



Lisbon School
of Economics
& Management
Universidade de Lisboa

MASTER MANAGEMENT & INDUSTRIAL STRATEGY

MASTER'S FINAL WORK DISSERTATION

**TRANSPORT MANAGEMENT SYSTEM IMPLEMENTATION IN A
PHARMACEUTICAL SUPPLY CHAIN: EFFECTS ON OPERATIONAL
EFFICIENCY, TRANSPARENCY, AND COLLABORATION**

ALEX AARON COHEN BERENGUER

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*To my family that were
asking me when I would
deliver the thesis so they can
buy the tickets to attend the
graduation, here is the proof.
Mission completed.*

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First, I wish to thank Professor Graça M. Silva for her guidance on this study and continued support through this journey. Your significant contributions were key to conduct and delivery this study.

To my family, especially my parents and siblings, that even though the distance they kept me motivated in the most challenging days.

Finally, to my friends in Portugal, you have been part of my extended family since the first day I arrived. Thanks all for your support on this journey, I will never forget it.

ABSTRACT

This study provides an empirical analysis of the effect of implementing SAP TM on transport operations, information transparency and collaboration with transport service providers (TSPs) within an anonymised pharmaceutical company operating a capability centre in Portugal. In light of the limited empirical evidence on transport digital systems in pharmaceutical supply chains, the study adopted an exploratory qualitative case study approach. Data were collected through four semi-structured interviews with employees from supply chain planning, global transportation and warehouse operations, conducted approximately six months after the implementation of the system. The interview data were analysed using thematic analysis.

The findings suggest that SAP TM has standardised routine transport activities, reduced the time spent searching fragmented information sources, integrated transport requirements into the planning process earlier, and centralised shipment and performance information. However, automation did not eliminate manual work entirely. Inaccurate package calculations, system bugs, incomplete process integration and late operational changes continued to necessitate manual validation and generate additional work. Information transparency improved due to greater access to shipment milestones and route information, as well as the enhanced use of data for monitoring carrier performance. Nevertheless, the reliability of this visibility remained dependent on timely and accurate updates from the TSPs' systems. Although collaboration became more structured for routine information exchange, uneven carrier adoption and technical integration difficulties meant that email and telephone communication remained necessary for urgent or complex situations.

These findings provide empirical insight into the adoption of TMS at an early stage in the pharmaceutical transportation sector and reinforce the understanding of digital transformation as an ongoing organisational and inter-organisational process.

Keywords: pharmaceutical supply chain digitalization, transport management system, transport service provider, visibility, operational efficiency, collaboration.

RESUMO

Este estudo apresenta uma análise empírica dos efeitos da implementação do SAP TM nas operações de transporte, na transparência da informação e na colaboração com os prestadores de serviços de transporte (TSPs) numa empresa farmacêutica anonimizada com um centro de competências em Portugal. Face à limitada evidência empírica existente sobre sistemas digitais de transporte nas cadeias de abastecimento farmacêuticas, o estudo adotou uma abordagem exploratória de estudo de caso qualitativo. Os dados foram recolhidos através de quatro entrevistas semiestruturadas realizadas a colaboradores das áreas de planeamento da cadeia de abastecimento, transporte global e operações de armazém, aproximadamente seis meses após a implementação do sistema. Os dados das entrevistas foram analisados através de análise temática.

Os resultados sugerem que o SAP TM permitiu normalizar as atividades rotineiras de transporte, reduzir o tempo despendido na procura de informação dispersa por diferentes fontes, integrar os requisitos de transporte mais cedo no processo de planeamento e centralizar a informação relativa a expedições e desempenho. No entanto, a automatização não eliminou totalmente o trabalho manual. Cálculos incorretos de volumes de expedição, falhas do sistema, integração incompleta dos processos e alterações operacionais tardias continuaram a exigir validações manuais e a gerar trabalho adicional. A transparência da informação melhorou devido ao maior acesso aos marcos das expedições e à informação sobre rotas, bem como à utilização mais eficaz dos dados para monitorizar o desempenho dos transportadores. Contudo, a fiabilidade desta visibilidade continuou dependente da atualização atempada e precisa dos dados nos sistemas dos TSPs. Embora a colaboração se tenha tornado mais estruturada para a troca de informação de rotina, a adoção desigual pelos transportadores e as dificuldades de integração técnica fizeram com que a comunicação por correio eletrónico e telefone continuasse a ser necessária em situações urgentes ou mais complexas.

Estes resultados fornecem evidência empírica sobre a adoção de sistemas de gestão de transportes (TMS) numa fase inicial do setor do transporte farmacêutico e reforçam a compreensão da transformação digital como um processo organizacional e interorganizacional contínuo.

Palavras-chave: digitalização da cadeia de abastecimento farmacêutica, sistema de gestão de transportes, prestador de serviços de transporte, visibilidade, eficiência operacional, colaboração

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GLOSSARY

TMS – Transport/Transportation Management System

SAP TM – SAP Transportation Management

AI – Artificial Intelligence

TSP – Transport Service Provider

API – Active Pharmaceutical Ingredient

EDI – Electronic Data Interchange

ERP – Enterprise Resource Planning

ETA – Estimated Time of Arrival

IoT – Internet of Things

IT – Information Technology

KPI – Key Performance Indicator

PSC – Pharmaceutical Supply Chain

ROI – Return on Investment

1. INTRODUCTION

Supply chains connect suppliers, manufacturing sites, distribution centres, transport providers, and customers. As supply chains become more global and complex, organizations require accurate and timely information to coordinate activities and support effective decision-making. Consequently, digital technologies have become an important enabler of supply chain integration by improving information sharing, process coordination, and collaboration among supply chain partners (Plekhanov et al., 2023; Seyedghorban et al., 2020).

Digitalization is particularly relevant in the pharmaceutical industry, where supply chains operate under strict regulatory requirements to ensure product quality, traceability, and patient safety. Pharmaceutical transportation frequently involves temperature-sensitive products, specialized packaging, international distribution networks, and extensive documentation requirements. These characteristics increase the need for reliable information, real-time visibility, and close coordination between internal functions and external transport providers (Ashiwaju et al., 2023; Ma et al., 2023).

Transportation is therefore a critical component of pharmaceutical supply chains because it links manufacturing, distribution, and customer delivery while ensuring that medicines reach patients safely and on time. Delays, incomplete information, or poor communication may compromise product availability, delivery performance, regulatory compliance, and ultimately patient care. Accordingly, effective transportation relies on information visibility and coordination across supply chain partners, which have been identified as key drivers of supply chain integration and operational performance (Caridi et al., 2010; Schoenherr & Swink, 2012).

Transport Management Systems (TMS) can support these activities by integrating transport planning, shipment execution, monitoring, and reporting within a single digital platform. These systems can reduce manual activities, improve access to transport information, and create more structured collaboration with Transport Service Providers (TSPs) (Helo & Thai, 2024). Moreover, digital technologies

support real-time information exchange and data-driven decision-making, enabling organizations to improve transport coordination and operational performance across supply chain partners (Franco et al., 2024). Understanding how these systems influence day-to-day transport operations is therefore an important area of research.

Although supply chain digitalization has received considerable attention in the literature, most studies examine digital transformation at a broad organizational level. Comparatively little empirical research has investigated how transport-focused digital systems, such as Transport Management Systems (TMS), influence transport operations, information transparency, and collaboration with Transport Service Providers within pharmaceutical supply chains (Wang & Sarkis, 2021). This research gap is particularly relevant because pharmaceutical transportation presents unique operational and regulatory requirements that differ from those of many other industries.

To address this gap, this study examines the implementation of SAP Transportation Management (SAP TM) in Company XYZ, an anonymized pharmaceutical company with a capability centre in Portugal. Prior to the implementation of SAP TM, transport information was managed through multiple systems and communication channels, resulting in fragmented information, limited visibility, and extensive manual follow-up activities.

Company XYZ implemented SAP TM across its European and Middle East operations (EMEA) in November 2025 as part of its digital transformation programme. The system was introduced to support transport planning, carrier integration, shipment monitoring, and performance reporting. Approximately six months after implementation, this study examines how SAP TM has influenced transport operations, information transparency, and collaboration with Transport Service Providers. Accordingly, this study seeks to answer the following research question: How has the implementation of SAP TM influenced transport operations, information transparency, and collaboration with Transport Service Providers at Company XYZ?

Specifically, this study has four objectives:

1. To identify the main operational changes resulting from SAP TM implementation in transport planning, execution, and monitoring;
2. To examine how SAP TM influences information transparency and shipment visibility;
3. To understand how SAP TM affects communication and coordination with Transport Service Providers; and
4. To identify the implementation challenges that limit the realization of the expected benefits.

The study adopts an exploratory qualitative case study approach. Primary data were collected through semi-structured interviews with employees from Supply Chain Planning, Global Transportation, and Warehouse Operations. The interview data were analyzed using thematic analysis, combining deductive codes derived from the literature with inductive codes that emerged from the empirical data.

The remainder of this dissertation is organized into five chapters. Following this introduction, Chapter 2 reviews the literature on supply chain digitalization, pharmaceutical supply chains, and Transport Management Systems. Chapter 3 presents the research methodology, including data collection and analysis procedures. Chapter 4 reports and discusses the empirical findings in relation to the existing literature. Finally, Chapter 5 concludes by presenting the study's theoretical and managerial contributions, limitations, and recommendations for future research.

2. LITERATURE REVIEW

2.1 Conceptual Foundations of Digitalization in Supply Chain

- *Digitalization in Supply Chain*

Supply chain digitalization refers to the integration of digital technologies, including cloud computing, the Internet of Things, blockchain, artificial intelligence, and advanced analytics, into supply chain processes in order to enhance information flows, decision-making, coordination, and collaboration among supply chain partners. It has been described as a shift from traditional information systems, such as electronic data interchange, towards integrated digital ecosystems enabled by interconnected technologies and data-driven capabilities (Seyedghorban et al., 2020). Rather than representing a single technological intervention, supply chain digitalization is widely understood as a multidimensional phenomenon involving technological integration, process automation, data connectivity, and inter-organizational information exchange (Mugurusi et al., 2021). The absence of universally accepted measurement frameworks further suggests that digitalization should be conceptualized as a combination of technological capabilities and broader organizational transformation processes.

In the digital era, supply chains are increasingly moving away from linear and sequential structures towards networked, data-driven ecosystems (Hennelly et al., 2020). This transformation is particularly relevant in industries such as pharmaceuticals, where traceability, cold chain management, regulatory compliance, and product integrity are critical operational requirements. Within this context, digital transformation should not be understood solely as the adoption of new technologies, but as an organizational transformation that affects processes, capabilities, and business models (Plekhanov et al., 2023). Successful digital transformation therefore requires the alignment of technology investments with strategic and operational objectives. In supply chain management, this means that digital tools such as transport management systems create value not only through automation, but also through enhanced coordination, responsiveness, visibility, and decision-making capabilities.

Artificial intelligence and big data analytics are increasingly recognized as central components of supply chain digitalization. The combination of AI and big data enables predictive decision-making, automation, and intelligent coordination across Industry 4.0 environments (Jagatheesaperumal et al., 2021). In supply chain management, AI applications support operational planning, predictive logistics, exception management, and decision support, thereby improving responsiveness and the quality of managerial decisions (Abyaneh et al., 2025; Helo & Hao, 2022). These technologies contribute to the development of more adaptive and intelligence-based supply chain processes, particularly where timely information processing and rapid operational responses are required.

These ideas emphasize that digitalization is not only merely a technological upgrade, but also a strategic reorientation that reshapes relationships with suppliers, customers and logistics providers. Digitalization also represents a strategic reorientation that reshapes relationships with suppliers, customers, and logistic providers by automating planning and execution processes reducing operational inefficiencies and improving the coordination of supply chain activities (Queiroz et al., 2022). Improvements in operational efficiency, responsiveness, and information management have also been associated with supply chain digitalization, contributing positively to organizational performance (Rajala & Makkonen, 2026). Similarly, adopting digital technologies strengthens supply chain capabilities by improving coordination, responsiveness and information management across supply chain operations (Jia et al., 2026). This indicates that digital technologies enable organizations to develop more adaptive and collaborative processes, supporting operational improvement and continuous innovation across supply chain activities.

However, the benefits of supply chain digitalization should not be assumed to occur automatically. The relationship between digital technology adoption and performance is contingent on organizational capabilities, managerial readiness, and environmental dynamism (Dubey et al., 2020). This challenges technologically deterministic views of digitalization and highlights the importance of complementary organizational resources, such as digital skills, process integration, data governance, and strategic alignment. Consequently, digitalization should be assessed not only in terms of technological

implementation, but also in terms of its capacity to generate operational and strategic value.

A distinction can also be made between the implementation and operational dimensions of supply chain digitalization. Implementation dimensions relate to technology adoption, infrastructure development, data integration, and system deployment, whereas operational dimensions concern visibility, agility, integration, responsiveness, and performance improvement (Deepu & Ravi, 2023; Zahid et al., 2025). This distinction is particularly relevant for understanding systems such as transport management systems, which move beyond technical deployment to influence operational outcomes. From this perspective, the value of digitalization lies not only in the introduction of digital tools, but in their effective integration into supply chain processes and their contribution to improved coordination, decision-making, and operational performance.

2.2 The Pharmaceutical Industry and the Digital Transformation

The pharmaceutical sector faces unique challenges, including complex regulatory environments, the need for cold chain logistics, vulnerability to counterfeiting and the requirement for a rapid response during health crises (Ashiwaju et al., 2023).

Digital technologies address these challenges by enabling real-time monitoring, secure data sharing and end-to-end traceability. In particular, digital transformation has been associated with improvements in the economic, social, and environmental dimensions of pharmaceutical supply chain performance, with information sharing and traceability acting as key mechanisms through which these benefits are achieved (Ma et al., 2023).

Recent disruptions, such as the pandemic and the conflict in the Middle East, have exposed vulnerabilities in the pharmaceutical sector. These disruptions affect access to critical medicines and lead to shortages of drugs, active pharmaceutical ingredients (APIs), and medical supplies (Papalexi et al., 2026). Organizations with higher levels of digital integration have demonstrated greater adaptability when responding to unexpected

changes in demand and supply disruptions, reinforcing the role of digital technologies in improving supply chain resilience (Özdemir et al., 2022).

The contribution of Industry 4.0 technologies to pharmaceutical supply chain resilience has also received increasing attention in recent literature. Digital technologies support organizations in anticipating, adapting to, and recovering from supply chain disruptions by strengthening resilience capabilities throughout the supply chain (Papalexi et al., 2026). The conceptual model presented in Figure 1 illustrates how Industry 4.0 technologies contribute to the development of resilient pharmaceutical supply chains by improving the organizational capabilities.

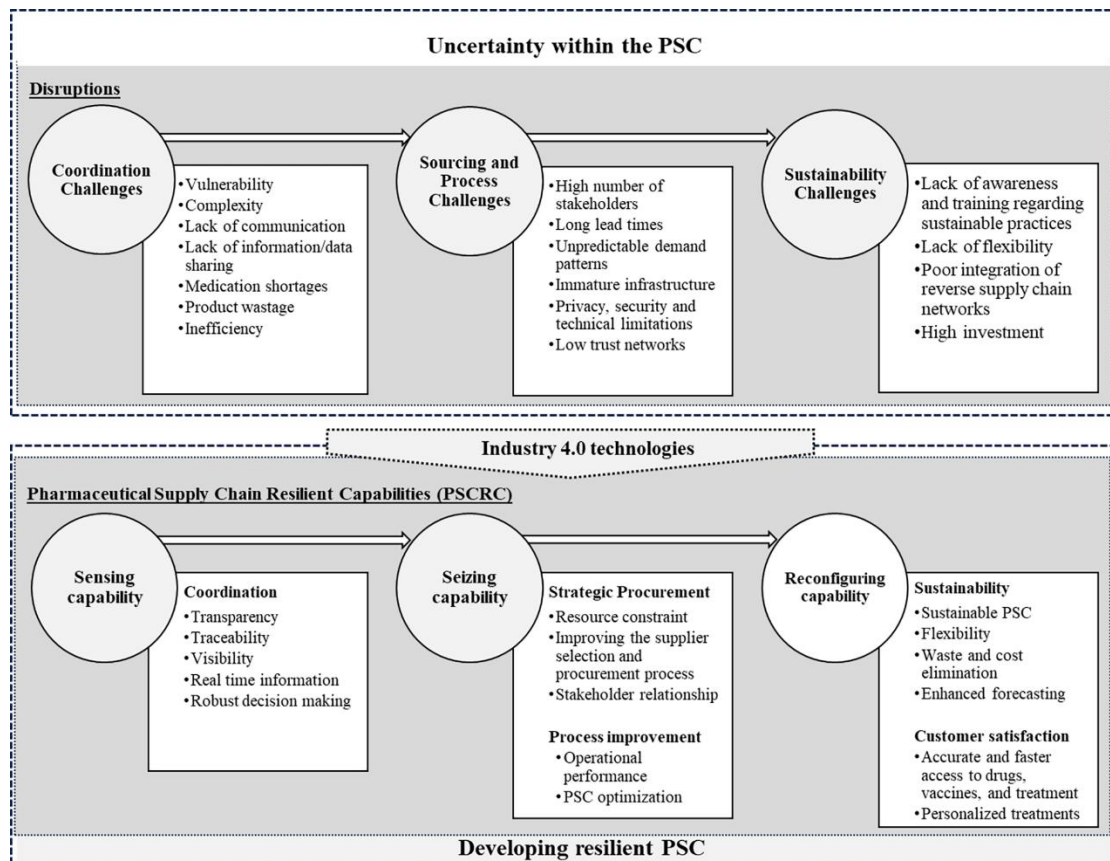


Figure 1. Conceptual Model of the pharma supply chain resilience capabilities with industry 4.0.

Source: Adapted from Papalexi et al. (2026).

Similarly, resilience can be strengthened through proactive risk management, diversifying their sourcing of raw materials and active pharmaceutical ingredients (APIs), bringing manufacturing plants back to their home countries, and investing in digital technologies (Naz et al., 2022). Adopting digitalization is linked to using Industry 4.0 technologies, which have emerged as a solution for improving traceability, visibility, flexibility, responsiveness and adaptability within complex, global networks (Chen, 2023; Chen et al., 2022). Furthermore, improvements in supply chain performance are achieved not simply through technology implementation, but through enhanced integration and visibility across supply chain partners, highlighting the importance of coordination as a mechanism linking digitalization and operational performance (Reaidy et al., 2026). This specific perspective is relevant in pharmaceutical logistics, as coordination among manufacturing sites, distributors, and transport providers is critical.

Although the digital transformation of PSC considers a wide range of technologies, its operational impact is most evident at the level of logistics execution. This is particularly evident in transportation, where digital capabilities are translated into performance outcomes. In this context, Transport Management Systems (TMS) are a key contributor, improving relationships with service providers by facilitating collaboration and integration, increasing operational efficiency through automation and optimization, and improving transparency across the supply chain by enabling tracking and tracing.

Beyond the operational improvements, digitalization has also become an important component of supply chain risk management. Enhanced visibility, predictive analytics, and real-time monitoring capabilities enable organizations to anticipate disruptions more effectively and respond proactively to operational risks, thereby strengthening resilience across complex global supply chains (Ghanbari et al., 2025).

2.3 Transport Management Systems (TMS)

- *The role of TMS in the digitalization of the supply chain*

While the broader literature on supply chain digitalization is well developed, the specific role of transport digital systems such as Transport Management Systems (TMS) remain not as explored as other systems in other top-tier journals. However, research on transport digitalization and logistics technologies provides a good theoretical and empirical base for understanding the importance of digital transport solutions in

improving coordination, visibility and operational efficiency across supply chains (Dolgui et al., 2020; Helo & Thai, 2024; Wang & Sarkis, 2021).

Research on logistics digitalization confirms that IT systems improve operational efficiency, reduce uncertainty, and enhance coordination across logistics networks (Wang & Sarkis, 2021). Moreover, Digital technologies are central to improving coordination, efficiency, and resilience in transport operations (Dolgui et al., 2020). Within the context of Logistics 4.0, smart connected systems further strengthen transportation management by enabling real-time tracking, end-to-end visibility, and data-driven decision-making throughout logistics operations (Helo et al., 2024). Similarly, Xue et al. (2026) explains that IoT implementation improves supply chain performance through improved information integration and reduced decision-making uncertainty. The review suggested that real-time data collection and connectivity enable more accurate and responsive operational decisions across supply chain activities, which within transportation, these capabilities support shipment monitoring, coordination and visibility.

In this context, TMS can be considered an important enabler of transport digitalization, as it integrates: transport planning, execution of shipments, monitoring, and performance management. The effectiveness of these systems is closely linked to the development of supply chain visibility capabilities. argued that supply chain visibility capabilities vary according to operational context and information requirements (Swink et al., 2024). In transportation environments, visibility depends basically on real-time operational data, shipment monitoring and event management capabilities. From this specific perspective, TMS functions as critical visibility-enabling systems by integrating transport execution, tracking, and communication processes.

As highlighted by Dubey et al. (2020), empirical evidence also shows that digitalization improves logistics efficiency and performance. At the transport level, contributes to these outcomes by:

- Optimizing routing decisions
- Improving planning
- Enhancing delivery reliability
- Reducing operational variability

Greater visibility also contributes directly to operational performance, and reducing information uncertainty enables organisations to make faster and more accurate decisions while improving routing, shipment management, and service reliability (Caridi et al., 2014). Within transportation management, visibility generated through digital systems supports proactive shipment management, improved routing decisions, and enhanced service reliability. Additionally, Queiroz et al. (2022) highlights that effective information exchange across organizations is essential for supply chain coordination. TMS plays a critical role in enabling this by standardizing communication with transport service providers.

2.4 Efficiency gains from Digital Transportation Management

In a survey of manufacturing firms in Malaysia, Lee et al. (2022) found that the implementation of digital supply chain technologies, including Transportation Management Systems (TMS), had led to a significant reduction in order cycle times, improved inventory turnover and enhanced delivery reliability.

The growing use of digital technologies also supports supply chain agility by enabling organisations to respond more effectively, and improvements in data availability and analytical capabilities strengthen managerial decision-making while increasing responsiveness throughout logistics operations (Jafari et al., 2026). In the context of the pharmaceutical industry, Abed et al. (2024) demonstrated that lean-Heijunka models supported by digital logistics platforms can significantly reduce delivery times and associated costs in environments characterized by unpredictable demand. This finding is particularly relevant for pharmaceutical transportation, where demand volatility, driven by factors such as disease outbreaks or regulatory changes, requires rapid responses.

In this context, the PSC requires specialized capabilities from digital transportation solutions. Kyeremeh et al. (2025) studied the Ghanaian PSC and found that integrating technology, particularly real-time tracking and automated alerts, significantly improved supply chain performance by enabling proactive intervention when shipment conditions deviated from specifications.

However, empirical findings are not always consistent. For example, Dubey et al. (2020) highlighted that performance improvements depend on contextual factors, such as organizational readiness and external uncertainty. This suggests that TMS

implementation alone may not guarantee performance gains, challenging the assumptions of this literature.

These findings are consistent with broader industry 4.0 literature, which argues that digital technology such as blockchain and integrated data-sharing platforms enhance operational efficiency by improving visibility, coordination and real-time decision-making across complex supply chains (Bai et al., 2024). Yu et al. (2024) further argue that visibility capabilities enable organizations to implement more resilient logistics practices by combining digital resources with organizational knowledge. Their findings suggested that visibility generated through digital transport systems contributes not only to efficiency, but also to operational adaptability during periods of uncertainty.

While the efficiency gains from TMS adoption are tangible, these systems offer more than just transport operation alignment. By digitizing shipment data and enabling real-time monitoring, TMS systems also play a central role in improving transparency across the supply chain.

2.5 Transparency and Supply Chain Visibility

Information transparency in the supply chain refers to the extent to which partners have access to accurate, timely and complete information about product flows and operational status (An & Qiao, 2025). In the pharmaceutical industry, transparency is not only a competitive advantage, but also a regulatory requirement, with authorities demanding full traceability of medicines from production to administration to patients (Ma et al., 2023).

Recent literature emphasizes that supply chain transparency, visibility and traceability are related but conceptually distinct in terms of concepts. Traceability primarily concerns the ability to monitor the movement of products and materials throughout different supply chain stages, whereas visibility refers to real-time access to operational information and shipment status (Roy, 2021). Transparency extends beyond visibility by involving the intentional disclosure and accessibility of information among supply chain stakeholders Jia et al. (2024). Similarly, supply chain visibility has been defined as a multidimensional capability involving information sharing, coordination, and real-time monitoring across

supply chain actors (Somapa et al., 2018). All of these distinctions are relevant in pharmaceutical supply chains (PSC), where product integrity, regulatory compliance and cold chain monitoring requires both accurate visibility and end to end traceability.

Digital transformation has been associated with improvements in sustainable pharmaceutical supply chain performance through enhanced information sharing and end-to-end traceability (Ma et al., 2023). These capabilities also improve coordination among supply chain partners by increasing the quality, accessibility, and timeliness of operational information while supporting a more efficient allocation of organizational resources (An et al., 2025; Chai et al. 2025). Their results confirmed that digital technologies enable more effective information sharing; however, the realization of transparency benefits depends on the quality of inter-firm relationships and governance structures.

Real time data sharing enabled by blockchain and other digital platforms enhances traceability, reduces operational uncertainty, strengthens trust among supply chain partners, and ultimately contributes to higher operational performance. Block-chain-enabled solutions further enhance transparency, traceability, and coordination by enabling secure, real-time information sharing across logistics networks (Aslam et al., 2025; Fang et al., 2024; Shahadat et al., 2024)

However, transparency does not inherently lead to improved performance. For example, Ma et al. (2023) found that information sharing alone may not produce significant results unless combined with traceability and governance mechanisms. Similarly, Sodero et al. (2019) argue that data availability does not automatically translate into value.

The relationship between visibility and resilience has also received increasing attention in recent literature. Stronger digital supply chain management capabilities improved organizational resilience through enhanced information orchestration, coordination mechanisms and decision-making during periods of disruption (Ye et al., 2022). Likewise, visibility mediates the relationship between digitalization and supply

chain survival, reinforcing the importance of digital systems in uncertain situations (Al Tera et al. 2024). Greater supply chain flexibility has also been associated with the combined effects of visibility, collaboration, digitalization, and risk management, particularly in environments characterized by economic uncertainty (Tran et al., 2026).

Ultimately, increased transparency alone does not guarantee improved supply chain performance. Transparency enabled by digital systems, such as TMS, must be complemented by strong collaboration and integration with transport service providers.

2.6 Collaboration and Integration with Transport Service Providers

- *Collaboration and Integration in Digital Supply Chains*

Digital supply chain technologies have increased the need for information sharing and coordinated decision-making across organisations, particularly where multiple supply chain partners participate in transport execution and planning (Budler et al., 2024). However, the implementation alone doesn't necessarily lead to improvements in supply chain performance, as organizations also depend on trust, collaboration, and information sharing to obtain operational benefits (Kyeremeh et al., 2025).

In regards integration, Gupta et al. (2022) examined strategies to overcome barriers to digitalization in supply chain logistics, emphasizing the importance of mobile technologies and cloud platforms in enabling resilient and collaborative networks. They concluded that successful initiatives involve not only technology adoption but also partner engagement. Digital integration also strengthens coordination across forward and reverse logistics by enabling more effective information exchange between organisations and transport service providers throughout transport operations (Song et al., 2019)

Digital supply chain systems also improve coordination by enabling integrated analysis, optimization, and information sharing across supply chain activities (Ivanov et al., 2024). Their findings suggest that digital technologies support more responsive and data-driven decision-making processes, therefore, improving coordination among supply chain partners and improving operational performance. Likewise, Industry 4.0 technologies further strengthen collaboration by supporting more connected and data-driven relationships between supply chain partners, improving coordination, responsiveness, and operational flexibility (Veile et al., 2024). These capabilities are

particularly relevant for pharmaceutical companies, which on a regular basis manage returns, reverse cold chain logistics, and recalls when needed, with the same criticality as regular distribution.

As expected, collaboration and integration with transport service providers are important when transitioning from manual to digital supply chain processes, but organizational governance is also a key point in successful outcomes. The successful implementation of digital technologies can be achieved by establishing clear responsibilities, contractual arrangements, key performance indicators (KPI), and joint planning processes that facilitate collaboration among supply chain (An et al., 2025). Similarly, clearly defined governance structures for data ownership, system responsibilities, and exception management contribute to more effective digital system implementation while reducing operational risks associated with transport digitalization (Xue et al., 2013).

Within transportation activities, these collaborative capabilities are supported by the Transport Management Systems (TMS), which integrate transport planning, shipment execution, shipment monitoring, and performance management within a single platform. As a result, communication between organizations and transport service providers (TSP) becomes more standardized, supporting greater coordination throughout transport operations.

2.7 Challenges of Digitalization in Supply Chains

Despite the operational benefits associated with supply chain digitalization, organizations may also face several challenges during the implementation and use of digital technologies. One of the main barriers concerns the integration of new digital solutions with existing legacy systems, particularly in organizations operating with fragmented information technology infrastructures, and limited interoperability between systems reduces the effectiveness of information exchange and makes it more difficult to achieve integrated supply chain operations (Queiroz et al., 2022). This issue is especially critical in PSC, where compliance requirements and validation processes constrain system modifications.

Another major challenge when implementing digital technologies is the data quality and standardization, as this influence the effectiveness of this implementation by

supporting transport planning, shipment monitoring and operational decision-making (Wang & Sarkis, 2021). Inconsistent master data, incomplete information, and the absence of common standards across supply chain partners reduce information quality and limit the operational benefits generated by digital systems. Confusion between visibility and traceability may also create unrealistic expectations regarding the capabilities of digital technologies during implementation (Roy, 2021).

Organizational and cultural barriers also play a critical role. Resistance to change, lack of digital skills, and insufficient training can hinder adoption of digital systems. Research shows that the value of digital technologies depends not only on the technology itself, but also on the organization's ability to adapt processes and develop the necessary capabilities (Sodero et al., 2019).

Inter-organizational challenges are also important on this matter. Digitalization requires collaboration and data sharing across supply chain partners, but issues related to trust, data ownership and governance often limit the willingness of organizations to fully integrate systems (Helo et al., 2024). Within the context of pharmaceutical industry, this aspect is critical as it related to regulatory requirements and data integrity and security.

Furthermore, investment costs and uncertain return on investment (ROI) can delay or limit digitalization initiatives. Firms must balance the high upfront costs of implementing systems such as TMS with the long-term benefits, which are often difficult to quantify in advance (Govindan et al., 2022).

Overall, the literature suggests that even though digitalization has the potential to significantly improve supply chain performance, its success depends on overcoming technological, organizational, and inter-organizational challenges. These challenges highlight the importance of studying digital system implementation, such as TMS, in real organizational contexts.

Recent studies have also highlighted continuing challenges related to data governance, information reliability, technological interoperability, and stakeholder alignment, despite the growing adoption of digital supply chain technologies (Jia et al., 2024). This view indicates that future research should move beyond technological adoption toward understanding how transparency capabilities are operationalized and governed across complex supply chain networks.

Even though previous literature reveals that digitalization improves visibility, transparency, and operational efficiency across supply chains, most studies remain conceptual or examine digitalization at a wider organizational level. Limited empirical research has specifically explored how transport-focused digital systems such as TMS influence operational transparency, collaboration with transport service providers, and execution within pharmaceutical supply chain (PSC). Additionally, existing research has mainly focused on manufacturing or generalized supply chain contexts, with limited attention given to the requirements from pharmaceutical transportation.

To address this gap, this project adopts an empirical approach to examine how the implementation of a TMS can influence on the transport operations, transparency and communication with transport service providers in a pharmaceutical company in Portugal.

3. METHODOLOGY

This study presents the approach adopted to understand how the implementation of a Transport Management System (TMS) affected transport operations, information transparency, and collaboration with Transport Service Providers (TSP) in a pharmaceutical company. According to its purpose, this project can be classified as exploratory as the aim of the research is to understand the organizational experiences, operational changes, and the inter-organizational coordination (Saunders et al., 2023).

The project is also exploratory as there's limited empirical knowledge about a phenomenon and the researcher aims to gain a deeper understanding of a real organisational context (Saunders et al., 2023). Even though supply chain digitalization has been widely studied, the specific role of a transport digital systems such as TMS is still less explored than other topics of digitalization in supply chain (Wang & Sarkis, 2021). This project therefore seeks to contribute to the existing literature by examining the effect of TMS implementation in a real pharmaceutical organizational context.

3.1 Company Characterization

The project was conducted in company XYZ which is a pharmaceutical company that has their capability center in Portugal, with their global distribution center located in the Netherlands. Although transportation operations are globally coordinated, the capability center in Portugal manages the transportation planning and coordination with distribution activities performed through the global distribution center located in the Netherlands.

Company XYZ has implemented a digitalization journey with goals until 2030, and as part of that roadmap, in November 2025 the TMS was implemented globally with the purpose of improving their operations, transparency and collaboration with TSPs. The TMS was implemented in different workstreams:

- a) Transportation Planning and Order Management → This workstream involves the lanes creation and management, and the end to end planning and order processing execution.
- b) Carrier Integration and Selection → Integration of the TSPs into our system to begin the freight collaboration, which connects our TSPs on a validated system to optimize the transportation.
- c) Execution and Monitoring → Track and trace application owned by company XYZ to replace the dependency on TSP tracker website for each order sent.
- d) Reporting → This workstream was linked to the generation of the data based on the information generated in the TMS for each order and TSP performance.

3.2 Data Collection

The primary data was collected through semi-structured interviews with employees directly involved in the transportation activities. Semi-structured interviews were selected because they allow the researcher to follow a predefined set of questions while giving participants the opportunity to discuss their experiences and opinions in greater detail (Saunders et al., 2023). This flexibility was important for understanding how the implementation of the Transportation Management System (TMS) influenced the daily transport activities. The interview guide is shown in Appendix I and was developed based on the literature review, also on their specific roles, and around the research topics such as:

- a) Processes before the TMS implementation
- b) Transport operations/efficiency
- c) Transparency and shipment visibility
- d) Collaboration with Transport Service Providers (TSP)
- e) Implementation Challenges
- f) Recommendations

The participants were selected through purposive sampling, as according to Patton (2015), this sampling technique is appropriate in qualitative research because it focuses on selecting information-rich participants who have direct knowledge of the phenomenon being studied. The below table describes the different functional areas and the reason why they were selected:

Table I: Profile of selected participants

Number	Role	Selection justification	Experience and years in the role	Interview Date and Duration
E1	Supply Chain Planner (Middle East)	Extensive use of TMS and daily interaction with TSPs for Middle East orders.	Role: 8 years Previous experience managing TMS: 1 year	20-MAY-2026 57 mins
E2	Supply Chain Planner (Europe)	Extensive use of TMS and daily interaction with TSPs for European orders.	Role: 6 years Previous experience managing TMS: 2 years	20-MAY-2026 42 mins
E3	Global Transportation Senior Associate	Owns TSP relationship and performance	Role: 5 years Previous experience managing TMS: No previous experience	15-MAY-2026 33 mins
E4	Warehouse Manager	Warehouse planning, execution and dispatch activities	Role: 15 years Previous experience managing TMS: 3 years	13-MAY-2026 48 mins

These interviews were conducted via Microsoft Teams in May 2026, six months after the TMS had been implemented. On average, the interviews lasted 30 minutes.. All

interviews were recorded with the participants' consent, and later transcribed for data analysis. In order to protect confidentiality, participants were not identified by name in the study, instead, only their job role was used when referring to their responses.

3.3 Data Analysis approach

The technique that was used to analyze the data was through thematic analysis. This specific technique is a flexible and accessible method to analyze qualitative data and involves coding the data to identify themes or patterns for further analysis, related to the research questions (Saunders et al., 2023).

A hybrid coding approach was adopted, combining deductive and inductive coding, as described by Braun and Clarke (2006). The deductive codes were developed from the literature review and the topics covered in the interview guide. Those codes were focused on operational efficiency, transparency, and collaboration with TSPs. Artificial Intelligence (AI) was then used as a support tool during the coding process. The interview transcripts were analysed using AI to help identify recurring ideas, group similar replies, and suggest possible codes based on the content of the interview. Additionally, AI also helped in comparing responses across participants and identifying the relationships between different codes. Similar codes were merged, and new inductive codes were identified once relevant themes emerged from the data. These codes were reviewed by the author and compared with the original interview.

After the coding was supported by AI, the codes were grouped into broader themes linked to the literature review in Chapter 2, such as operational efficiency, transparency, and collaboration with TSPs. These themes were then compared to the empirical evidence which were the interviews. The coding results can be found in Appendix II, while the results of the theme grouping are discussed in Chapter 4.

The interpretation of the data, the definition of the themes and the interpretation of the findings were carried out by the researcher.

4. FINDINGS AND DISCUSSION

This section of the project will present the findings from the semi-structured interviews made to company XYZ selected participants that are involved in the use of the Transport Management System (TMS). As mentioned in the previous section, a combined deductive and inductive approach was used to analyze the data gathered and to support the generation of codes. The entire coding framework is presented in Appendix II.

The findings were organized in five main themes:

- a) Operational Efficiency
- b) Transparency
- c) Collaboration with Transport Service Providers (TSP)
- d) Challenges in not achieving all the benefits from TMS

The following sections will present the interviewees' perceptions of each of these themes.

4.1 Operational Efficiency

Operational Efficiency is one of the main expected benefits of supply chain digitalization in the pharmaceutical context. In a general way, the interview findings support these expectations, however, participants also identified several operational challenges that continue to impact their activities even with TMS implemented.

- *Automation and Process Standardization*

The interviewees indicated that the implementation of SAP Transport Management (TM) automated several transportation activities that were previously performed manually, such as emailing and direct communication. The main improvements were related to package calculations, transport planning, booking activities, and the preparation of shipment information. The following quotes support this idea:

“We reduced significantly the time to calculate the packages required for each order”
(E1, Supply Chain Planner, Middle East).

“My team is now receiving more standardized shipment information” (E4, Warehouse Manager)

These examples suggest that automation created two benefits. First, it reduced the need for repeated manual input. Second, it provided planning, transportation and warehouse functions with more consistent information for routine activities. SAP TM therefore changed not only the speed of these activities but also the way they were organised among different functions.

This partly reflects previous research linking digital logistics systems with more integrated and standardized transport processes (Helo & Thai, 2024; Ivanov et al., 2024). However, the interviews didn't show complete automation, as users still needed to review system outputs when the proposed results didn't meet operational requirements.

- *Operational Benefits*

The interviewees also reported that centralised transport information reduced time spent searching for updates and supported better coordination between internal functions.

An example is some of the feedback that we got from the Supply Chain Planner (Europe) (E2): *"It has reduced the time spent searching for transport information and has increased the visibility for the shipments"*. It was similar to what the Global Transportation Senior Associate (E3) mentioned: *"now the whole team is looking at the same information"*

The Supply Chain Planner (Europe) (E2) also explained that transport information was included earlier in the planning process: *"Previously, transportation was often considered after supply decisions had already been made. Today, transportation information is incorporated earlier in the planning process, allowing us, the planners, to understand the delivery risks and adjust plans accordingly"*

Taken these together, these comments show that the main time operational benefit came from reducing the effort needed to find and compare information across emails, spreadsheets, and separate systems. Earlier access to transport requirements also allowed the planners, transportation team and warehouse to coordinate activities before shipment execution began.

The operational benefit was therefore not the removal of every manual activity. Instead, SAP TM reduced the time needed to collect information and helped employees

use a more consistent source when planning transport activities. Digital supply chain systems can generate this type of value by integrating information across organizational functions and supporting more coordinated decisions (Ivanov et al., 2024)

At the same time, the Warehouse Manager's comment shows that better planning information didn't remove the effects of urgent shipments or unexpected transport changes. The efficiency gains were therefore stronger in routine activities than in situations that required rapid adjustments.

- *Factors Limiting Complete Operational Efficiency*

Even though participants recognized important improvements after the implementation of SAP TM, interviewees also described limitations that reduced the expected operational efficiency gains.

The most frequently discussed issue was the inconsistency of the system's automated calculations. Interviewees from Planning and Warehouse explained that the packaging solutions proposed by the system were not always operationally or economically efficient. Due to this, users often needed to manually review and correct proposed solutions, impacting in export documentation and therefore delaying shipments.

The Supply Chain Planner (Middle East) (E1) mentioned: *"Operational accuracy is sometimes not as smooth as we expect as there are many cases where the TMS calculates that an order requires certain number of shippers, and the warehouse team then says that it's not accurate as it can fit in less shippers, causing rework"*.

Also, the Warehouse Manager (E4) described the following: *"Out of ten orders, this happens to six of them"*.

The interviews therefore show that automation didn't improve every order in the same way. When the automated calculation was accurate, SAP TM reduced processing time. When the calculation was incorrect, employees needed to review the proposal, compare it with operational knowledge and work instructions, and correct the result manually, and in worst-cases, notify the carrier of the correction after all the shipping documentation was already prepared. In these cases, automation didn't remove manual work, it moved part of the work from package calculation to manual validation and correction.

Operational changes after shipment preparation had already started also created rework. The Warehouse Manager described a case involving eighteen shipments, three of which had their assigned TSP changed after the warehouse had completed the packaging process:

“We had to reopen the shipments, replace labels and generate new documentation. The TMS gave visibility of the change, but the operational work still remained with us”(E4).

What can be said with this example is that visibility of a change isn't the same as removing its operational impact. SAP TM communicated the updated information, but the warehouse still needed to repeat physical and documentation activities. The system therefore supported information flow, while the operational consequences of the change continued to require human intervention.

The mixed results also explain why technology adoption alone doesn't automatically improve organizational performance. The benefits of digitalization depend on reliable data, effective system integration, and the organizational capabilities needed to manage both standard activities and operational exceptions (Dubey et al., 2020; Govindan et al., 2022)

Overall, SAP TM improved operational efficiency mainly in routine and predictable activities. It reduced time spent on manual calculations and information searches and created more standardized transport processes. However, inaccurate calculations, system limitations, and late operational changes continued to create manual checks and rework.

4.2 Transparency

This section presents the findings related to transparency and visibility following the implementation of the TMS. Across the interviews, participants described the transparency as one of the areas that were improved. The system centralised transport information, increased access to shipment milestones, and reduced dependence of fragmented sources such as carrier website, emails, and spreadsheets. However, the improvement was not complete, as the reliability of the information remained dependent on data quality and the timely submission of milestones by TSPs.

- *Milestone visibility and shipment monitoring*

The interviews indicated that the TMS significantly improved the visibility of transport operations by centralizing milestone information and making shipment status more accessible to users. A recurring pattern across participants was that the system reduced the need to rely entirely on external carrier websites or email feedback. Instead, users could access transport milestones directly through the TMS or the related track-and-trace application. The following quote from the Supply Chain Planner (Europe) (E2) supports this idea: *“I can now access to the transportation milestones and shipment progress without depending entirely on TSP websites”*.

Another participant noted that the system now gives visibility once the order is accepted or rejected by the carrier, enabling the team to see where the goods are expected to pass, such as airports or ports, which wasn't possible in the same way before. Similarly, the Global Transportation Senior Associate (E3) highlighted that the system now supports shipment monitoring and visibility, KPI analysis, and TSP performance reviews based on the data provided.

The main benefit was the availability of the same transport information across different departments. This reduced fragmented information searches and supported operational monitoring and performance management activities. These findings supports previous research showing that digital visibility creates value through shared operational information, event monitoring, and data-driven decision-making (Fang et al., 2024; Helo & Thai, 2024; Shahadat et al., 2024)

- *Access to Transport Information and Operational Decision-Making*

Interviewees explained that the improved visibility provided by SAP TM supported operational decision-making. Earlier access to shipment information allowed employees to identify transport disruptions, monitor carrier performance, and evaluate potential risks before they escalated into larger operational problems. For example, the Supply Chain Planner (Europe) (E2) mentioned the following: *“We received a notification about the risk of flooding, which allowed us to cancel the order and reallocate the stock to another market”*.

This example shows that the value of visibility wasn't limited to monitoring of shipment status. Earlier access to information enabled the organization to take preventive action and redirect the stock before the disruption affected supply. Participants also reported that route information helped identify deviations from approved transport plans and supported the discussion with TSPs regarding service performance. The following quote supports this:

“Actually this helped us to even detect deviations in terms of routing, we proposed a routing to the carrier, they accepted the routing but then we saw that actually they used another routing that wasn't approved by us, therefore, deviating from our standards. This kind of detections are reactive but give us also that transparency and an additional variable to measure the performance of our carriers” (Supply Chain Planner – Middle East, E1).

The findings therefore indicate that transport visibility improved decision-making by reducing uncertainty and supporting more proactive responses to operational risks. Similar benefits have been associated with digital visibility, which enables earlier identification of disruptions and more responsive logistics decisions (Caridi et al., 2014; Fang et al., 2024). The results also support the view that digital technologies generate operational value when visibility is combined with integration and coordinated action across supply chain partners (Reaidy et al., 2026).

- *Visibility gaps and information reliability*

Even though SAP TM improved access to transport information, all participants identified limitations affecting the completeness and reliability of transparency. The most frequently reported issue was the dependence on milestone updates provided by Transport Service Providers (TSP).

Interviewees explained that shipment information only became available in SAP TM after the carrier updated its own system. The Supply Chain Planner (Europe) (E2) mentioned the following:

“The system gives us the shipment status; however, it also relies on the update from the carrier system.”

A similar issue was reported by the Supply Chain Planner (Middle East) (E1):

“Sometimes the goods have already arrived, but the carrier has not sent the milestone even after 24 hrs of the arrival”.

The delayed or missed updates created differences between the shipments’s physical location and the status displayed in the system. In these situations, employees still needed to contact carriers directly to confirm transport information. The TMS therefore centralised shipment data, but it couldn’t independently guarantee that the information was current or complete.

This finding qualifies the benefits of digital visibility identified in previous research. Information sharing and digital integration can improve transparency, but their value depends on the reliability of the information exchanged and the effectiveness of collaboration between supply chain partners (Ma et al., 2023, Reaidy et al., 2026).

The findings therefore show that SAP TM improved transport visibility without achieving complete transparency. Its main contribution was the centralization and accessibility of shipment information, while its principal limitation was the continuing dependence on external carrier updates. Transparency in this case should be understood as an interorganizational outcome where the technology can provide the platform, but accurate and timely information from TSPs determines the reliability of the visibility achieved.

4.3 Collaboration with TSPs

This section examines how SAP TM influenced collaboration between the company and its TSPs. Interviewees described communication and coordination as more structured because routine transport information was increasingly exchanged through a shared digital platform rather than through fragmented email chains. However, collaboration was not fully transferred to the system. Urgent disruptions, technical issues, and inconsistent carrier adoption continued to require emails and telephone calls.

The findings therefore indicate that SAP TM has currently created an hybrid collaboration process. The system supported routine information exchange and coordination, while traditional communication channels remained necessary for complex and time-sensitive cases.

- *System-based freight collaboration*

Interviewees described the frequent communication from email to SAP TM as one of the main changes following implementation. Before SAP TM, transportation orders, shipment updates, documentation, and confirmations were mainly exchanged through email. This resulted in long communication chains, duplicated information, and uncertainty regarding the latest transport requirements. The Supply Chain Planner (Europe) (E2) explained:

“Communication is basically now via the system and not via email”

A similar change was reported by Supply Chain Planner (Middle East) (E1):

“Instead of relying just on email exchanges, all this information is now communicated through SAP TM”

The interviews indicate that SAP TM standardised the exchange of routing transport information by providing a defined process for communicating orders, documentation, and confirmations. Its main contribution was therefore not necessarily a change in the relationship with carriers, but a more controlled and consistent method of exchanging operational information.

As mentioned by Ivanov et al., (2024), standardised information exchange can strengthen interorganizational collaboration by reducing ambiguity and integrating routine activities across supply chain partners, and in this case, SAP TM reduced dependence on fragmented email communication and provided both the company and its TSPs with clearer information regarding transport requirements.

- *Resistance to change and partial adoption*

Although SAP TM created more structured communication process, interviewees reported that its adoption was not consistent across all TSPs. Some carriers continued to use email even when the required communication could be completed through the system. This reduced the standardization expected from the digital process and required

employees to manage communication through both SAP TM and traditional channels. The following quote supports this idea:

“For urgent or complex issues, it has not replaced the traditional communication channels” (Warehouse Manager, E4).

Interviewees also reported differences in how quickly carriers accepted transport orders, updated information, and followed the agreed system process. These findings indicate that the implementation of SAP TM didn't automatically result in full behavioural adoption. The system established a common process, but its effectiveness depended on the willingness and ability of each TSP to use it consistently.

Digital collaboration therefore remained not fully transitioned because the company and its TSPs hadn't reached the same level of digital adoption. Similar barriers have been identified in previous research, where resistance to change, differences in digital capabilities, and limited partner commitment reduced the benefits of interorganizational digitalizations (Budler et al., 2024; Kyeremeh et al., 2025). In this case, incomplete adoption created a hybrid process in which system-based communication operated also with email and telephone contact.

- *Technical integration and dependency*

Interviewees also identified technical limitations affecting collaboration between SAP TM and carrier systems. Information wasn't always transferred correctly, and some TSPs experienced integration problems that interrupted order confirmations, milestone updates or other routine activities.

When the system didn't transfer the information correctly, employees needed to contact the TSP directly repeat activities outside SAP TM. The Warehouse Manager (E4) indicated the following:

“When problems occur, my team still needs to call the TSP directly because operational decisions require immediate action”.

These situations show that the shared digital process depended on the technical connection between the company's system and the systems used by external transport providers. SAP TM could provide a common collaboration platform, but it couldn't

independently ensure that every carrier system transmitted information correctly or on time. In this sense, technical integration problems therefore reduced the continuity of digital collaboration and increased the need of manual follow-up. This finding supports previous research that interorganizational digitalization depends on system interoperability, reliable information exchange, and clear governance across participating organizations (Gupta et al., 2022). In this study, technical limitations didn't eliminate the collaborative benefits of SAP TM, but they prevented the process from becoming fully system-based.

4.4 Challenges in achieving the full benefits of SAP TM

The previous sections showed that SAP TM improved transport operations, visibility, and collaboration. However, the interviews also identified several connected challenges that limited these improvements. Poor master data affected the accuracy of automated outputs, system limitations increased the need for manual work, and different levels of adoption among users and TSPs prevented that transport process from becoming fully digital.

These challenges influences each other. For example, inaccurate master data produced results that required manual correction, which reduced users' confidence in the system. Technical problems and incomplete integration also caused employees to return to email, manual checks, and direct communication with TSPs. As a result, some of the previous working methods continued alongside SAP TM.

The findings therefore show that the full benefits of the system depend on more than its technical implementation. Reliable data, integrated processes, user adoption, and consistent participation from TSPs are also required. When one of these elements was missing, the improvements in efficiency, transparency or collaboration were reduced.

The interviews were conducted six months after the implementation of SAP TM, therefore, some of the reported challenges may reflect an early stage of system adoption rather than permanent limitations. Continuous data maintenance, technical improvements, training, and alignment with TSPs will be needed to increase the value of the system over time. This idea supports that digital transformation is an ongoing organizational process rather than a one-time technological implementation (Deepu & Ravi, 2023; Plekhanov et al., 2023;).

5. CONCLUSION

This study examined how the implementation of SAP Transportation Management (SAP TM) influenced transport operations, information transparency, and collaboration with Transport Service Providers (TSPs) in a pharmaceutical company based in Portugal. The findings answer the research question by showing that SAP TM positively influenced all three areas through greater process standardization, improved access to transport information, and more structured collaboration with TSPs. However, these benefits were only partially achieved because they remained constrained by data quality, system limitations, incomplete process integration, and varying levels of TSP adoption.

Regarding the first objective, SAP TM standardized routine transport activities, reduced the time spent searching for information, and supported earlier consideration of transport requirements during planning. However, inaccurate packaging calculations, system bugs, incomplete process integration, and late operational changes continued to require manual validation and generate rework. Consequently, the operational improvements were more evident in routine activities than in exception handling.

Regarding the second objective, SAP TM centralized shipment milestones and made transport information more accessible. This improved shipment monitoring, enabled earlier identification of route deviations and transport risks, and supported TSP performance evaluation. However, the study found that improved visibility did not result in complete information transparency because its reliability continued to depend on timely and accurate updates from TSPs.

Regarding the third objective, SAP TM created a more structured process for routine communication and enabled internal teams and TSPs to operate from a common source of transport information. Nevertheless, urgent or complex situations continued to require emails and telephone calls, while different levels of TSP adoption and technical integration prevented collaboration from becoming fully system-based.

Finally, the fourth objective identified several implementation challenges that limited the realization of the expected benefits. These included poor master data quality, inaccurate package calculations, technical bugs, incomplete process integration, and inconsistent TSP participation. Together, these challenges reduced

the effectiveness of automation, visibility, and collaboration despite the successful implementation of SAP TM.

Overall, the findings demonstrate that implementing a TMS alone is insufficient to fully transform transport operations. The value generated by SAP TM depends on high-quality master data, reliable system performance, effective process integration, user adoption, and consistent collaboration with TSPs. Accordingly, SAP TM implementation should be understood as an ongoing organizational and inter-organizational transformation rather than a one-time technological implementation.

5.1 Theoretical Implications

This study provides empirical evidence on the implementation of a Transport Management System in pharmaceutical transport operations. It contributes to the literature by explaining how automation, information transparency, and digital collaboration operate in practice during the early stages of TMS implementation.

The findings make three main theoretical contributions. First, automation did not eliminate manual work but changed its nature. When system calculations were accurate, SAP TM reduced operational effort; however, inaccurate calculations required users to validate and correct system outputs. These findings suggest that automation complements rather than replaces human intervention during the early stages of digital transformation.

Second, the findings demonstrate that visibility and transparency are not solely technological outcomes. Although SAP TM improved information accessibility, the reliability of that information remained dependent on timely and accurate updates from TSPs. Information transparency therefore emerged as a joint outcome of technological capability and inter-organizational collaboration.

Third, collaboration with TSPs became more structured but not fully digital. SAP TM supported routine information exchange, while emails and telephone calls remained essential during disruptions and exceptions. These findings reinforce the view that digital transformation extends beyond technology implementation and requires changes in organizational processes, user capabilities, and inter-organizational relationships (Dubey et al., 2020; Plekhanov et al., 2023).

5.2 Managerial Implications

The empirical contribution of this study is the identification of the areas in which Company XYZ should improve to obtain greater value from SAP TM. Master data management should become a strategic priority, as inaccurate information affected package calculations, planning activities, and user confidence in the system. Clear data ownership, governance reviews, and regular data quality checks could reduce manual corrections and improve system performance.

The company should also prioritise reducing operational rework by addressing inaccurate package proposals, technical bugs, limited flexibility during disruptions, and activities that remain outside SAP TM. Operational users should be actively involved in system testing and continuous improvement because they possess detailed process knowledge across transportation and warehouse operations.

To strengthen collaboration with TSPs, Company XYZ should establish clear expectations regarding order confirmations, milestone reporting, and process discipline. Technical integration with each TSP should be continuously tested, while recurring delays should be monitored through regular performance review meetings.

Proactive alerts for missing milestones, delayed collections, and route deviations could further reduce manual monitoring. Progress should be evaluated through KPIs such as processing time, manual corrections, first-time-right order processing, milestone completeness, and carrier responsiveness. Together, these actions would support a more consistent, reliable, and digitally integrated transport operation.

5.3 Main Limitations and suggestions for future research

One limitation of this study is that it examined a single pharmaceutical company within one implementation context, limiting the generalisability of the findings to other pharmaceutical companies or industries.

In addition, the study was based on four semi-structured interviews with internal employees. Although these participants possessed direct experience with SAP TM, including perspectives from IT specialists and Transport Service Providers would have provided a more comprehensive understanding of the implementation process and inter-organizational collaboration.

The interviews were conducted approximately six months after SAP TM implementation. Consequently, some of the reported challenges may reflect an early stage of system adoption rather than permanent technological limitations, as data quality, user capabilities, system stability, and TSP adoption are likely to improve over time.

Future research could examine SAP TM implementation after twelve or twenty-four months, include TSP and IT perspectives, compare different geographical regions or organizations, and investigate whether the implementation challenges identified in this study diminish as the system and its users become more mature.

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APPENDICES

Appendix I – Interview Guide

I am currently working on my master's thesis in Management and Industrial Strategy at ISEG. The goal of this project is to understand how the implementation of a Transport Management System (TMS) have influenced the transport operations, information transparency and collaboration with our TSP (transport service providers).

Your insights and experience throughout this time will be very valuable for my master thesis.

This interview will include several open questions, which I ask you to answer based on your own experience at the company. There are no right or wrong answers; we are simply interested in your opinion.

I would like to ask you to record the interview for the sole purpose of being able to listen to the recording later and gather more information from it. All these responses will remain confidential and anonymous, as I will only be using the current job role name.

Can you confirm that you understand the information I just provided and that you consent to proceeding with the recording of the interview?

This interview will take no more than 40 mins. The interviewees are:

Supply Chain Planner – Middle East Scope

Supply Chain Planner - Europe Scope

Global Transportation Senior Associate – TSP Management

Warehouse Manager – Operations

INTERVIEW GUIDE

Supply Chain Planner – Middle East

General Questions	Can you briefly describe your current role and core responsibilities within the organization? How long have you been working for this company? How many years of professional experience do you have in your current or a similar role? In what ways are you involved in transportation and logistics operations?
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	What is your level of involvement in coordinating or collaborating with Transport Service Providers (TSPs)? How has your role been affected, if at all, by the implementation of the Transportation Management System (TMS)?
Pre-TM implementation	Were you already working in this area before the Transportation Management System (TMS) was implemented? If so, what was your role at that time? Can you describe how your responsibilities and daily transport-related activities were managed before the implementation of the TMS? Which tools, systems, or processes were primarily used before the TMS was introduced? What were the main limitations or inefficiencies associated with them? Before the TMS implementation, how were transport bookings, shipment updates, delivery confirmations, transport documentation, and transport exceptions managed? What were the main communication and coordination challenges with Transport Service Providers (TSPs) prior to the TMS implementation?
TMS Implementation	How frequently do you interact with the TMS or use information generated by the system in your daily activities? How did Transport Service Providers (TSPs) respond to the implementation of the TMS? To what extent were they engaged, cooperative, or resistant during the transition? What challenges did you face during the adoption of TMS? (e.g., system integration, data quality)? Were there any implementation challenges that were particularly related to the pharmaceutical supply chain context or to the Portuguese operational environment? If so, how were these challenges addressed or managed?
Operations Efficiency	Can you describe how the Transportation Management System (TMS) has impacted supply chain and transportation planning activities within your organization? In particular, how has the TMS affected shipment planning, planning accuracy, transport execution,

	coordination with warehouse operations and Transport Service Providers (TSPs), and the management of urgent or high-priority shipments? To what extent has the TMS improved visibility and coordination between supply planning, transportation, and warehouse functions? Has the TMS helped reduce operational errors, delays, miscommunication, or escalations related to shipment planning and execution? Please explain. Can you provide an example of a planning or coordination process that became more efficient—or less efficient—after the implementation of the TMS? Have any bottlenecks, manual workarounds, or process inefficiencies emerged as a result of the TMS implementation? If so, please describe them. In your opinion, has the TMS improved responsiveness and decision-making in situations involving urgent shipments, shortages, or transport disruptions? Please provide an example if possible. Were there any unexpected positive or negative impacts of the TMS on broader supply chain operations?
Transparency	How has the implementation of the Transportation Management System (TMS) affected your ability to monitor and track shipments within the broader supply chain planning process? To what extent has the TMS improved your access to timely and reliable information to support planning decisions? How has improved visibility through the TMS influenced your planning accuracy and responsiveness to changes in demand or supply conditions? Has the TMS improved your ability to anticipate or react to transportation-related risks that impact supply continuity? Please explain. Can you provide an example where improved visibility through the TMS supported better planning decisions or helped avoid a supply disruption? Are there any information gaps or limitations in visibility that still affect your planning activities?

	Overall, do you consider that the TMS has significantly improved transparency and visibility in transport operations? Why or why not?
Collaboration with TSP	How often do you interact and coordinate with Transport Service Providers (TSPs) through the Transportation Management System (TMS) during the planning phase? How has the TMS changed the way you communicate and coordinate with TSPs during shipment planning and scheduling activities? Has the system helped reduce misunderstandings or misalignment between planning requirements and carrier execution? Please explain. Can you provide an example where the TMS improved—or failed to improve—coordination with a TSP during planning or exception handling? In your opinion, what could be improved in the TMS to strengthen collaboration between supply planning teams and TSPs?
Recommendations	What are the main challenges or limitations you currently experience when using the Transportation Management System (TMS) in supply chain planning and coordination activities? In your opinion, what should be improved in the way TSPs use the TMS? What additional functionalities or features would bring more value to your planning activities?
Closing Questions	Is there any important aspect of the TMS impact on supply chain planning or coordination that we have not discussed but that you consider relevant?

Supply Chain Planners - Europe

General Questions	Can you briefly describe your current role and core responsibilities within the organization? How long have you been working for this company? How many years of professional experience do you have in your current or a similar role? In what ways are you involved in transportation and logistics operations?
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	What is your level of involvement in coordinating or collaborating with Transport Service Providers (TSPs)? How has your role been affected, if at all, by the implementation of the Transportation Management System (TMS)?
Pre-TM implementation	Were you already working in this area before the Transportation Management System (TMS) was implemented? If so, what was your role at that time? Can you describe how your responsibilities and daily transport-related activities were managed before the implementation of the TMS? Which tools, systems, or processes were primarily used before the TMS was introduced? What were the main limitations or inefficiencies associated with them? Before the TMS implementation, how were transport bookings, shipment updates, delivery confirmations, transport documentation, and transport exceptions managed? What were the main communication and coordination challenges with Transport Service Providers (TSPs) prior to the TMS implementation?
TMS Implementation	How frequently do you interact with the TMS or use information generated by the system in your daily activities? How did Transport Service Providers (TSPs) respond to the implementation of the TMS? To what extent were they engaged, cooperative, or resistant during the transition? What challenges did you face during the adoption of TMS? (e.g, system integration, data quality) ? Were there any implementation challenges that were particularly related to the pharmaceutical supply chain context or to the Portuguese operational environment? If so, how were these challenges addressed or managed?
Operations Efficiency	Can you describe how the Transportation Management System (TMS) has impacted supply chain and transportation planning activities within your organization?

	In particular, how has the TMS affected shipment planning, planning accuracy, transport execution, coordination with warehouse operations and Transport Service Providers (TSPs), and the management of urgent or high-priority shipments? To what extent has the TMS improved visibility and coordination between supply planning, transportation, and warehouse functions? Has the TMS helped reduce operational errors, delays, miscommunication, or escalations related to shipment planning and execution? Please explain. Can you provide an example of a planning or coordination process that became more efficient—or less efficient—after the implementation of the TMS? Have any bottlenecks, manual workarounds, or process inefficiencies emerged as a result of the TMS implementation? If so, please describe them. In your opinion, has the TMS improved responsiveness and decision-making in situations involving urgent shipments, shortages, or transport disruptions? Please provide an example if possible. Were there any unexpected positive or negative impacts of the TMS on broader supply chain operations?
Transparency	How has the implementation of the Transportation Management System (TMS) affected your ability to monitor and track shipments within the broader supply chain planning process? To what extent has the TMS improved your access to timely and reliable information (e.g., shipment status, delays, ETA changes, or disruptions) to support planning decisions? How has improved visibility through the TMS influenced your planning accuracy and responsiveness to changes in demand or supply conditions? Has the TMS improved your ability to anticipate or react to transportation-related risks that impact supply continuity (e.g., delays, customs holds, temperature excursions)? Please explain. Can you provide an example where improved visibility through the TMS supported better planning decisions or helped avoid a supply disruption?

	Are there any information gaps or limitations in visibility that still affect your planning activities? Overall, do you consider that the TMS has significantly improved transparency and visibility in transport operations? Why or why not?
Collaboration with TSP	How often do you interact and coordinate with Transport Service Providers (TSPs) through the Transportation Management System (TMS) during the planning phase? How has the TMS changed the way you communicate and coordinate with TSPs during shipment planning and scheduling activities? Has the system helped reduce misunderstandings or misalignment between planning requirements and carrier execution? Please explain. Can you provide an example where the TMS improved—or failed to improve—coordination with a TSP during planning or exception handling? In your opinion, what could be improved in the TMS to strengthen collaboration between supply planning teams and TSPs?
Recommendations	What are the main challenges or limitations you currently experience when using the Transportation Management System (TMS) in supply chain planning and coordination activities? In your opinion, What should be improved in the way TSPs use the TMS? What additional functionalities or features (e.g., forecasting, exception alerts, integration with demand planning or ERP systems) would bring more value to your planning activities?
Closing questions	Is there any important aspect of the TMS impact on supply chain planning or coordination that we have not discussed but that you consider relevant?

Global Transportation Senior Associate

General Questions	Can you briefly describe your current role and core responsibilities within the organization? How long have you been working for this company? How many years of professional experience do you have in your current or a similar role? In what ways are you involved in transportation and logistics operations? What is your level of involvement in coordinating or collaborating with Transport Service Providers (TSPs)? How has your role been affected, if at all, by the implementation of the Transportation Management System (TMS)?
Pre-TM implementation	Were you already working in this area before the Transportation Management System (TMS) was implemented? If so, what was your role at that time? Can you describe how your responsibilities and daily transport-related activities were managed before the implementation of the TMS? Which tools, systems, or processes were primarily used before the TMS was introduced? What were the main limitations or inefficiencies associated with them? What were the main communication and coordination challenges with Transport Service Providers (TSPs) prior to the TMS implementation?
TMS Implementation	How frequently do you interact with the TMS or use information generated by the system in your daily activities? Can you describe how the TMS is integrated into your day-to-day responsibilities and decision-making processes? How did Transport Service Providers (TSPs) respond to the implementation of the TMS? To what extent were they engaged, cooperative, or resistant during the transition? What challenges did you face during the adoption of TMS? (e.g., system integration, data quality)? Were there any implementation challenges that were particularly related to the pharmaceutical supply

	chain context or to the Portuguese operational environment? If so, how were these challenges addressed or managed?
Operations Efficiency	Can you describe how the TMS has impacted transportation operations and transport management activities within your organization? How has the system affected transport planning and execution, shipment visibility, freight cost control, operational accuracy, carrier coordination, and exception management? To what extent has the TMS improved coordination and communication with Transport Service Providers (TSPs)? Has the TMS contributed to reducing transport delays, operational escalations, miscommunications, or shipment execution issues? Please explain. Can you provide an example of a transportation process that became more efficient—or less efficient—because of the TMS? Have any bottlenecks, system limitations, or manual workarounds emerged following the implementation of the TMS? If so, please describe them. Beyond transportation activities, were there any broader operational impacts—positive or negative—resulting from the TMS implementation? How has the TMS impacted your work?
Transparency	How has the TMS changed your ability to track and monitor transport operations across different carriers, lanes, and shipment types? How reliable and actionable is the information provided by the TMS for transportation control and decision-making? Do you still face any blind spots or limitations in transport visibility despite the system? Overall, do you consider that the TMS has significantly improved transparency and visibility in transport operations? Why or why not?
Collaboration with TSP	How often do you interact and collaborate with Transport Service Providers (TSPs) through the Transportation Management System (TMS)?

	How has the implementation of the TMS changed communication with TSPs in terms of speed, frequency, structure, and communication channels? How effective is the TMS in supporting real-time collaboration with TSPs during transport disruptions or exception management? Can you provide an example where the TMS significantly improved—or limited—collaboration with a TSP during transport execution? What improvements would you suggest to enhance communication and collaboration with TSPs through the TMS?
Recommendations	What additional TMS functionalities (e.g., advanced analytics, carrier performance dashboards, automated exception handling, or improved integration with TSPs) would bring the most value to your role?
Closing Questions	Is there any important aspect of the TMS impact on transportation operations that we have not discussed but that you consider relevant?

Warehouse Manager

General Questions	Can you briefly describe your current role and core responsibilities within the organization? How long have you been working for this company? How many years of professional experience do you have in your current or a similar role? In what ways are you involved in transportation and logistics operations? What is your level of involvement in coordinating or collaborating with Transport Service Providers (TSPs)? How has your role been affected, if at all, by the implementation of the Transportation Management System (TMS)?
Pre-TM implementation	Were you already working in this area before the Transportation Management System (TMS) was implemented? If so, what was your role at that time? Can you describe how your responsibilities and daily transport-related activities were managed before the implementation of the TMS?

	Which tools, systems, or processes were primarily used before the TMS was introduced? What were the main limitations or inefficiencies associated with them? What were the main communication and coordination challenges with Transport Service Providers (TSPs) prior to the TMS implementation? Before the TMS was implemented, what were the main limitations related to shipment visibility, information transparency, or traceability?
TMS Implementation	How frequently do you interact with the TMS or use information generated by the system in your daily activities? Can you describe how the TMS is integrated into your day-to-day responsibilities and decision-making processes? What challenges did you face during the adoption of TMS? (e.g., system integration, data quality)?
Operations Efficiency	Can you describe how the TMS has impacted warehouse-related transportation activities and coordination with transport operations? Has the TMS improved coordination between warehouse operations, transportation planning, and Transport Service Providers (TSPs)? Please explain. To what extent has the TMS improved the scheduling and management of warehouse activities, such as loading times, dock scheduling, shipment preparation, and dispatch coordination? Has the TMS helped reduce delays in loading, dispatch, carrier waiting times, or transport documentation generation once shipments are ready to leave the warehouse? How has the TMS affected communication and coordination between warehouse teams and carriers during daily operations? Can you provide an example of a warehouse or dispatch process that became more efficient—or less efficient—after the implementation of the TMS? Have any bottlenecks, operational constraints, or manual workarounds emerged due to the implementation of the TMS? If so, please describe them.

	In your opinion, has the TMS improved the handling of urgent shipments, shipment prioritization, or exception situations within warehouse operations? Were there any additional positive or negative impacts of the TMS on warehouse efficiency, workload, or operational visibility?
Transparency	How has the TMS affected your visibility over inbound and outbound shipments linked to warehouse operations? To what extent has the TMS improved your ability to track shipment readiness, carrier arrivals, loading status, and dispatch execution? Has the system improved visibility into delays or disruptions that impact warehouse scheduling and dock operations? Can you provide an example where TMS visibility helped improve loading efficiency, reduce delays, or avoid operational issues in the warehouse? Are there any limitations in the information provided by the TMS that still affect warehouse planning or execution?
Collaboration with TSP	How often do you interact with Transport Service Providers (TSPs) through the TMS in relation to warehouse loading, dispatch, and carrier coordination? Has the TMS helped reduce misunderstandings, waiting times, or coordination issues at the warehouse-carrier interface? If yes, how? Can you provide an example where the TMS improved—or did not improve—communication with a TSP during loading or dispatch operations? What could be improved in the TMS to better support collaboration between warehouse teams and Transport Service Providers?
Recommendations	What are the main challenges or limitations you currently experience when using the TMS in relation to warehouse operations and coordination with transport? What additional functionalities would bring more value to your operations?
Closing Questions	Is there any important aspect of the TMS impact on warehouse operations or coordination with transport

	providers that we have not discussed but that you consider relevant?
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Thank you for sharing your experience.

Appendix II – Coding Framework

Theme	Subtheme	Code	Evidence
Operational Efficiency	Automation and Standardization	Automated package calculator	“Now the system automatically calculates the packages required in the order”
	Automation and Standardization	Standardized shipment information	“The warehouse is now receiving more standardized shipment information”
	Automation and Standardization	Earlier use of transport information in planning	“Today, transportation information is incorporated earlier in the planning process, allowing us, the planners to understand the delivery risks and adjust plans accordingly”
	Time Saving and Internal Coordination	Reduced time spent searching for information	“It has reduced the time spent searching for transportation information and has increased the visibility for the shipments”
	Factors limiting operational efficiency	Incorrect automated calculation	“Sometimes the system is proposing solutions that are more costly and not efficient, this leads to workarounds and corrections which take us more time than the previous process”

	Factors limiting operational efficiency	Manual validation of system outputs	“We can see that TMS proposes “X” quantity of shippers, but considering our past experience and our work instructions, we know that the quantity isn’t the one that TM proposes”
	Factors limiting operational efficiency	Rework after shipment changes	“We had to reopen the shipments, replace labels, and generate new documentation”
	Factors limiting operational efficiency	Limited flexibility during disruptions	“Once the order is sent, we can’t make a lot of modifications”
	Factors limiting operational efficiency	Incomplete process integration	“These sub-processes are not integrated into the lanes app and the users spend time trying to look for this in the app”
	Factors limiting operational efficiency	System bugs causing repeated work	“Some of the fields disappeared... this causes that the user again had to enter those details”
Transparency	Milestone Visibility and Shipment Monitoring	Direct access to shipment milestones	“I can now access the transportation milestones and shipment progress without depending entirely on TSP websites”
	Milestone Visibility and Shipment Monitoring	Visibility of expected transport routes	“We automatically see in our track and trace app where the goods are going to pass, for example airports or ports for air or sea shipments”

	Milestone Visibility and Shipment Monitoring	Centralised reporting and performance information	“The system now supports shipment monitoring and visibility. KPI analysis through the reporting, and TSP performance reviews based on the data provided”
	Access to Transport Information and Operational Decision-Making	Early identification of transport risks	“We received a notification about risk of flooding, which allowed us to cancel the order and reallocate the stock to another european market”
	Access to Transport Information and Operational Decision-Making	Use of information for carrier decisions	“It supports our decision-making and.. helps us switch lanes from one TSP to the other in case performance isn’t good”
	Access to Transport Information and Operational Decision-Making	Detection of route deviations	“We saw that they used another routing that wasn’t approved by us... this kind of detection is reactive, but give us transparency and an additional variable to measure the performance of our carriers”
	Visibility gaps and information reliability	Dependency on carrier milestone updates	“The main limitation is the dependency on carrier updates. If those milestones aren’t updated consistenly or on time, visibility gaps still exists”

	Visibility gaps and information reliability	Dependency on carrier milestone updates	“Sometimes the goods already arrived, but in the track and trace app the carrier hasn’t sent their milestone, causing a discrepancy between what’s in our system and the actual physical location.
	Visibility gaps and information reliability	Dependency on carrier milestone updates	“In a sample of 10 shipments, I can say that 4 of them have delays on milestones”
	Visibility gaps and information reliability	Lack of automatic exception alerts	“We are not receiving direct notifications whenever a milestone hasn’t been reported on time, so we need to go manually to the shipment reference”
Collaboration with TSPs	System-Based Freight Collaboration	Routine communication moved from email to SAP TM	“Communication is basically now via the system and not via email. We just use email for exceptions”
	System-Based Freight Collaboration	Routine communication moved from email to SAP TM	“Email exchanges were confusing and at some point either party was mixing shipment details or routings, which was a risk in terms of compliance and shipment requirements.
	System-Based Freight Collaboration	Joint prioritization of critical shipments	“Because shipment priorities were visible in the system, us and the TSP could focus the resources on the most critical deliveries”
	Resistance to change and	Continued use of email by TSPs	“They have been a little bit resistant to the change.. They still

	incomplete adoption		want to send emails for basic communication”
	Resistance to change and incomplete adoption	Different levels of adoption by each TSP	“Even today we still struggle with adoption maturity across different TSPs”
	Resistance to change and incomplete adoption	Traditional channels still used for exceptions	“For urgent or complex issues, it has not replaced the traditional communication channels, email or telephone”
	Technical Integration and Dependency	Unequal technical integration across TSPs	“The technical integration wasn’t equally straightforward for all providers”
	Technical Integration and Dependency	Carrier lack of readiness for onboarding	“We also faced delays in the onboarding of the TSP, as some of them were short of resources or had complexities in their own business processes”