DRIVING DIGITAL TRANSFORMATION: ENABLERS AND INHIBITORS OF DATA ANALYTIC CAPABILITY IN TRANSPORTATION AND LOGISTICS COMPANIES

Alinda Kokkinou	Breda University of Applied Sciences / AVANS Hogeschool
Albert Mandemakers	Breda University of Applied Sciences
Hans Quak	Breda University of Applied Sciences / TNO

Summary

Many of the challenges that transportation and logistics companies are facing can be addressed through digitalization, and in particular by developing their data analytic capability. This is however a complex socio-technical process that poses unique challenges to transportation and logistics companies. Through a multiple case study approach, the present study examines the enablers and inhibitors of data analytic capability in transportation and logistics companies. We find that the development of data analytic capability by transportation and logistics companies has many enablers and inhibitors in common with other industries. These include linking digitalization efforts to the company strategy, introducing knowledge of digitalization to the company, and management lacking knowledge of digitalization that inhibits them from making appropriate decisions. However, our findings also show that transportation and logistics companies experience a lack of interoperability of systems more severely than other industries as their processes and corresponding data flows are entangled with those of other actors in the supply chain such as customers, suppliers, other logistics and transportation companies, customs etc. The lack of standardization is thus a much more serious threat than acknowledged previously. While transportation and logistics companies still try to address this issue by harmonizing their systems, recent technological developments such as the emergence of integration platforms and Artificial Intelligence could be an effective shortcut.

1. Introduction

While the transportation and logistics sectormakes every effort to remain vital, Dutch companies in this sector are encountering significant challenges. As a result of societal pressure and the ensuing legislation, the transportation and logistics sector needs to take steps towards becoming more sustainable (Transport and Logistiek Nederland, 2023). Yet, it is encountering urgent challenges in the area of labor productivity and financial sustainability (Supply Chain Magazine, 2023). In 2023, labor shortages remained a concern, with the number of vacancies for truck drivers further increasing and vacancies for other transportation and logistics related jobs staying high (Sectorinstituut Transport en Logistiek, 2023a). A reduction in industrial production and construction, in combination with decreased international trade also causes financial concerns. It is therefore not surprising that when asked, transportation and logistics companies report labor shortages (34%) and financial sustainability (41%) as the most important topics of concern (Sectorinstituut Transport en Logistiek, 2023b). In the same report, only 4% of companies identify digital transformation and digitalization as an important topic for the coming two years, even though the challenges encountered by transportation and logistics companies can be addressed through digitalization (PWC, 2023).

Digitalization is a broad concept, generally defined as "*the use of the technologies and data to improve and transform the business processes*" (Machado et al., 2019) that has led to distinct concepts across industries, depending on their characteristics. These technologies encompass the Internet of Things (IoT), robotics, Machine Learning (ML), and Artificial Intelligence (AI) amongst others. While these technologies are uniform across industries, the way in which they have been applied has differed depending on the industry needs and characteristics. The introduction of the term "Industry 4.0" during the Hannover (Germany) technology fair in 2011 to refer to "the current trend of automation technologies in the manufacturing industry" (Shahin et al., 2020, p. 2928) was fairly revolutionary, however other terms have been used to refer to the same in other settings, such as Smart Industry in US manufacturing (Rosin et al., 2020). Nevertheless, the benefits of digitalization extend to many other types of companies beyond manufacturing (Björkdahl, 2020).

Digitalization is a promising avenue for transportation and logistics companies to improve the efficiency of their processes, thereby decreasing costs, reducing mistakes, accelerating delivery times and thus increasing competitiveness (Tsonkova, 2018). Digital tools have promising applications for a variety of industry actors such as ports, trucking companies, warehouses and intermodal transport (Altuntaş Vural et al., 2020; Harris et al., 2015). IoT tools such as connected sensors allow real-time tracking and thus increased visibility (Papert and Pflaum, 2017). Applications using ML and AI such as Transportation Management Systems (TMS) enable organizations to use real-time traffic data to optimize routes, reduce delays, costs and increase sustainability. Automation technologies such as robots can be used to automate order-picking in warehouses, reducing reliance on human labor, especially in regions where it is scarce. Nevertheless, the application of digital tools to single processes is not sufficient. As transportation and logistics companies often need to align with other actors in their network, they need to develop digital capabilities, and even evolve in digital service providers (Altuntaş Vural et al., 2020). In the context of supply chain management, an important manifestation of digitalization has been the combination of technologies such as sensors and data analytics to improve a company's capability to deploy data, technology and people to quickly turn data into actionable insights (Garmaki et al., 2016; Yu et al., 2021). This capability to orchestrate data assets, IT infrastructure, and human talent in such a way that they create competitive advantage has been denoted Data Analytic Capability (DAC) (Mikalef et al., 2018). Implemented successfully, DAC can lead to improved supply chain visibility (Brandon-Jones et al., 2014), supply chain agility (Dubey et al., 2019; Ghasemaghaei et al., 2017) and supply chain robustness (Kokkinou et al., 2022, 2023c). Additionally, DAC can improve decision-making quality (Awan et al., 2021), leading to improved productivity, sustainability and competitiveness (Fosso Wamba et al., 2015).

Nevertheless, despite the extensive attention given to the benefits of DAC, its implementation remains challenging for companies (Björkdahl, 2020). The implementation of DAC is a complex socio-technical process, involving people, processes and technology and thus requiring a comprehensive approach, tailored to the context of the organization (Kokkinou et al., 2023b). The present study therefore examines the enablers and inhibitors of digitalization and DAC in transportation and logistics companies. Using Dynamic Capability View as an overarching theory, a multiple case study approach is employed to examine the development of DAC by three companies, allowing for an in-depth exploration of the enablers and inhibitors of digitalization and DAC in its industry context.

The next section develops the Dynamic Capability View as an overarching theory and reviews the literature on enablers and inhibitors of digitalization and DAC. Subsequently, the steps to selecting cases, collecting, and analyzing data are detailed. The findings of the within and between case analysis are presented, followed by their discussion.

2. Review of the literature

2.1. Digitization, Digitalization, and Digital Transformation

Digitalization can be viewed as the application of tools to improve business processes, or from the perspective of the Dynamic Capability View (DCV). In this first perspective, three different phenomena are oftentimes confounded: digitization, referring to "the technical process of converting analog signals into a digital form, and ultimately into binary digits" (Legner et al., 2017, p. 301), digitalization as the "the use of the technologies and data to improve and transform the business processes" (Machado et al., 2019, p. 1114), and digital transformation as "encompassing changes in the business models, activities, processes, and competences to enable to have all benefits of the full deployment of the new technologies" (Machado et al., 2019, p. 1114). The application of digitalization tools to improve company and supply chain performance has been explored across various disciplines, leading to the emergence of related concepts such as Industry 4.0 (Kagermann et al., 2013), smart manufacturing (Rosin et al., 2020) and big data analytics (Wamba et al., 2017).

In practice, digitization and digitalization projects often take place in organizational silos, in the form of self-contained projects. Companies have incorporated digitalization technologies (e.g. sensors, big data, virtual reality, automated guided vehicles and robots to their existing continuous improvement initiatives such as lean and six sigma, (see Kokkinou et al., under review). This area of research highlights the need for companies to introduce knowledge of digitalization to their organization, link these efforts to the company strategy, and formulate appropriate Key Performance Indicators (KPIs) in order for the benefits of digitalization to extend beyond the single department or organizational unit.

2.2. Data Analytic Capability as a Dynamic Capability

From the perspective of DCV, DAC is considered a dynamic capability as it allows a company to sense its environment (e.g. identify new patterns) (Mikalef et al., 2019), seize opportunities through improved data-driven decision-making (Ellström et al., 2022), and transform and reconfigure its activities in response to these changes. In addition to being a dynamic capability, DAC is also an enabler of other capabilities (Helfat and Peteraf, 2009), including supply chain agility (Dubey et al., 2019; Ghasemaghaei et al., 2017), process innovation capability (Mikalef and Krogstie, 2020), and sustainable innovation capability (Yu et al., 2022).

The Dynamic Capability View (DCV) provides a theoretical foundation to examine how companies develop their DAC. DCV introduces the concept of dynamic capabilities as allowing companies to evolve in response to market and other environmental changes (Teece et al., 1997; van de Wetering et al., 2019). DCV extends the Resource Based View (RBV) of the firm (Eisenhardt and Martin, 2000). RBV views competitive advantage as resulting from the valuable, rare, inimitable, and non-substitutable resources that a company has acquired or developed (Barney, 1991). While very powerful in explaining competitive advantage, RBV is criticized for viewing these resources as static (Wang and Ahmed, 2007). DCV addresses this criticism through the concept of dynamic capabilities. Dynamic capabilities are processes or routines that organizations develop that enable them to "integrate, build, and reconfigure internal and external competencies to address rapidly changing environments" (Teece, 2007) and are distinct from ordinary capabilities. Ordinary capabilities are processes used by organizations to generate value at a specific moment (Laaksonen and Peltoniemi, 2018) and consist of first-order capabilities and second-order capabilities. First-order capabilities are processes that allow companies to deploy resources for a specific objective, whereas second order capabilities are of strategic importance to the company as they contribute to its competitive advantage (Wang and Ahmed, 2007). In this view, dynamic capabilities are third-order capabilities. They allow companies to modify their ordinary capabilities as a response to changes in the environment (Laaksonen and Peltoniemi, 2018).

By applying the DCV lens to the development of DAC, the assets, resources, and processes needed to develop it can be disentangled, providing a strong theoretical framework for the examination of enablers and inhibitors of DAC in transportation and logistics company. In addition to manufacturing and supply chain management, the concept DAC has been examined across several disciplines, including Information Systems (IS), operations research and business. Gupta and George (2016) identified three types of resources needed for the development of DAC, namely (1) tangible and tradeable resources such as time, financial, data and technology, (2) intangible company-specific resources such as a data-driven culture and organizational learning, and (3) human resources that need to be acquired developed such as managerial and technical skills. These were further refined to include six interlinked categories of assets and resources, namely management, knowledge and skills, data, data analytics, technology, and structure and processes (Kokkinou et al., 2023a, 2023b).

While DAC approaches digitalization from the perspective of a company capability, it can also be seen as the application of digitalization tools to improve company performance. Companies approaching digitalization in such a way can also achieve significant benefits.

2.3. Enablers and Inhibitors of DAC and Digitalization

By reviewing the literature on enablers and inhibitors of DAC and digitalization, nine categories of interlinked technological and organizational enablers and inhibitors can be identified. These are briefly discussed below and depicted in Figure 1.

For all digitalization initiatives, a *Link to Strategy* needs to be apparent. Companies initiating digitalization projects need to ensure that these are aligned to the company strategy as this will facilitate communication, coordination, and the effective allocation of resources and identification of relevant KPIs (Kokkinou et al., 2023a, 2023b). Instead, many transportation and logistics companies still are driven to adopt a technology because of customer pressure (Perego et al., 2011). *Management & Leadership* need to show commitment and support, communicate the objective and importance of the digitalization initiatives, and coordinate efforts across the company. To do so effectively, managers and leaders need to develop their analytics acumen. *Knowledge and skills* have been identified as important pre-requisites for digitalization efforts (Harris et al., 2015). Lack of awareness of digitalization was identified as an inhibitor (Kokkinou et al., 2023b). Knowledge of digitalization solutions is required for employees and managers to be able to envision the possibilities of digitalization for the company (Perego et al., 2011). Technical knowledge (IT, data analytics, data sciences…) can be acquired either through hiring consultants, hiring employees, or training employees. Even if the technical knowledge is concentrated in technical experts, domain experts need sufficient knowledge of data analytics for the two groups to be able to communicate and cooperate.

Depending on the technical knowledge present in the company and the objectives formulated, different types of *Data Analytics* can be used, with companies typically starting with descriptive analytics (e.g.

Dashboards), moving on to predictive analytics (e.g. forecasting) and prescriptive analytics. Once analytics are in place, companies need to re-consider their *Structure*. As analytics become more widespread, employees can be empowered to act more independently, requiring changes to how the company is organized. Additionally, companies differ in how they organize their analytics departments, with some choosing a centralized department while others choose a decentralized or matrix approach.

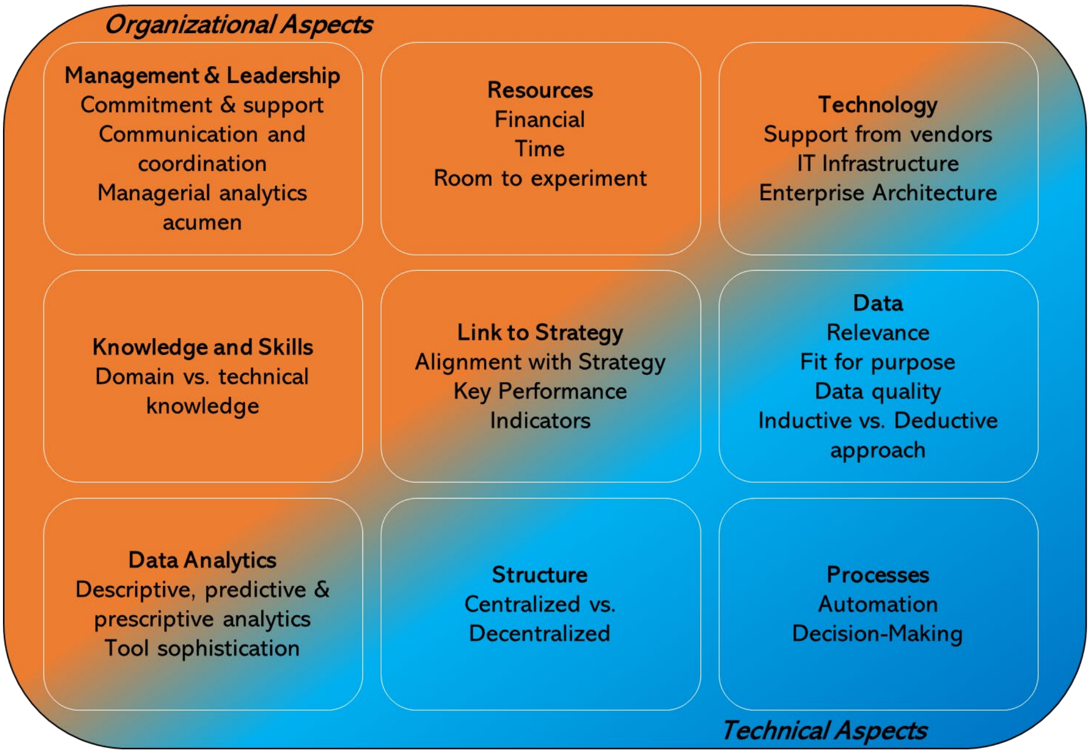

Figure 1. Conceptual Framework

Similarly, *Processes* need to be adjusted in parallel to structure, to ensure that decision-making processes are aligned with structure as data analytics allow certain decisions or processes to become automated. Processes also need to be re-examined to ensure they are aligned with data requirements. Introducing new digital tools to collect data will require processes to be reviewed. *Data* is both an output of digitalization efforts and an input for further digitalization projects. Many companies struggle with collecting data that is relevant and fit for purpose, but also that is of sufficient quality. Quality is often impacted by the processes generating the data, and by the *Technology* and IT Infrastructure supporting them. The lack of interoperability of systems, standardization and data safety, also fueled by the presence of legacy systems, are all perceived as hindering factors (Harris et al., 2015). In the context of transportation and logistics, the lack of technological standards is fueling incompatibility with supplier, customer, and other partner systems (Evangelista and Sweeney, 2006). This is why *Resources* allocated by management to digitalization and DAC are an important enabler while conversely, the lack of on payback times and return on investment have been identified as barriers (Harris et al., 2015).

Previous research further highlights that while enablers and inhibitors of DAC and digitalization are relatively uniform across industries, organizational context still plays a role in how they should be orchestrated. Transportation and logistics companies have several characteristics that may distinguish them from other types of organizations, leading to the need to examine the enablers and inhibitors of transportation and logistics companies in particular.

3. Multiple Case Study Approach

As the combination of internal and external factors making up the context of each company is unique, the development of DAC can be qualified as a complex phenomenon, rendering a qualitative research approach appropriate (Yin, 2013). A theory elaboration multiple-case study approach was used to examine how transportation and logistics companies can develop their DAC (Ketokivi and Choi, 2014). DCV and known enablers and inhibitors of DAC were used as a starting point, and were expanded to the context of transportation and logistics companies. The unit of analysis for the study was the company, therefore semi-structured interviews with key informants were conducted to investigate the process of developing DAC. For each company, the semi-structured interviews were supplemented with relevant company reports documenting the decision-making processes supporting the development of DAC.

3.1. Case Selection

Purposeful homogenous sampling was applied to select three transportation and logistics companies (Gray, 2014). The three criteria for inclusion were (1) documented interest and efforts in developing DAC, (2) geographical proximity to the researchers, and (3) access to key informants and documents. Key informants were selected based on the extent of their involvement in decisions related to the development of DAC and were typically in a senior management role, with decision authority. Intake interviews were used to confirm that the selected companies and key informants met the specified criteria. While efforts were made to interview more than one key informant at each company, this was not always possible due to time and availability constraints. Instead, the same key informant was interviewed multiple times.

The three selected transportation and logistics companies are third-party logistics companies (company A, company B and company C). Companies A and B are part of family-owned business groups, whereas company C is part of a publicly traded company. All three companies have expressed the need to take steps towards developing DAC but are at different stages and use different processes. Companies A and C are mostly pushing digitalization initiatives top-down, whereas at company B this process is undertaken bottom-up. Table 1 shows characteristics of each company and the findings of the within-company analysis are shown in section 4.1.

Table 1. Case Study

	Description	Size*	Semi-Structured Interviews	Other Sources
Company A	3rd party logistics provider, part of family-owned conglomerate. Family-owned business.	Fewer than 5 locations, fewer than 250 employees	Intake interview with COO (30′) Interview 1 with COO (75′) Interview 2 with COO (75′)	Public information Company tour (observations) Internal development report
Company B	3rd party logistics provider (transportation, warehousing, value-added services)	Between 5 and 10 locations, between 1000 and 2000 employees	Intake interview with Commercial manager (20′) Interview 1 with Business Intelligence Manager (90′) Interview 2 with warehouse manager (30′)	Public information Warehouse tour (observations) Company presentation
Company C	Benelux subsidiary of international, publicly-traded company. 3rd party logistics provider (transportation, warehousing, value-added services)	Over 10 locations, over 5,000 employees	Intake interview with hq business process improvement (45′) Interview with [warehouse] site manager (60′) Interview with on-site business process improvement (60′)	Company presentation Public information Warehouse tour (observation) Internal continuous improvement report

* on purpose vague for confidentiality reasons

3.2. Data Collection

The complete dataset consisted of interview transcripts, interview and participant observation notes, and documents. Each interview consisted of (a) an introduction by the researcher(s) to the study, (b) the history, motivation, and current status of digitalization at the company, and (c) the various aspects of DAC identified in the literature review. To ensure that all topics relevant to the study objective were addressed, an interview guide was used during each semi-structured interview (shown in Appendix 1). The order and depth in which the topics were discussed differed per interview and per interviewee. When the researchers established retrospectively that a topic had not been addressed sufficiently, a follow-up interview was organized. The majority of interviews were conducted in-person, recorded and transcribed. A minority of follow-up interviews were conducted online. Per the request of one company, interviews were not recorded but instead extensive notes were made by the researchers during and after the interviews. For each company, publicly available materials were gathered to prepare the interviews and supplemented later with company documents. During the first interview, a site visit allowed researchers to gather observations, also documented through notes and included in the dataset.

3.3. Data Analysis

Thematic analysis procedures were applied to analyze the dataset (Braun and Clarke, 2006) and identify enablers and inhibitors of DAC in transportation and logistics companies. Steps included (a) familiarizing with the data, (b) deductive coding with codes developed from the literature reviews supplemented with inductive coding, (c) iteratively formulating themes, and (d) selecting illustrative quotes.

4. Findings

4.1. Case Descriptions

While all three companies sampled are transportation and logistics companies undergoing a process of digitalization and development of their DAC in particular, they each do so in a different way. Company A is a relatively small 3rd party logistics provider, part of a family-owned conglomerate. Company A has recognized the need for digitalization, and in particular the role that digitalization can play in developing new service offerings to customers. Being a relatively small company (less than 250 employees), the Chief Operating Officer (COO) has a good overview of the processes of the organization. The COO is actively pursuing opportunities to himself learn more about digitalization, digital technologies, and data analytics in particular. He is also building a group of employees skilled in data engineering and data science, and getting involved in projects to automate processes.

Company B is a family-owned business that has grown through opportunistic acquisition over a longer period of time. The company focuses on being a reliable low-cost domestic provider but has no specific strategy for growth. The newly acquired businesses (transportation and warehouses) were incorporated in the company network slowly, but not from an IT perspective. For example, each warehouse kept running its own WMS, and these systems remained not linked to each other, nor to the customer order system and TMS. As a result, the company was working with over 20 systems. Initial attempts to harmonize these systems were not successful, however, recently the company completed a major IT project to link these various legacy systems through an outer layer, without however changing them. This was combined with the implementation of a TMS, allowing the company to track orders, which was considered an important step forward in digitalizing. Company B works with small margins, so an important objective related to digitalization was for them to be able to use data and diagnose problems that jeopardize profitability. For example, the company wants to be able to analyze various types of orders to get a better understanding of their profitability. At company B, efforts to develop in the area of digitalization and DAC are fueled by middle-management who recognizes the importance of DAC, especially in relation to customers, but is experiencing resistance both from top management and from employees.

Company C is a global third-party logistics provider. For the purpose of the study, only part of their European operations are included in the study. At company C, both regional headquarters and local subsidiaries recognize the importance of developing DAC to remain at the forefront of a competitive market. The company is pursuing digitalization as a way to improve performance, but also to reduce reliance on human labor. The company has an extensive operational excellence program in place and has a solid track record in experimenting, adopting, and implementing digital technologies. Nevertheless, managers from both headquarters and local subsidiaries experience these more as projects taking place in organizational silos, and less as the development of an organization-wide capability. Company C devotes extensive resources to digital projects both at headquarter and subsidiary level, however it requires a positive return on investment for each project at the subsidiary level. While both headquarters and subsidiaries recognize the importance of digitalization in general, they have different priorities in terms of what aspects should be developed and how.

4.2. Cross case Analysis

The findings of the case studies confirmed, complemented, and supplemented the research framework as shown in Figure 1. In this section, we highlight some of the key findings regarding the development of DAC by transportation and logistics companies that are novel compared to the framework.

Digitalization of the Supply Chain Can Lead to New Competitive Strategies

An important enabler for digitalization and DAC is for companies to link it to their strategies. The findings of the thematic analysis showed that while the benefits of digitalization were recognized, this was not enough for the companies to be able to link these benefits to their strategy. Perceived benefits of digitalization included better insights, data-driven decision-making, automation, and more visibility for customers. The companies in our sample recognized that digitalization could contribute to the quality of their services, customer satisfaction, and cost reductions, all important outcomes. However, both company B and C described a lack of focus of their digitalization efforts, partially explaining the lack of company-wide objectives in this area. Neither company had explicitly formulated goals for digitalization that could be linked to their strategic objectives, relying instead on external pressure. Company B described the urgency of digitalization as "*if you want to move forward like competition does, you really have to make this switch [to digitalization]*" and "*to have the right data available and use this data to to transform it into information where you can steer your business is crucial and important to survive in the current world*." However, the key informant of Company B also recognized that "*you cannot do it all, you have to focus on what fits in your strategy*." Company C described a tension between local subsidiaries and headquarters in linking digitalization objectives to the company strategy: "*digitalization works in so many areas, and that's why I am such a believer in and advocate of digitalization. So it's on the corporate agenda but for it to work in the subsidiaries, I think headquarters needs to decide how it wants to do that*."

Conversely, company A had formulated very specific goals for digitalization, linked to a vision of how their role in the supply chain would evolve in response to digitalization. Company A described an evolution of supply chains from physical to digital "*our customers don't see anything physical anymore. They sit in an office behind a computer and only see a small piece of the chain. But the chain has many more parts that have an impact on their business and that they need to report on*" [Company A – COO] and a corresponding evolution of their role as a third-party logistics provider to a purveyor of information "*for example they need to report on CO_2 emissions, that happens with us, but they need to report on it so we can serve the customers better than way*" [Company A – COO]. Yet, while this company had a vision, it fell short of formulating objectives.

Silos of Digitalization Projects

Even though digitalization and the development of DAC were embraced by all three companies as an important company-wide initiative, the development of DAC took place through digitalization projects. Key informants from the various companies described multiple projects meant to develop one or multiple aspects of DAC. These projects were mostly technical and aimed at connecting systems (Company B and C), introducing automation (Company B and C), capturing data (Company A, B, and C) and improving the quality of data (Company A and B). A few of the described projects also aimed at valorizing data through improved analytics (Company A and B) and sharing more information with external partners (Company A, B and C). Nevertheless, these projects took place in organizational silos, spanning at most 2 or 3 functional areas. For example, Company B had connected their WMSs and TMS through an extra layer to give the customer service departments the ability to track orders. However, this increased visibility only addressed operational objectives of the respective departments, with limited usefulness for other parts of the organization.

Legacy systems and interoperability

An important inhibitor for companies developing their DAC was a lack of interoperability of systems, caused by a variety of reasons. First, a characteristic of transportation and logistics companies is that they have to work with information and thus systems from other companies, mostly customers, but sometimes suppliers. For example, company C operates multi-customer warehouses, and thus has to deal with multiple customer warehouse management systems. Second, another characteristic in this industry is the relatively high incidence of mergers and acquisitions. For example, company B acquired several warehouses and maintained their operating systems, including warehouse management systems. In their own words: "*in the course of the last 10 years [the company] has acquired a few other logistic companies and as a result we have to deal with a quite a complex situation with all kind of warehouse management systems which were the systems of the companies we acquired, and that means it's very difficult to get a good overview of or at least we don't have a common system where we can easily see how every sites is operating because everyone has as its own ICT systems"* [Company B].

Continuity of Operations as Affected by External Stakeholders

An important motivation for companies in our sample to not engage in large improvement projects to their IT infrastructure or operational process, such as harmonizing warehouse management systems within their own company (company B and company C) was the need to preserve the continuity of operations. The transportation and logistics industry is characterized by customer satisfaction being driven by "delivery on time and in full" and thus creating risk aversion for any activity that could endanger this KPI. In company C's words: "*New systems are more complex and take longer to implement. But you don't have the information you need these days and customers do not have the patience*." Furthermore, as the number of supply chain actors increases, the complexity of understanding what processes will be affected by a change in systems increases, further promoting reluctance to change.

Role of External Stakeholders

In addition to customers, digitalization efforts in our sample were heavily influenced by the companies' external stakeholders such as suppliers, other supply chain actors, and software vendors. These stakeholders affected the case organizations in different ways, such as supplying data, requiring data, imposing (legal) constraints, or operational requirements. For example, company A expressed being highly dependent on arrival times of vessels, however not having an efficient way to acquire and valorize this data to improve their own operations. Acquiring this information would help them improve the efficiency of their operations, and visibility for their customers.

The large number of stakeholders impacting or being impacted by the case companies illustrated the complexity of transportation and logistics operations. These companies are part of a larger ecosystem, where each supply chain actor interacts with many more supply chain actors, and it is difficult to formulate standards.

Lack of In-Company Knowledge and Role of Middle Management

All three case companies expressed a lack of in-company knowledge to steer decisions about digitalization and the development of DAC in a way that fit with strategic objectives and operational constraints. The lack of knowledge was felt particularly strongly in middle-management. Middle-management was seen as a catalyst for change due to their role in recognizing (digitalization) talent, knowledge of processes, role in allocating resources, and making decisions about processes. Furthermore, middle management was expected to model data-driven decision-making, thereby acting as an agent of change for the rest of the organization. Nevertheless, middle-managers were perceived being too much part of the current culture. As company B explained: *"if you look at the people working on our let's say middle management level in the company, I think in 80 or 90% of the cases people have already working for the company for decades and have grown up in the situation. They are very operationally driven and decide more from experience, gut feeling and instinct side. More than from the fact side."* This lack of knowledge of digitalization was also felt in other layers of the organization, as an inhibitor to the organizational change required for digitalization. As the business process improvement manager of Company C noted: "*we have a lot of people who work here for the majority of their careers, so they they don't have a clue what else is out there. So the change management perspective, I think that requires a change*." Company C had the most extensive access to expertise, due to the scale of the organization, through their headquarters. However, the final decision to adopt technological innovations was made at the subsidiary level, and thus dependent on the knowledge and expertise of the middle management. Company A was different in that the Chief Operating Officer was actively engaged in learning about digitalization themselves, and using this knowledge to (a) build a team of experts, and (b) decide which digitalization projects the company would pursue.

New Technological Developments

Many of the projects that the companies were pursuing were either not started, or unsuccessfully completed. For example, Company B described several attempts at harmonizing the various warehouse management systems employed at their different locations. These attempts were repeatedly undertaken with the aid of consultants yet failed. An ultimate attempt succeeded, not by replacing the various systems by a single one, but by building a supplemental layer around existing (legacy) systems using cloud technology. This allowed Company B to bypass the issue of maintaining operational continuity and keep working on their legacy systems while experimenting with data analytics applications. Similarly, company A recognized the need to connect various sources of data in a dynamic way. Company A chose to do so by building solutions in-house using low code and using third-party IT integrators whenever possible. In their case, the prior knowledge acquired by the COO and their willingness to experiment was essential in making these decisions.

5. Discussion

Digital transformation requires transportation and logistics to develop their DAC through a sequence of digitization and digitalization projects. Our findings show that the development of DAC by transportation and logistics companies is in many ways subject to the same enablers and inhibitors as other industries, namely linking digitalization efforts to the company strategy and management lacking appropriate knowledge of digitalization and thereby having difficulties making decisions (Kokkinou et al., 2023a; Mikalef et al., 2018). The companies in our sample were therefore not able to engage in the development of DAC, focusing instead on self-contained digitization and digitalization projects spanning at most two or three departments.

Complementing prior research, we found that the lack of interoperability of systems was a more severe inhibitor in the transportation and logistics industry as opposed to other industries (Harris et al., 2015). Yet, information integration between companies and their third party logistics providers is an important drive of company performance in the context of supply chain management (Jayaram and Tan, 2010). Transportation and logistics companies' processes and their data flows are profoundly intertwined with those of other actors in the supply chain, yet subject to a lack of standardization (Harris et al., 2015). to their history of mergers and acquisitions, and the overreliance on legacy systems. The strong operational focus on continuity of operations further inhibits the prioritization of digitalization.

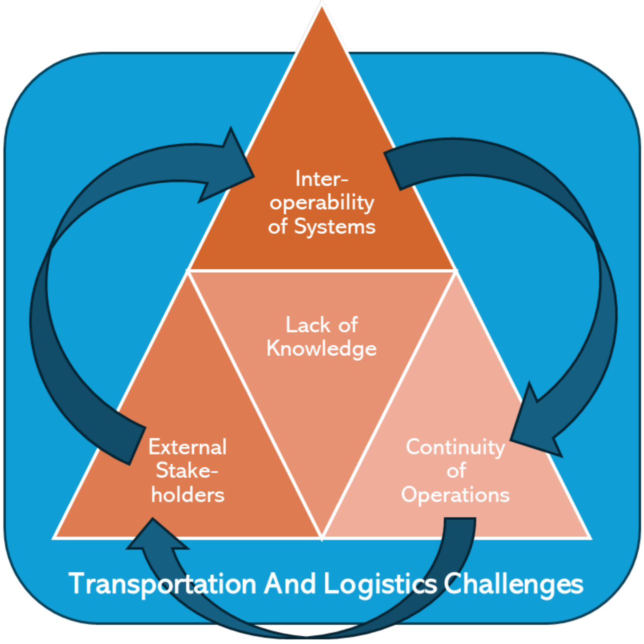

Figure 2. Inhibitors of DAC of Transportation and Logistics Companies

The lack of standardization apparent in the industry is thus a much more serious threat than previously acknowledged in the literature (Evangelista and Sweeney, 2006). Also, these companies typically prioritize the continuity of operations, and thus lag in dealing with legacy and other systems following, for example, mergers and acquisitions. These three inter-related inhibitors: lack of interoperability of systems, fueled also by the reliance on external stakeholders for data flows, and the complexity they cause in ensuring continuity of operations (see Figure 2) are thus an impediment to transportation and logistics developing their DAC in a company-wide and comprehensive manner.

An important development taking place that can contribute to solving this issue is the advent of AI-powered platforms which are improving the speed and efficiency with which third-party integration platforms can be deployed to harmonize systems. Instead of replacing key systems like WMS and ERP, transportation and logistics companies are taking increased advantage of the possibility to easily couple them.

6. Limitations & Recommendations for Future Research

The sample for this study consisted of case studies conducted with transportation and logistics companies. While this research approach enables the in-depth analysis of how context influences the development of DAC, is also obviously limits the generalizability of the findings. Furthermore, the study was limited to the focal companies, not including data collection directly for the other actors in the supply chain. Future research should investigate more in-depth the issue of interoperability of systems by using the network of actors as the unit of analysis.

This study identified the role of third-party IT integrators as a possible solution. Nevertheless, this approach may also have disadvantages not yet apparent without a longitudinal approach. Further research should take a longitudinal approach to examine the development and implementation of such solutions, and track them over time to examine the impact of relying in legacy systems in relation to more recent applications.

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References

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. https://doi.org/10.1016/j.rtbm.2020.100525

Awan, U., Shamim, S., Khan, Z., Zia, N.U., Shariq, S.M., Khan, M.N., 2021. Big data analytics capability and decision-making: The role of data-driven insight on circular economy performance. Technological Forecasting and Social Change 168, 120766. https://doi.org/10.1016/j.techfore.2021.120766

Barney, J., 1991. Firm Resources and Sustained Competitive Advantage. Journal of Management 17, 99–120. https://doi.org/10.1177/014920639101700108

Björkdahl, J., 2020. Strategies for Digitalization in Manufacturing Firms. California Management Review 62, 17–36. https://doi.org/10.1177/0008125620920349

Brandon-Jones, E., Squire, B., Autry, C.W., Petersen, K.J., 2014. A Contingent Resource-Based Perspective of Supply Chain Resilience and Robustness. J Supply Chain Manag 50, 55–73. https://doi.org/10.1111/jscm.12050

Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. Qualitative Research in Psychology 3, 77–101. https://doi.org/10.1191/1478088706qp063oa

Dubey, R., Gunasekaran, A., Childe, S.J., 2019. Big data analytics capability in supply chain agility: The moderating effect of organizational flexibility. MD 57, 2092–2112. https://doi.org/10.1108/MD-01-2018-0119

Eisenhardt, K.M., Martin, J.A., 2000. Dynamic capabilities: what are they? Strategic management journal 21, 1105–1121.

Ellström, D., Holtström, J., Berg, E., Josefsson, C., 2022. Dynamic capabilities for digital transformation. JSMA 15, 272–286. https://doi.org/10.1108/JSMA-04-2021-0089

Evangelista, P., Sweeney, E., 2006. Technology usage in the supply chain: the case of small 3PLs. The International Journal of Logistics Management 17, 55–74. https://doi.org/10.1108/09574090610663437

Fosso Wamba, S., Akter, S., Edwards, A., Chopin, G., Gnanzou, D., 2015. How 'big data' can make big impact: Findings from a systematic review and a longitudinal case study. International Journal of Production Economics 165, 234–246. https://doi.org/10.1016/j.ijpe.2014.12.031

Garmaki, M., Boughzala, I., Wamba, S.F., 2016. The effect of Big Data Analytics Capability on Firm Performance. Presented at the PACIS, p. 301.

Ghasemaghaei, M., Hassanein, K., Turel, O., 2017. Increasing firm agility through the use of data analytics: The role of fit. Decision Support Systems 101, 95–105. https://doi.org/10.1016/j.dss.2017.06.004

Gray, D.E., 2014. Doing research in the real world, 3. ed. ed. Sage, Los Angeles, Calif.

Gupta, M., George, J.F., 2016. Toward the development of a big data analytics capability. Information & Management 53, 1049–1064. https://doi.org/10.1016/j.im.2016.07.004

Harris, I., Wang, Y., Wang, H., 2015. ICT in multimodal transport and technological trends: Unleashing potential for the future. International Journal of Production Economics 159, 88–103. https://doi.org/10.1016/j.ijpe.2014.09.005

Helfat, C.E., Peteraf, M.A., 2009. Understanding dynamic capabilities: progress along a developmental path. Strategic Organization 7, 91–102. https://doi.org/10.1177/1476127008100133

Jayaram, J., Tan, K.-C., 2010. Supply chain integration with third-party logistics providers. International Journal of Production Economics 125, 262–271. https://doi.org/10.1016/j.ijpe.2010.02.014

Kagermann, H., Hellinger, A., Wahlster, W., 2013. Recommendations for Implementing the Strategic Initiative Industrie 4.0: Securing the Future of German Manufacturing Industry, Final report of the Industrie 4.0 Working Group. Communication Promoters Group of the Industry-Science Research Alliance, Frankfurt, Germany.

Ketokivi, M., Choi, T., 2014. Renaissance of case research as a scientific method. J of Ops Management 32, 232–240. https://doi.org/10.1016/j.jom.2014.03.004

Kokkinou, A., Kollenburg, T. van, Mandemakers, A., 2023a. Development of data analytic capability in organizations, in: Presented at the 2023 EUROMA Conference. Leuven, Belgium.

Kokkinou, A., Kollenburg, T. van, Mandemakers, A., Hopstaken, E., Elderen, J. van, 2023b. The Data Analytic Capability Wheel: an implementation framework for digitalization, in: Pucihar, A., Kljajić Borštnar, M., Bons, R., Ongena, G., Heikkilä, M., Vidmar, D. (Eds.), Proceeedings of the 36th Bled eConference Digital Economy and Society: Balancing Act for Digital Innovation in Times of Instability: June 25 - 28,. Univerza v Mariboru, Univerzitetna založba, Bled, Slovenia.

Kokkinou, A., Kollenburg, T. van, van Doren, S., Matthijssen, G., Visser, E., under review. Enablers and inhibitors of digitalization as part of continuous improvement. International Journal of Lean Six Sigma.

Kokkinou, A., Mandemakers, A., Mitas, O., 2023c. Developing Resilient and Robust Supply Chains through Data Analytic Capability. Continuity & Resilience Review 5, 320–342. https://doi.org/10.1108/CRR-07-2023-0013

Kokkinou, A., Mandemakers, A., Mitas, O., 2022. Data-analytic capability as a path to a resilient supply chain: an empirical investigation, in: Presented at the 2022 EurOMA Conference. Presented at the EUROMA, Berlin.

Laaksonen, O., Peltoniemi, M., 2018. The essence of dynamic capabilities and their measurement. International Journal of Management Reviews 20, 184–205.

Legner, C., Eymann, T., Hess, T., Matt, C., Böhmann, T., Drews, P., Mädche, A., Urbach, N., Ahlemann, F., 2017. Digitalization: Opportunity and Challenge for the Business and Information Systems Engineering Community. Bus Inf Syst Eng 59, 301–308. https://doi.org/10.1007/s12599-017-0484-2

Machado, C.G., Winroth, M., Carlsson, D., Almström, P., Centerholt, V., Hallin, M., 2019. Industry 4.0 readiness in manufacturing companies: challenges and enablers towards increased digitalization. Procedia CIRP 81, 1113–1118. https://doi.org/10.1016/j.procir.2019.03.262

Mikalef, P., Krogstie, J., 2020. Examining the interplay between big data analytics and contextual factors in driving process innovation capabilities. European Journal of Information Systems 29, 260–287. https://doi.org/10.1080/0960085X.2020.1740618

Mikalef, P., Pappas, I.O., Krogstie, J., Giannakos, M., 2018. Big data analytics capabilities: a systematic literature review and research agenda. Inf Syst E-Bus Manage 16, 547–578. https://doi.org/10.1007/s10257-017-0362-y

Mikalef, P., Van de Wetering, R., Krogstie, J., 2019. From Big Data Analytics to Dynamic Capabilities:: The Effect of Organizational Inertia. Presented at the Pacific Asia Conference on Information Systems, AIS Electronic Library, pp. 1–14.

Papert, M., Pflaum, A., 2017. Development of an Ecosystem Model for the Realization of Internet of Things (IoT) Services in Supply Chain Management. Electron Markets 27, 175–189. https://doi.org/10.1007/s12525-017-0251-8

Perego, A., Perotti, S., Mangiaracina, R., 2011. ICT for logistics and freight transportation: a literature review and research agenda. International Journal of Physical Distribution & Logistics Management 41, 457–483. https://doi.org/10.1108/09600031111138826

PWC, 2023. How much is technology transforming supply chains?

Rosin, F., Forget, P., Lamouri, S., Pellerin, R., 2020. Impacts of Industry 4.0 technologies on Lean principles. International Journal of Production Research 58, 1644–1661. https://doi.org/10.1080/00207543.2019.1672902

Sectorinstituut Transport en Logistiek, 2023a. Uitdagingen op de arbeidsmarkt nemen toe.

Sectorinstituut Transport en Logistiek, 2023b. Sectormonitor 2023 Q2.

Shahin, M., Chen, F.F., Bouzary, H., Krishnaiyer, K., 2020. Integration of Lean practices and Industry

4.0 technologies: smart manufacturing for next-generation enterprises. Int J Adv Manuf Technol 107, 2927–2936. https://doi.org/10.1007/s00170-020-05124-0

Supply Chain Magazine, 2023. Uitdagingen arbeidsmarkt transport en logistiek nemen toe.

Teece, D.J., 2007. Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. Strat. Mgmt. J. 28, 1319–1350. https://doi.org/10.1002/smj.640

Transport and Logistiek Nederland, 2023. Duurzaamheid.

Tsonkova, A., 2018. Digitalization in Transport and Logistics—Modern Challenges and Opportunities. Int. J. Innov. Manag. Technol. 9, 108–111.

Wamba, S.F., Gunasekaran, A., Akter, S., Ren, S.J., Dubey, R., Childe, S.J., 2017. Big data analytics and firm performance: Effects of dynamic capabilities. Journal of Business Research 70, 356–365. https://doi.org/10.1016/j.jbusres.2016.08.009

Wang, C.L., Ahmed, P.K., 2007. Dynamic capabilities: A review and research agenda. Int J Management Reviews 9, 31–51. https://doi.org/10.1111/j.1468-2370.2007.00201.x

Yin, R.K., 2013. Validity and generalization in future case study evaluations. Evaluation 19, 321–332. https://doi.org/10.1177/1356389013497081

Yu, D., Tao, S., Hanan, A., Ong, T.S., Latif, B., Ali, M., 2022. Fostering Green Innovation Adoption through Green Dynamic Capability: The Moderating Role of Environmental Dynamism and Big Data Analytic Capability. IJERPH 19, 10336. https://doi.org/10.3390/ijerph191610336

Yu, W., Wong, C.Y., Chavez, R., Jacobs, M.A., 2021. Integrating big data analytics into supply chain finance: The roles of information processing and data-driven culture. International Journal of Production Economics 236, 108135. https://doi.org/10.1016/j.ijpe.2021.108135