of COVID, labour shortage, and raw material shortage. The consequences imply increasing prices and long lead times for orders. Also, a general lack of knowledge to deal with disruptions is considered a disruption.
Strategies associated with disruptions	To mitigate supply chain disruptions, the following strategies are used: increasing inventory, risk diversification by forming multiple new relationships with suppliers/ customers, increasing time buffer in planning operations and reorganising some processes that needed revision.
Lessons learned	Change management in a maritime organization is more important than ever, also at the strategic level regarding business model rethinking. Also, supply chain visibility could have helped by dealing with disruptions. This needs vertical and horizontal data and knowledge sharing in maritime supply chains.
Open code: Current state BDA and supply chain resilience	
Categories	**Explanation selective codes**
BDA and supply chain resilience	BDA is moderately used in the maritime industry. Also, supply chain resilience strategies are in their infancy. BDA: the necessary data is available to analyse the past and predict future outcomes, although the data is moderately used. Supply chain resilience: business processes are changing to improve business resiliency against disruptions. Another commonly mentioned current state is that inventory has been increased.

Table 4 (continued): Explanation of selective codes

Open code: Strategic insights	
Categories	**Explanation selective codes**
Desired state	Investing in big data generation that can be accumulated in data warehouses. When data is available, it can be analysed using filter techniques and visualised by business intelligence technologies. Common desired states include end-to-end supply chain visibility by sharing data with partners in the supply chain.

What is needed to get to the desired state	Business model re-engineering to transition towards a data-driven (maritime) industry.
Relation between supply chain resilience and firm performance	Relationships with other actors in the supply are considered a key driver towards resilience. Regarding the labour shortage, a well-established HR talent management, especially in the digital and technical domain is becoming more important. Knowledge sharing by digitally skilled people can improve learning from past events.
Open code: Further research directions	
Categories	**Explanation selective codes**
Further research directions	Respondents indicated the following further research topics: market intelligence to enhance resilience, how dwell times affect supply chain performance, the effects of collaboration in the supply chain on supply chain resilience, and the effects of supply chain integration on supply chain visibility, all applied to the maritime industry.

The results from the interviews reveal insights when consolidating the findings of the categories. After the open questions labelling in the next section, the strategic insights are in-depth described.

3.2.1 Strategic Insights

Sharma et al. (2020) formed strategic insights using a thematic analysis by analysing tweets associated with supply chain management. In this study, the strategic insights are formed using the input of the interview respondents and the thematic analysis identifying the gaps in current supply chain resilience strategies in the maritime industry. This results in the strategic insights shown in Table 6.

Table 6: Strategic insights

Strategic insights derived from interviews.	
No.	**Explanation**
Strategic insight 1	A **change in business models** of service providers in ports towards more **data-driven organisations** is needed.
Strategic insight 2	There is a need for **data sharing** to create more **visible** maritime supply chains.
Strategic insight 3	**Supply chain collaboration** is needed when creating more visible maritime supply chains. Strong collaborations in the supply chain improve **flexibility** and thus resilience.
Strategic insight 4	**Analyse** the past**,** and **forecast** the future**.**

Strategic insight 1: As respondents 1 and 3 described, a change in business models of service providers in ports towards more data-driven organizations is needed. The respondents indicated that data-based decision-making in all layers of a maritime organization is becoming more important to anticipate on potential supply chain disruptions.

Strategic insight 2: Furthermore, respondents 2, 3 and 5 of the interviews and the open question respondents underlined a need for data sharing to create more visible maritime supply chains. Maritime firms are usually attached to their own data which makes data

sharing currently non-existent. Also, there is a shortage of digitally skilled people that can translate data into tables or a business intelligence dashboard.

Strategic insight 3: Regarding the previous strategic insight about supply chain visibility, participants emphasized that supply chain collaboration is needed when creating more visible maritime supply chains. If there are strong collaborations in the supply chain, flexibility and thus supply chain resilience can be improved (Dubey et al., 2021).

Strategic insight 4: Moreover, the results reveal the following insight: Analyse the past, and forecast the future. Respondents indicated that BDA and supply chain resilience strategies are still in their infancy. Market intelligence can be created by analysing the past, which has a positive effect on supply chain resilience if future patterns can be predicted.

4 Discussion

4.1 Interview Insights

Strategic insight 1 is highlighted by respondents 1 and 3 and emphasizes that a change in business models in ports towards more data-driven organisations is needed. "What you notice anyway, our business model is fading a bit. Our business model will be more set up on explaining something with the support of data. So I am focused on data for decision-making." … "I think the maritime industry is not very responsive to disruptions yet, changing to a data-driven industry could help to anticipate disruptions more throughout the supply chains". Moreover, strategic insight 2 highlighted a need for data sharing to create more visible maritime supply chains. Respondents 2, 3 and 5 highlighted: "I think we can improve as an industry here. There is not that much insight at all yet. They all pretend data is very secret. Terminals are seeing themselves rather as competitors than a collaborating supply chain. Whereas if you make that transparent and visible through dashboards, it comes more alive for people. Then they will understand that this is a much more transparent way of working". Furthermore, strategic insight 3 is built upon the previous insight. Regarding the previous strategic insight about supply chain visibility, participants emphasized that supply chain collaboration is needed when creating more visible maritime supply chains. If there are strong alliances in the supply chain, flexibility and supply chain resilience can be improved. Respondents 1, 2 and 3 argued: "Switching between partners and an optimized supply chain is possible when you are collaborating. The disruptions show that we have to make contact with more suppliers to be independent. Perhaps overarching systems could be created to respond more on supply chain disruptions together." Last, the respondents reveal the following additional insight: Analyse the past, and forecast the future. Respondents 1 and 4 shared the following: "I notice too little analyses of data. I think an important step is to analyse the past to predict the future. Performance metrics should be much more data-driven, analysing past trends in the market. The recorded data must be tracked so that a response to disruptions in our supply chains can be established, but there are still a lot of steps to take in that respect".

The present study has aimed to handle important associations between BDA, supply chain resilience, and firm performance of service providers in ports. At foremost, this study pointed out that it was challenging to establish service providers in ports as the unit of analysis. However, Pu & Lam (2021) and port authorities divided the sectors that were included in this study. BDA in different contexts influences supply chain resilience among service providers in ports. The strategic insights reveal enablers to enhance supply chain resilience, namely adoption, accuracy, integration, decision-making, and innovation. However, the absence of

some enablers can bring barriers in responding to supply chain disruptions. For instance, there is a high chance if no data sharing is established between actors in maritime supply chains, that no strong supply chain collaborations are formed. Thus, can be seen that the strategic insights are correlated with each other. A key takeaway regarding the main question of this research is that there is found evidence that adoption, accuracy, integration, decision-making, and innovation are facilitators in responding to disruptions in ports. Effectively, a change in business models, data sharing, supply chain collaboration, and analytics of data is needed in the short term to go towards more resilient maritime supply chains.

5 Conclusion

5.1 Theoretical Implications

This study attempted to link BDA in different contexts to supply chain resilience and firm performance among service providers in ports. In the literature, there has been an increased focus on how firms can improve firm performance by developing BDA strategies (Akter et al., 2016; Fosso Wamba et al., 2017; Ashrafi et al., 2019; Aydiner et al., 2019; Maheshwari et al., 2021). Also concerning the effects of BDA on supply chain resilience (Singh & Singh, 2019; Dubey et al., 2021; Bahrami et al., 2022; Iftikhar et al., 2022). Despite growing interest, limited literature is developed about the relatedness of BDA, supply chain resilience, and firm performance. Supply chain resilience is found to be a strong mediator between BDA and firm performance. This study clarifies the argument related to the essential role played by BDA in enhancing maritime supply chain resilience. A strategic roadmap to go towards enhanced supply chain resilience is drawn based on interviews. This theoretical finding is important, as it provides insights to capitalize on the relationships.

5.2 Managerial Implications

This research has also important implications for managers in ports. This study confirms that BDA positively influences the supply chain resilience of a firm. Under the circumstances of increasing supply chain complexity and disruptive events, managers can be skeptical about adopting BDA to enhance supply chain resilience and firm performance. With the evidence of this study, managers are encouraged to invest in data analytics technologies and specialists, because there are positive effects found between supply chain resilience and firm performance. Generally, BDA, and resilience strategies are in their early stages in the maritime industry. Therefore, this study clarifies that BDA plays a significant positive role in retrieving insights from data to respond to supply chain disruptions, leading to supply chain resilience.

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Appendix A. *Interview questions*

Semi-structured interview

As previously communicated by e-mail, I am doing research for my master thesis on the effects of big data analytics on supply chain resilience and firm performance at service providers in ports. This is done by investigating the resilience of the supply chain. Are there any current challenges taking place at this organization or in this supply chain? Are strategies being formed to mitigate disruptions in the supply chain? What influence does big data analytics have on this?

Interesting and relevant topics to talk about. A semi-structured interview means that questions are being prepared to get in the right direction for the conversation, however, these questions are prepared to promote a two-way conversation. This interview will last 30 to 45 minutes.

Current view on supply chain resilience

Q1: As a maritime supply chain manager, how have you experienced supply chain disruptions in your company? How were these disruptions different from others?

Q2: What are the measures/strategies your company has taken to deal with these situations?

Q3: What are the most important lessons in dealing with these disruptions?

BDA and supply chain resilience

Q4: In an uncertain and complex environment during the previous two years, when the supply chain was at high risk, how your company utilised big data analytics to minimise the risk of disruptions?

Strategic insights

Q5: What is your desired state of anticipating on future supply chain disruptions?

Q6: Is there a gap to fill?

Q7: How does supply chain resilience relate to firm performance in your company?

Survey distribution and further research directions

Q8: Do you have tips to distribute a survey (with a target of over 100 respondents) on these topics among office workers for different companies in ports?

Q9: Any tips for further research? I begin with an interesting one: Business intelligence.

Bonus questions

Q10: What is essential to make big data analytics succeed at service providers in ports?

Q11: Do my questions meet your expectations? Did I forget to cover anything?

Q: Other questions?

Sources: (Cohen et al., 2022), (Ralston & Blackhurst, 2020) and (Modgil et al., 2022)