Alignment of transportation strategy with supply chain strategy
a conceptual framework with illustrative evidence

Khakdaman, Masoud; Rezaei, Jafar; Tavasszy, Lóránt

DOI
10.1080/23302674.2025.2610956

Publication date
2026

Document Version
Final published version

Published in
International Journal of Systems Science: Operations and Logistics

Taylor & Francis
Taylor & Francis Group

International Journal of Systems Science: Operations & Logistics

ISSN: 2330-2674 (Print) 2330-2682 (Online) Journal homepage: www.tandfonline.com/journals/tsyb20

Alignment of transportation strategy with supply chain strategy: a conceptual framework with illustrative evidence

Masoud Khakdaman, Jafar Rezaei & Lóránt Tavasszy

To cite this article: Masoud Khakdaman, Jafar Rezaei & Lóránt Tavasszy (2026) Alignment of transportation strategy with supply chain strategy: a conceptual framework with illustrative evidence, International Journal of Systems Science: Operations & Logistics, 13:1, 2610956, DOI: 10.1080/23302674.2025.2610956

To link to this article: https://doi.org/10.1080/23302674.2025.2610956

Published online: 05 Jan 2026.

INTERNATIONAL JOURNAL OF SYSTEMS SCIENCE: OPERATIONS & LOGISTICS
2026, VOL. 13, NO. 1, 2610956
https://doi.org/10.1080/23302674.2025.2610956

Taylor & Francis
Taylor & Francis Group

RESEARCH ARTICLE

Alignment of transportation strategy with supply chain strategy: a conceptual framework with illustrative evidence

Masoud Khakdaman[a], Jafar Rezaei[b] and Lóránt Tavasszy[b]

[a]Department of Marketing, Operations and Information Systems, College of Business, Abu Dhabi University, Abu Dhabi, United Arab Emirates; [b]Transport and Logistics Section, Faculty of Technology Policy and Management, Delft University of Technology, Delft, The Netherlands

ABSTRACT

Alignment of core supply chain functions with corporate supply chain strategy is a key success factor for firms. Misalignments can lead to inefficiencies, higher costs, risks, and weaker performance. In particular, misalignment between transportation strategy and supply chain strategy can reduce responsiveness and flexibility, increase risks, and amplify environmental impacts. Although classic supply chain frameworks established the theoretical foundations of supply chain strategy, they treated transportation as a secondary issue and overlooked contextual decision factors such as product density, perishability, product life cycle, resilience, and sustainability. Consequently, a conceptual model that systematically integrates the complexity of the transportation and supply chain strategy alignment is not yet present in the literature. To address this gap, we develop a conceptual framework that introduces four transportation strategies, i.e. Cost-Oriented, Flexibility-Reliant, Modal-Control-Intensive, and Value-Enhanced, mapped against supply chain strategies across thirteen contextual criteria. Using the Best-Worst Method, we supplement the framework with an illustrative survey study of Global Fortune 500 companies. The results indicate that no single transportation strategy is right across all supply chains, but tailor-made service bundles can lead to alignment. Our study extends alignment theory to transportation and offers practical insights for managers of shipper firms and logistics service providers.

ARTICLE HISTORY
Received 6 April 2025
Accepted 24 December 2025

KEYWORDS
Conceptual framework; alignment; transportation strategy; supply chain strategy; best-worst method; logistics service provider

1 Introduction

Strategic fit between business strategy and supply chain strategy is essential to operations management (Hossain et al., 2025; Qi et al., 2011). Once a firm's supply chain strategy is determined, core functions of the supply chain need to align their strategies with the targeted supply chain strategy (Chopra & Meindl, 2007; Kumar et al., 2023). Decisions taken within each core supply chain function should be mutually consistent and converge with the overall supply chain and business strategy (Joshi et al., 2003; Sun & Hong, 2002). The likely effect of misalignment is the development of disconnected practices that reproduce imperfections and flaws along the supply chain. This can compromise business goals' achievement, deteriorate overall supply chain performance, and increase total supply chain costs (Bodendorf et al., 2024; de Carvalho Borella & Padula, 2010; Joshi et al., 2003). In this respect, transportation is a major but under-researched component of strategic alignment formation.

Among different supply chain functions, transportation is the most strategic one because it accounts for the most significant proportion of logistics costs (Ke et al., 2015; Stank & Goldsby, 2000). Transportation is crucial in connecting various elements and actors in the supply chain (Sanchez-Rodrigues et al., 2010), linking supply chain structure and performance (Green et al., 2008) to enable smooth movement and delivery of materials/goods/services throughout the supply chain. Transportation is closely tied to customer satisfaction, supply chain efficiency, and overall competitive advantage (Ke et al., 2015). Recent disruptions, such as the COVID-19 pandemic, port congestion, and geopolitical conflicts, have highlighted that a weak or inappropriate transportation strategy makes firms vulnerable to systemic risks (Ivanov, 2020; Sarkis, 2021). Transportation strategy has often been placed on the operational or tactical

CONTACT Masoud Khakdaman masoud.khakdaman@adu.ac.ae Department of Marketing, Operations and Information Systems, College of Business, Abu Dhabi University, PO Box 59911, Abu Dhabi, United Arab Emirates

level, such as mode choice or carrier selection, instead of being conceptualised as a strategic construct that interacts with supply chain strategy. As a result, the alignment of transportation strategy (TS) with the overall supply chain strategy (SCS) is a primary strategic fit for supply chains (Ke et al., 2015).

Existing SCS frameworks fail to configure proper TSs to achieve strategic alignment. Fisher (1997) distinguishes between functional and innovative products, where the former products require a supply chain that is efficient and the latter products require greater responsiveness. Lee (2002) further developed this dichotomy to four SCSs, i.e. efficient, responsive, risk-hedging, and agile, thus highlighting the necessity of adaptability and responsiveness. Christopher (2000) identified supply-chain agility and integration as central to competitive advantage. These seminal frameworks, however, have rarely included TS as a key component of alignment. The available literature, which does address TS, often treats it in a stand-alone manner, such as the rich literature on transportation modal choice in the context of cost-time trade-offs (see, for example, Reis (2014)), but not as a component of a set of strategic archetypes in a broader supply chain setting (Holter et al., 2008). This gap still exists in the current literature.

To address this research gap, we formulate the research question of *how supply chains' TS and SCS should be aligned to achieve strategic fit?* To answer this question, we initially identified a taxonomy of TSs and relevant decision criteria that are prominently discussed in the logistics literature. Then, we developed a conceptual framework that connects these TSs to SCSs, considering the decision criteria, thus expanding Lee (2002) typology. Lastly, we demonstrated the framework using empirical data driven from our survey of international companies. Our hybrid methodology is mainly conceptual, aiming to develop theory on alignment by formally incorporating TS into SCS frameworks. In parallel, empirical survey data are produced as illustrative exemplars, rather than inferential evidence. We demonstrate the alignment of TS and SCS of international supply chains using a structured multi-criteria decision-making (MCDM) method called Best-Worst Method (BWM) (Rezaei, 2015; Rezaei, 2016). BWM is one of the recent developments in MCDM, which requires less data and produces more reliable results (Rezaei et al., 2016). BWM is suitable because it is capable of identifying the strategic significance of transportation attributes across industries and SCSs, whereas mainstream mode choice techniques, such as discrete choice models, are more appropriate for shipment-level operational decisions and necessitate large and context-specific datasets. To depict a global perspective on the alignment of TS with SCS, we conducted our study among Global Fortune 500 companies (Fortune magazine, 2023) and major customer firms of the 40 largest global logistics service providers (LSPs) (Logistics Quarterly magazine, 2023), including various industries and commodity types that account for the majority of global transportation volume and value (Khakdaman et al., 2020). These companies are usually leading firms in their industry with international supply chain operations and rely heavily on LSPs' logistics services for flowing their goods globally (Khakdaman et al., 2020).

We advance the existing literature via the following contributions: (i) We expand the literature on alignment theory by incorporating TS into the main structure of SCS. This highlights the importance of TS and SCS alignment for improving overall supply chain performance. (ii) We introduce a conceptual framework for TS and SCS alignment by defining TS in conjunction with different transportation service attributes and demonstrating which TSs should be applied to better fit with different SCSs, considering several contemporary decision-making criteria, e.g. product life cycle and density, demand and supply uncertainties, supply chain sustainability and resilience, among all. The proposed framework guides managers to identify proper SCS, formulate suitable approaches to TS and its alignment with SCS, and consequently improve resilience and sustainability. (iii) We demonstrate the alignment between TS and SCS for international supply chains, considering different contextual factors. We conduct our study among global supply chains, while earlier studies were limited in their geographical diversity, operational complexity, and sample size.

Following this section, we present the theoretical background by synthesising the literature on the alignment theory, supply chain typologies, and transportation literature. Section 3 introduces the proposed conceptual framework, and the four TS types are defined and charted against the SCSs. Section 4 presents an illustrative case survey. The last section provides managerial implications, conclusions, and future research directions.

2 Theoretical background

2.1 Alignment theory and strategic fit

The alignment concept has dominated the organisational and strategic management literature for decades. Rooted in the Alignment Theory (Chorn, 1991) and Strategic Fit Theory (Venkatraman & Camillus, 1984; Venkatraman, 1989), the idea holds that organisations perform best when their strategies, structures and processes are in harmony with external contingencies. This idea has been used in many areas, such as business strategy, information systems, and supply chain management (Sabherwal et al., 2001; Wei et al., 2023; Wong et al., 2012). Within the supply chain context, alignment theory asserts that a lack of alignment between SCSs and operational strategies (e.g. transportation) can negatively affect performance.

While transportation has historically been seen as an operational activity, it takes a strategic stance in enabling or constraining alignment. As Goldsby et al. (2023) argue, the misalignment between TS and SCS can make transportation the 'weakest link' as established by the Theory of Constraints (Goldratt & Cox, 1986). If transportation cannot meet the necessary responsiveness or efficiency that the supply chain requires, it becomes a bottleneck, thus reducing the overall performance of the supply chain.

Misalignment in this context can be conceptualised on different levels. At the operational level, it occurs when transportation performance, e.g. delay, unreliability, and excessive costs, fails to satisfy supply chain requirements. At the strategic level, misalignment occurs when the characteristics of a TS (cost, time, reliability, and flexibility) are set in a manner that is inconsistent with the current supply-chain strategy. For example, a cost-based TS in a supply chain focusing on responsiveness will lead to reduced flexibility and increased customer dissatisfaction. Finally, at the performance level, misalignment leads ultimately to competitive disadvantage, including weak resilience, higher costs, and worse environmental performance (Denham et al., 2015; Randall et al., 2003).

Foundational models of SCS provide theoretical frameworks to examine the misalignments within supply chains. Considering uncertainties in demand, Fisher (1997) distinguished between functional products, for which efficient supply chains are required, and innovative products, for which responsive supply chains are needed. Extending Fisher's distinction, Lee (2002) expanded the typology by introducing supply-side uncertainties, and identified four different SCS types (efficient, responsive, risk-hedging, and agile) suited to varying combinations of demand and supply uncertainty. Similarly, Christopher et al. (2006) proposed the lean, agile, and leagile taxonomy, where supply lead time and demand predictability are given special attention.

Although these frameworks have made significant progress in developing theoretical foundations of SCS, they share some limitations with respect to guidance of TS design. Fisher (1997), Lee (2002), and Christopher et al. (2006) place most of their focus on production and inventory strategies, giving transportation an implicit or secondary role. In addition, their frameworks neglect the foundational factors in shaping transportatoin strategy in transportation mode choice literature, and relevant product and industry-specific contextual factors for decision making, such as, product density, perishability, product life cycle, resilience and sustainability, among all. These pitfalls lead to incapability of current frameworks to capture the complexity of TS–SCS alignment, in light of dynamic strategic, operational, and industry-specific constraints. When it comes to devising a proper TS for SCSs, it remains uncertain which TS should be used for each of these SCSs. Does an efficient TS always mean a low-cost one, or could it mean a lower transportation time or better modal control for some industries? A common interpretation is that efficiency means lower cost. However, when it comes to transportation operations, an efficient TS could mean a fast TS that secures lower total supply chain costs by responding effectively to demand fluctuations. This promotes an outside-in perspective to redefine proper TSs with regard to various SCSs.

Thus, when extended to the transportation domain, alignment theory provides an essential analytical framework: transportation is not just a support function but a strategic enabler whose misalignment can defeat the intended performance goals of the higher-level SCS.

2.2 Transportation strategy as a strategic lever

Transportation has long been recognised as a crucial determinant of supply-chain performance. Early studies, e.g. McGinnis, (1989), argued that transportation must be viewed as a strategic, not simply an operational function. Their work defined TS as a multidimensional concept that includes cost efficiency, service quality, and flexibility (Reis, 2014). Subsequent empirical research has supported this view, showing that transportation-related decisions have an impact on both operational efficiency and competitive differentiation (Holter et al., 2008). More recently, Goldsby et al. (2023) have focused on how transportation has become a critical part of the integration of complex, global supply chains.

The literature on transportation mode choice provides a strong base for theorising TS. Decades of empirical research converge on three main criteria: reliability, cost, and time. For instance, Shinghal and Fowkes (2002) found that reliability is the most important preference for shippers after cost, thereby confirming that service quality is a strategic determinant rather than a peripheral indicator. Feo-Valero et al. (2011) supported this observation by showing that both time and reliability substantially impact freight demand models with direct implications for system-wide efficiency and competitiveness. Reis (2014) used agent-based modelling to confirm that travel time, cost, and service frequency define short-distance intermodal strategy. Arencibia et al. (2015) developed advanced choice experiments to measure the cost, time, and reliability trade-offs over various shipment contexts, shedding additional light on shippers' decision rules. Going beyond traditional characteristics, Khakdaman et al. (2020) add a behavioural dimension, showing how trust and willingness to delegate modal control condition shippers' strategic mode choice decisions. At the methodological frontier, Keya et al. (2021) present a coupled model of mode choice and destination choice, thereby capturing their interdependencies and improving prediction. The recent study by Xu (2024) uses interpretable machine-learning techniques to identify nonlinear preference patterns and latent interactions that can be used to predict the strategic configuration of transportation systems.

However, an exclusive focus on this traditional triad underlines the rising importance of flexibility as a strategic resource. In today's turbulent environment, businesses need transportation systems that can accommodate unpredictable disruptions, volatile demand, and regulatory change. Empirical evidence of the significant role of transportation flexibility in reducing supply-chain vulnerability comes from Pellegrino et al. (2021), who show that transportation flexibility allows firms to have alternatives when a primary mode is compromised. Likewise, Khakdaman et al. (2020) note that shippers are increasingly willing to pay for flexible transportation services because of these services' ability to improve resiliency and service continuity. More recently, Ke et al. (2025) show that the air freight flexibility and speed help firms improve resilience and maintain inventory efficiency under increased uncertainty.

These results suggest that flexibility should be considered in addition to cost, time and reliability as a fourth major determinant of the TS. Importantly, this broadened perspective challenges the traditional view that *efficient* transportation is synonymous with low-cost solutions. In practical terms, efficiency is often about choosing transportation attributes that minimise overall supply chain costs by avoiding stock-outs, reducing lead times, or maintaining service reliability. For instance, in the fast-fashion industry, the dependence of Zara on quick and reliable transportation reflects the idea that the best modality in terms of both cost and time may be strategically efficient when it enables responsiveness and competitive agility (Orcao & Pérez, 2014).

Collectively, this body of research implies that TS should be thought of as a set of service attributes, i.e. cost, time, reliability, and flexibility, arranged in bundles that support and complement the overall supply-chain strategy. This conceptualisation places transportation as a strategic lever whose alignment (or misalignment) with SCS defines the degree to which the supply chain is able to meet its intended goals.

2.3 Research gap on TS-SCS alignment

The relationship between SCS and TS is rarely investigated (theoretically and practically) in the current literature. While only a handful of relevant studies exist, they mainly focus on TS-related factors and ignore its alignment with SCS (e.g. Ke et al., 2015). Lagoudis et al. (2002) concerned sea transportation and investigated which sea shipping vessel should be applied relevant to the TS of a supply chain. The authors considered different transportation-related factors (e.g. supply volume, product cost, shipping distance) in their case study analysis. They concluded that when cost-efficient transportation is needed, conventional shipping vessels should be applied, while high-speed vessels should be used when transportation flexibility is the market winner. Baker (2004) showed that the structure of distribution centre operations should be based on the broader SCS, thus placing such facilities as enablers of SCS rather than the traditionally neutral cost-centre view. Orcao and Pérez (2014) investigated how the fitness of transportationand logistics into the production network could provide major Spanish retailers with a competitive advantage. They indicated that efficient logistics and sufficient fast transportation have enabled Spanish fast fashion companies (i.e. Zara) to have short lead times needed to fulfil demand in economically and geographically very disparate markets. Zhang et al. (2014) applied Fishers' SCS categories (Fisher, 1997) to study the link between port strategy and SCS in the port of Hong Kong and highlighted the importance of this alignment in supporting shippers with agile/responsive SCS. Using the US trade and manufacturing datasets and regression methods, Ke et al. (2015) investigated how industry characteristics (i.e. the cost of capital, contribution margin ratio, demand uncertainty, and competition) influence the alignment of transportation mode choice decisions with SCSs. They conclude that the strategic alignment between industry characteristics and SCSs leads to transportation modal mix decisions in supply chains. Haial et al. (2016) introduced a model for pharmaceutical supply chains, highlighting that TSs should balance cost, service quality, and regulatory compliance to become more resilient. Jazairy (2020) extended the alignment discourse to consider sustainability aspects, thus highlighting the need for coordinated actions between shippers and logistics service providers in executing green logistics practices. More recently, Ke et al. (2025) showed that the inherent speed and flexibility of air freight can guide supply-chain resilience and inventory efficiency when faced with high levels of uncertainty.

In light of the identified limitations in current literature, the alignment between TS and SCS is undertheorized. While existing alignment models (e.g. Christopher et al., 2006; Fisher, 1997; Lee, 2002) have provided helpful taxonomies of SCSs, they are missing explicit attention to TSs, leaving a lack of guidance for the alignment of TS and SCS. On the other hand, mode choice studies have dealt in detail with the transportation determinants such as cost, time, reliability, and flexibility, but they tend to consider transportation as an operational optimisation problem rather than a strategic alignment decision. Despite advances in alignment theory and mode choice modelling, no broad framework exists to clarify how TSs should be systematically designed to complement SCSs. To fill this research gap, the present study proposes a conceptual framework for TS-SCS alignment that integrates a taxonomy for TSs and explores how these strategies could be mapped to different SCS types.

3 Proposed conceptual framework for TS-SCS alignment

3.1 Introducing four TSs and relevant decision criteria for TS-SCS alignment

The alignment of TS and SCS is a multidimensional decision-making problem that requires a joint consideration of theoretical foundations and practical constraints. Extending previous SCS frameworks (Christopher et al., 2006; Fisher, 1997; Lee, 2002), this study contributes to the literature by developing a taxonomy of four different TS types, i.e. Cost-Oriented Transportation Strategy (CTS), Flexibility-Reliant Transportation Strategy (FTS), Modal-Control-Intensive Transportation Strategy (MTS), and Value-Enhanced Transportation Strategy (VTS), with existing SCS typologies, i.e. Efficient, Responsive, Risk-Hedging, and Agile, by Lee (2002). The resulting framework is structured around a set of key decision criteria identified in the transportation and logistics literature.

As explained in Section 2.2, TS can be defined as the combination of service attributes (cost, time, reliability, flexibility, etc.) that together describe the company's strategic position in managing freight flows. Firms' TS determines (and is directly related to) their transportation service choice (Bolis & Maggi, 2003). As customers, shipper firms usually request freight transportation services from LSPs such as third-party logistics providers (3PLs), carriers, and forwarders. LSPs are considered as the main actors of the global freight transportation network that flow goods among different nodes of the international supply chains (i.e. suppliers, manufacturers, distribution centres, retailers, and customers). As a strategic decision in a supply chain, once a firm's TS is determined, the main characteristics of its TS is reflected in the long-term contracts with the LSPs as attributes of the transportation/logistics services delivered by the LSP. The combination of different service attributes shows the type of TS the firm seeks from the LSP. Thus, the bundle of service attributes that a shipper requires indicates the nature of TS pursued, and these attributes ultimately determine the extent to which transportation facilitates or undermines broader SCSs.

Recent studies have also suggested additional factors that contribute to the formulation of TS. Following Arencibia et al. (2015), Ben-Akiva et al. (2008), Roso et al. (2009), Swafford et al. (2006) and Khakdaman et al. (2020), we divide these into three broad categories: (i) the classic transport service choice determinants (cost, time and reliability); (ii) Modal control which concerns whether firms explicitly prescribe specific transport modes as strategically important or outsource mode decisions to LSPs within contract service limits; (iii) adaptive and extended attributes reflect firms' adaptation to evolving business conditions, including flexibility and value-added services (VAS), e.g. packaging, tracking and tracing, customs, etc. Collectively, these attributes form the configuration of transportation services that define a firm's TS. The following are our proposed four TSs:

Cost-Oriented Transportation Strategy (CTS): This strategy is used where the cost per transport unit is the dominant priority. Some of the primary applications of CTS are in the commodity industries, agriculture, and mining, where transportation costs account for a significant proportion of the delivered price (Stank & Goldsby, 2000). Transportation modes are primarily sea and rail since they enable economies of scale and predictable freight flows. In CTS, cost reduction is the principal focus, and time and reliability are maintained at a level that ensures the continuation of normal operations. Other service components, such as flexibility, modal control, and VAS, are only applied at the minimum acceptable levels where needed. (Fisher, 1997; Lee, 2002).

Flexibility-Reliant Transportation Strategy (FTS): The FTS is applied when companies experience uncertain demand, short product life cycles, or changing customer requirements. Under this approach, companies use the services of logistics firms to provide flexible types of transport, including the possibility to switch destinations, change the delivery time, or increase or decrease the shipment volumes (Khakdaman et al., 2022; Mason & Nair, 2013). The most common modes are road and air, and most multimodal networks are used to offer rerouting options. FTS is about flexibility, speed, and reliability to maintain service quality. Cost and modal control are accepted at higher levels than in CTS, but they are not the core decision drivers. VAS is applied if needed to support adaptability. This approach enhances resilience and is especially applicable in volatile or uncertain markets (Pellegrino et al., 2021).

Modal-Control-Intensive Transportation Strategy (MTS): MTS focuses on controlling transport modes by shippers rather than LSPs. This strategy is applicable when there are stringent regulatory or security concerns in the industries and when the loss of control can lead to compliance or quality risks. Modes may differ, but air, rail, or secure multimodal solutions are commonly selected for compliance and traceability. MTS focuses on modal control and reliability, while maintaining time and flexibility at functional levels as dictated by regulations or product features. Cost is a secondary consideration and is accepted at higher levels as needed. VAS, including tracking and specialised handling, can support control (Khakdaman et al., 2020; Tongzon, 2009; Tsai et al., 2012).

Value-Enhanced Transportation Strategy (VTS): VTS is focused on applying value-added services beyond the main transportation service to act as a source of differentiation, sustainability, and competitive advantage. VAS can be packaging, labelling, assembly, customs clearance, storage and handling, tracking and tracing, and increasingly sustainability-oriented services (Khakdaman et al., 2020). This approach is common in businesses providing luxury goods like fashion, pharmaceutical, and online selling where customers have high expectations of service and compliance (Christopher, 2000). The most common modes are premium road transport, air freight, and specialised multimodal solutions. VAS and reliability are the focus in VTS, which creates additional value beyond pure cost and speed. Flexibility facilitates these services, but is not a priority. Cost is accepted at a higher level when these services create a strategic value (Evangelista et al., 2018; Jazairy, 2020).

Developing a TS that is aligned with SCS can't be reduced to isolated tradeoffs between cost, time, or reliability. In reality, companies are operating in a context where a variety of contextual factors, including product attributes, uncertainty, service needs, sustainability pressures, and digital capabilities, influence transportation decisions. Failure to account for these factors could result in a static representation of transportation, despite its dynamic nature in relation to product life cycles, market volatility, and regulatory or technological changes. Drawing on previous logistics and supply chain management studies, we identify thirteen decision criteria that form the contextual envelope for theorising transportation and SCS alignment. These criteria are divided into three general categories: (i) product-related factors, (ii) uncertainty and service conditions, and (iii) Sustainability, resilience, regulatory, and technology enablers.

I. **Product-related factors**

Product Life Cycle (PLC): is a concept that explains how a product passes through the life cycle stages of Introduction, Growth, Maturity, and Decline. It is one of the key determinants of supply chain and transportation requirements (Harris et al., 2010). During the Introduction stage, demand is unpredictable, product volumes are minimal, and companies are concerned about speed and ability to respond to the market (e.g. pharmaceuticals). In the Growth stage, demand grows at a high rate, logistics complexity increases, and a tradeoff arises between responsiveness and efficiency. At Maturity, demand better matches supply, economies of scale can be achieved, and cost efficiency in transport becomes the most crucial issue. Lastly, cost minimisation is almost all that matters in the Decline stage, as demand is diminishing. Thus, TSs must evolve throughout the PLC: fast and flexible early, transitioning to low-cost later, and reaching the end of life (Fisher, 1997; Stank & Goldsby, 2000). In alignment terms, responsive supply chains require fast and dependable services to handle demand uncertainty in their initial stages, whereas efficient supply chains in later stages are better positioned to utilise slow and low-cost transportation modes (Lee, 2002).

Product value: can be defined as the economic value of goods in transit. It helps to determine the level at which firms are willing to pay for transport services. Low-value products, such as grains or coal, typically require transport solutions with low prices per unit, e.g. by sea or rail. The products of medium value (e.g. appliances and packaged food) represent a compromise between cost and service level, and multimodal strategies are appealing. Premium transport (e.g. secure truck and air freight) is justified by high-value products (e.g. luxury fashion, semiconductors, biopharma) because the cost of stockouts or damage exceeds the cost of transportation (Stank & Goldsby, 2000). In terms of alignment, products of high value can be aligned with responsive or agile supply chains, while those of low value can be aligned with efficient supply chains. The misalignment may lead to unnecessary costs or risks (Qi et al., 2009).

Product density (Value-to-Weight (V/W) ratio): measures the economic density of a product, and has long been considered as a key determinant of modal choice decisions. Sea or rail is optimal for low V/W ratio commodities (such as iron ore and coal), where the cost per ton is the controlling variable. Shipment of products with Medium density (electronics peripherals, household goods) can be done via truck or rail to balance cost and speed. Air freight can be used for high V/W ratio products (e.g. semiconductors, luxury jewellery, vaccines), as the high value corresponds to the high per-unit shipping costs (Solanki et al., 2023). Product density is critical because it ties economic density to transportation costs: it makes sense to ship a $1M chip via airline, but not a million dollars' worth of bulk coal. Companies that do not consider this criterion (e.g. delivering low-value fresh goods by premium airfreight) can incur significant waste (Díaz et al., 2015). From the TS-SCS alignment perspective, efficient supply chains should use low-cost transportation for low-density commodities. In contrast, fast and reliable transportation is essential for responsive supply chains that carry high-density, time-sensitive products (Arencibia et al., 2015).

Perishability (time-sensitivity): is a metric of the rate at which a product depreciates in value or functionality if not delivered quickly. Low-perishability goods (e.g. machinery and steel) can bear long lead times. Goods with medium perishability (e.g. packaged food and seasonal clothing) need predictable delivery windows for transportation. Goods with high perishability (e.g. fresh products, vaccines, blood products) require a fast-response transportation system, often including cold-chain capabilities, such as air transportation (Haial et al., 2021). The TS of perishable goods could be aligned with responsive or agile SCSs in fast transportation modes. In contrast, non-perishable goods are well-suited to efficient supply chains with slow, low-cost transportation modes (Christopher, 2000).

II. Uncertainty and service conditions

Demand uncertainty: reflects the predictability of market demand over time. Commodities and staple FMCGs are low uncertainty products with stable and predictable demand. Therefore, they are good candidates for cost-effective, capacity-driven transportation. Products with highly uncertain demand (e.g. fashion clothing, electronics, or seasonal items) need to use fast and flexible transportation to address changes and avoid running out of stock. These conditions have to be reflected in the TS. Misalignments can happen when responsive supply chains use cost-oriented TSs in volatile markets, leading to failures to fulfil demand. Matching flexible and fast TSs with high-uncertainty markets will allow firms to leverage speediness and reliability as a competitive edge (Fisher, 1997).

Supply uncertainty: captures the risk of disruptions and unreliability in sourcing inputs (Lee, 2002). Low supply uncertainty is an attribute of stable commodities or suppliers who deliver with solid schedules. Global sourcing, geopolitical instability, or reliance on a single supplier (such as semiconductors) leads to high supply uncertainty (Ke et al., 2015). In cases of high supply uncertainty, TSs can improve resilience through flexible options, such as multimodal routing. There is also the interaction of supply uncertainty and demand uncertainty: TSs that can handle agility will remain competitive in a scenario of double-uncertainty. Firms experiencing low uncertainty in supply can align their efficient SCS with stable transportation contracts (Pettit et al., 2010).

Customer service level: is a measure that describes how responsive, reliable, and customised the supply chain is supposed to be. Delays and inexpensive transport are tolerated in low-service-level contexts (e.g. bulk raw materials). Medium service levels apply to products with predictable demand cycles, e.g. consumer durables. A high level of service is essential in contexts such as e-commerce, healthcare, and fashion, particularly when temperature control or same-day delivery is not negotiable (Kayikci et al., 2018). In alignment terms, Haial et al. (2021) introduce service level into TS and demonstrate that high-service industries usually cannot support cost-efficient TS without compromising competitiveness. Instead, the high-service requirements drive firms toward a faster and reliable TS where service differentiation is integrated into the transport design.

Mode choice: Mode choice is the oldest recognised area of research in TS, which is traditionally driven by cost, reliability, and transport time. Airfreight is fast yet expensive. The truck has flexibility in short/middle hauls but has limited capacity. Rail is cheap for bulk transport. At the lowest cost per ton, sea freight is the slowest mode. Multimodal transportation allows for hybrid optimisation (Tongzon, 2009). Regarding the TS-SCS alignment, effective supply chains tend to opt for low-cost bulk modes, whereas responsive or agile supply chains prefer faster or multimodal solutions that strike a balance between flexibility and service performance (Arencibia et al., 2015; Goldsby et al., 2023).

III. **Sustainability, resilience, regulatory, and technology enablers**

Environmental sustainability: aims to minimise the environmental impact of various corporate functions, including transportation. At the low end, companies focus on cost and speed, paying minimal or no attention to environmental performance, which is common when sustainability is not a component of the corporate strategy (Jazairy, 2020; Stank & Goldsby, 2000). On the medium level, firms implement partial measures, including shifting some freight from road to rail or acquiring fuel-efficient fleets, which helps reduce emissions while balancing cost and service requirements (Evangelista et al., 2018). At a high level of environmental sustainability, companies can directly incorporate environmental goals into their transportation policies by, for example, implementing carbon-neutral logistics, fleet electrification, or sustainable multimodal systems. These practices can make green transport a source of competitive advantage and supply chain legitimacy (Kayikci et al., 2014). To facilitate alignment, companies adopting environmental sustainability need to apply greener modes or technologies that increase supply chain compliance with environmental standards (Kayikci et al., 2014).

Social sustainability: concerns labour conditions, safety, and ethics (Kayikci et al., 2014). At a low level, TSs overlook social impacts and only consider cost and efficiency, which may subject firms to reputational risk and stakeholder criticism (Jazairy, 2020). At the medium level, companies follow minimum labour and safety standards or demand that logistics partners become certified, but the responsibility remains reactive rather than strategic. At a high level, TS encompasses social sustainability, where companies proactively ensure fair labour conditions, safe and healthy working conditions, and ethical business practices with their suppliers, thereby aligning with corporate sustainability objectives and strengthening long-term legitimacy (Evangelista et al., 2018). This criterion is important for TS-SC alignment because supply chains that prioritise resilience and stakeholder trust also require TSs that integrate social responsibility with cost and service performance (Goldsby et al., 2023; Kayikci et al., 2014).

Resilience: is the ability of supply chain and transport systems to continue functioning in the face of disruptions such as pandemics, natural disasters, or political shocks. Low-resilience supply chains rely on a single supplier or route, whereas medium-resilience firms utilise redundant carriers or safety stock. Highly resilient supply chains enhance resilience through measures such as multimodal routing, contingency contracts, and dynamic monitoring tools. (Pellegrino et al., 2021). TSs in highly uncertain environments should prioritise redundancy and flexibility to keep aligned with supply chains that strive to be robust and responsive in the face of disruption (Ivanov, 2020).

Regulatory and compliance pressure: is the degree to which formal standards, such as safety, packaging, cold-chain provision, etc, constrain transportation. There is little control over, for example, bulk raw materials at the low level of regulatory pressure. Compliance is at a medium level when, for example, food and consumer products are involved, and certain safety standards must be met. At a high level, compliance prevails in areas such as pharmaceuticals, chemicals, and defence, where tested and reproducible logistics are enforced by law (Haial et al., 2016). From the TS-SCS alignment lens, highly regulatory settings require TSs with a focus on compliance, traceability, and control over transportation mode. However, industries that need fewer regulatory requirements can adopt cost-driven TSs (Evangelista et al., 2018; Zhang et al., 2014).

Technology and digitalisation capability: reflects the level of visibility and intelligence of supply chain and transportation operations, using IoT, AI, blockchain, and predictive analytics, among others. At the low level, firms use manual tracking or paper-based processes. On the medium level, companies use ERP systems and GPS tracking. On a high level, transport networks use IoT, blockchain, and AI to facilitate predictive decision-making and real-time coordination (Goldsby et al., 2023). Companies with advanced digital capabilities are better positioned to coordinate transportation with SCSs that prioritise agility, resilience, and sustainability, because digital capabilities allow companies to make more informed decisions and proactively mitigate risks (Ning & Yao, 2023).

3.2 The conceptual framework for TS-SCS alignment

To synthesise the literature and our conceptual reasoning, we propose a framework that systematically aligns TSs with SCSs. Figure 2 presents this conceptual framework for TS–SCS alignment. The figure illustrates how four TSs interact with the four SCSs defined by Lee (2002) (Efficient, Responsive, Risk-hedging, and Agile) (see Figure 1). We choose the framework introduced by Lee (2002) since it considers both demand and supply uncertainties of products to comprehensively introduce four SCSs (e.g. Efficient SCS for products with low demand and supply uncertainty, and Responsive SCS for products with low supply uncertainty and high demand uncertainty). The proposed framework incorporates the contextual factors introduced in section 3.1 to guide TS-SCS alignment decisions.

The proposed framework in Figure 2 for aligning a firm's TS with its SCS consists of two interlinked sections. The former defines how a proper SCS is set, and the latter provides the rationale for choosing the most suitable TS that supports the TS. Both decisions are rooted in the overall corporate strategy.

Three contextual factors that influence the identification of the SCS are the PLC, demand uncertainty, and supply uncertainty. The PLC entails four stages: Introduction, Growth, Maturity, and Decline. Each stage presents a distinct pattern of demand and supply uncertainty. Evaluation of these levels of

		Demand uncertainty	
		Low (Functional products)	***High (Innovative products)***
Supply uncertainty	***Low (Stable process)***	Efficient supply chains	Responsive supply chains
	High (Evolving process)	Risk-hedging supply chains	Agile supply chains

Figure 1. SCS and the product characteristics alignment model by Lee (2002).

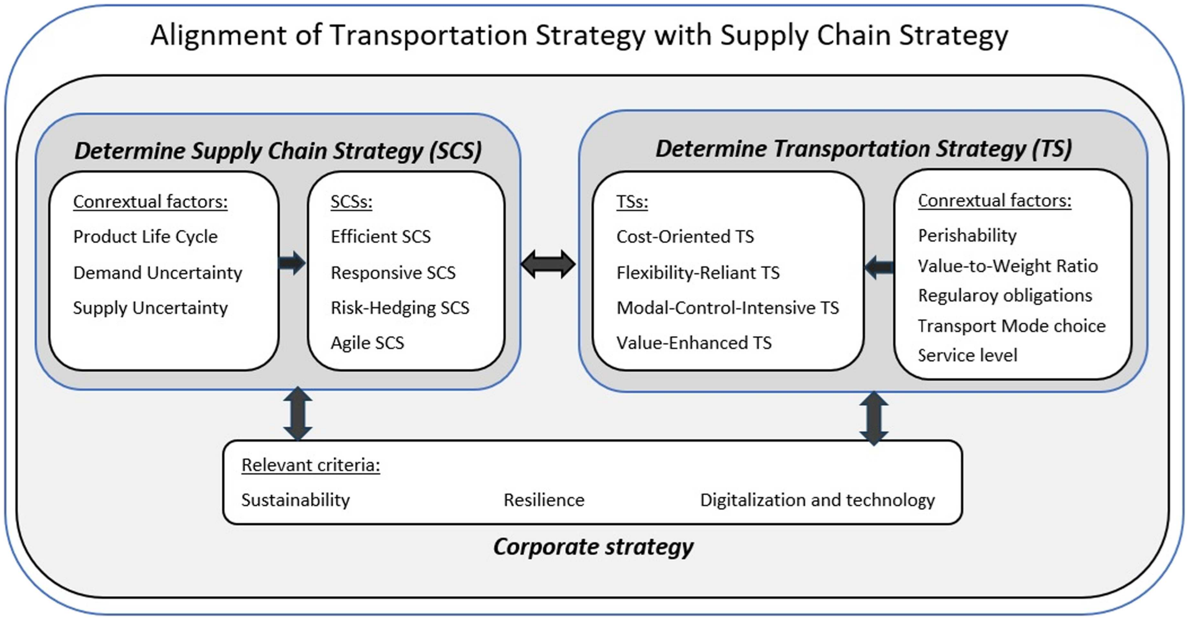

Figure 2. Proposed conceptual framework for TS–SCS alignment.

uncertainty, ranging from low to high, enables firms to establish the most suitable strategy among the four SCSs: Efficient, Responsive, Risk-Hedging, and Agile.

After confirming the SCS, the second section of the framework will be used to determine the TS. The decision will be made based on five primary factors: the perishability of the product, the value-to-weight ratio, regulatory and compliance requirements, the mode of transportation, and the required service level. These indicators have an impact on the urgency, economic viability, compliance requirements, and performance expectations of the transportation system. Their assessment can enable the firm to choose between four TSs: the Cost-Oriented Transportation Strategy (CTS), the Flexibility-Reliant Transportation Strategy (FTS), the Modal-Control-Intensive Transportation Strategy (MTS), and the Value-Enhanced Transportation Strategy (VTS).

Alignment between the SCS and the TS is most effective when both align with the firm's corporate strategy. The corporate strategy in this framework has three main criteria, namely sustainability, resilience, and digitalisation. Sustainability encompasses economic, social, and environmental considerations; resilience relates to the firm's ability to continue operating; and digitalisation pertains to the technological capacity to enhance supply chain and logistics performance.

To provide a practical guide for applying the proposed conceptual framework, we have developed a step-by-step flowchart (Figure 3) that guides managers through this decision process.

Part A of the Flowchart in Figure 3 presents the rational and systematic methodology for determining the relevant SCS based on the PLC and the uncertainties in demand and supply. It begins with identifying the stage of the PLC of the product under analysis. The PLC stage is crucial because it influences the level of demand and supply uncertainty. During the Introduction phase, both the demand and supply uncertainty are usually high. The demand is highly unpredictable, as no historical data or patterns of customer behaviour are yet known. The supply uncertainty is also high because the supply base has not yet been developed, and production processes could be untested or unstable. In this scenario, the Agile SCS is recommended, which supports the speed, flexibility, and fast responsiveness required. In the second scenario of the Introduction phase, although demand uncertainty is high, supply uncertainty can be low or medium, for example, in cases where the product is a new version of an existing product line or where the company already possesses an existing and trusted supply base. The Responsive SCS is more suitable in such situations.

The Growth phase has two common situations. Under the first scenario, historical data, customer behaviour information, and demand patterns are available from the Introduction phase. This allows

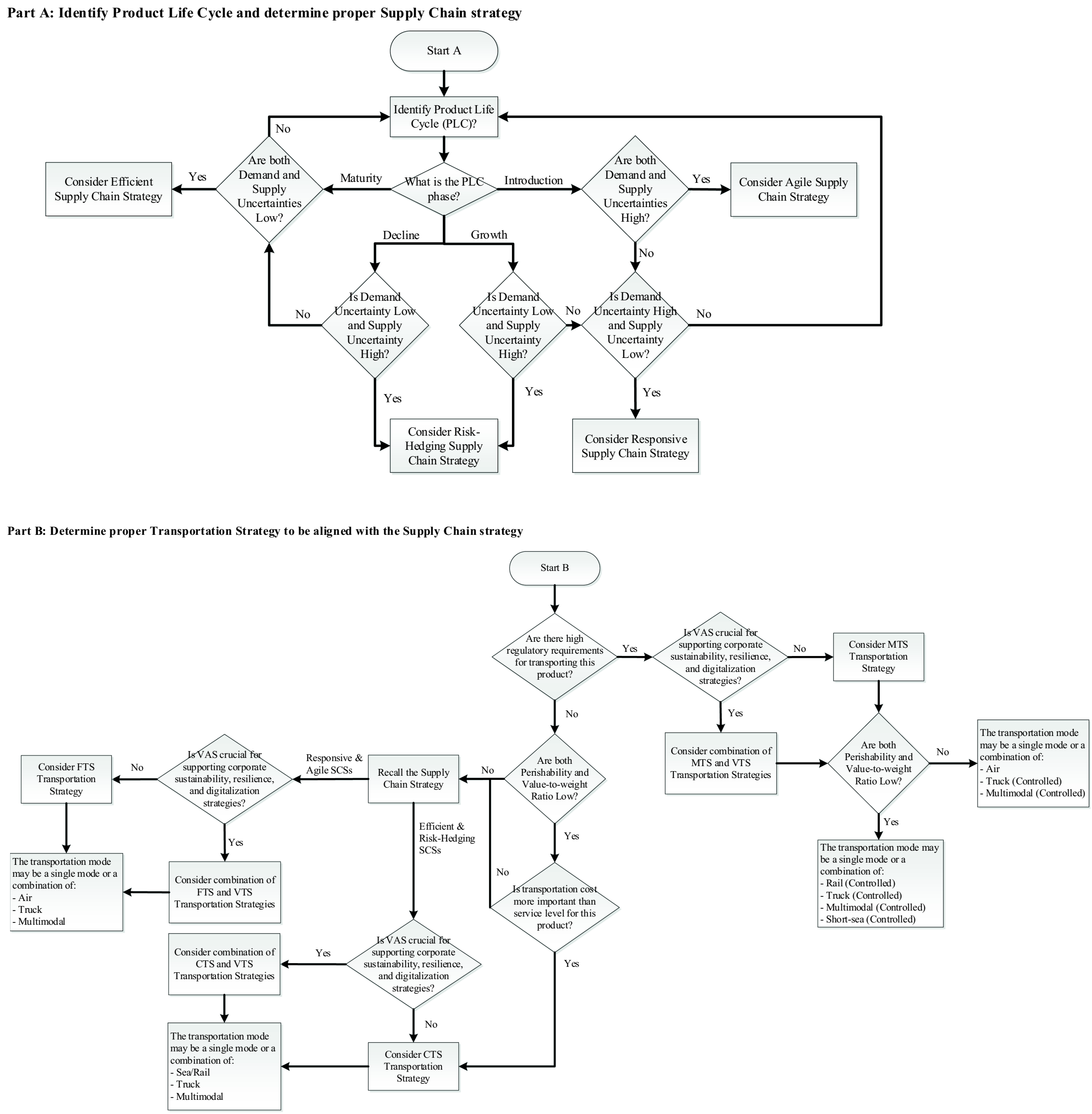

Figure 3. Step-by-step flowchart guidance for applying the proposed conceptual framework in practice. Part A: Determining the right SCS, and Part B: Determining the proper TS to be aligned with SCS.

managers to predict the growing demand more accurately and experience medium to low demand uncertainty. However, the supply base may not be fully developed to meet increasing demand, and the uncertainty in supply is medium to high. Under this mix, the flowchart suggests the Risk-Hedging SCS, which shields the company against the upstream volatility and promotes further growth in the market. The second Growth scenario occurs when uncertainty in demand is high, but the company has established and stabilised its supply base, resulting in low uncertainty in supply. In such circumstances, the Responsive SCS is suggested because it allows for quick responses to changing customer demands using a stable supply. The other two combinations of uncertainties, where both demand and supply uncertainties are high, or both are low, are not typical of the Growth phase. When both are high, the product behaves as if it is still at the Introduction stage; when both are low, the product is at the Maturity stage.

In the Maturity phase, uncertainty in demand is minimal, as the behaviour of consumers is well understood and sales patterns over the long term are more predictable. Similarly, the uncertainty of supply is minimal, as the supply base is well-developed, production processes are efficient, and the company can consistently meet demand with sufficient supply. In the Maturity phase, the Efficient SCS is the best option for focusing on minimising costs and maximising processes and economies of scale. Lastly, the flowchart considers the Decline stage. During this phase, demand starts to decline as customers transition to the new product or technology. Due to the predictability of the downward trend in demand, the uncertainty of demand is low to medium. Uncertainty tends to be higher, though, on the supply side. The supply base established in Maturity might no longer be sustainable, and suppliers may drop components or materials as they transition into newer products, leading to medium to high supply uncertainty. In the conditions of low demand uncertainty and high supply uncertainty of the Decline phase, the flowchart suggests the Risk-Hedging SCS. Nevertheless, there is also a possibility that the uncertainty of demand and supply is low during the initial stages of Decline. When this happens, the Efficient SCS remains a fitting one.

Overall, the first section of the flowchart coordinates the four phases of the PLC with the respective mixes of demand and supply uncertainty and the resulting four SCSs.

Part B of the Flowchart in Figure 3 aims to define the relevant TS and how it must be aligned with the four SCSs established during the first stage. During this second phase, the choice of TS is motivated by several contextual conditions, including perishability, value-to-weight ratio, regulatory factors, mode of transportation, and the level of transportation service. Considering these factors, the flowchart will help managers select a TS that is not only justified by the product features but also aligns with the SCS identified in Part A.

The regulatory requirements will serve as the starting point for the decision-making process. This factor is initially considered in cases where a product (e.g. pharmaceuticals, biologics, hazardous goods) requires high regulatory adherence; in such instances, the mode of transportation should be carefully chosen. If the regulatory requirements are high, the flowchart directly suggests the MTS to support the regulatory and compliance standards. Once the need for MTS is identified, the flowchart directs the manager to determine whether the company also requires value-added services, such as tracking, temperature monitoring, sustainability metrics, and digital visibility tools, among all, to support its corporate strategies in terms of sustainability, resilience, and digitalisation. In cases where value-added services are needed, the flowchart suggests using MTS with VTS. The choice of transportation mode depends on the perishability and value-to-weight ratio when applying MTS or a combination of MTS and VTS. In cases of low perishability and a low V/W ratio, it is suggested to use a controlled sea, rail, or truck mode. In instances where perishability, value-to-weight ratio, or both are high, more sophisticated and expedited modes, such as air, truck, or controlled intermodal, are recommended. One of the main characteristics of the value-to-weight ratio is that it serves as an intrinsic indicator of the product's value and its life cycle. The value of the product in most cases remains constant throughout the life cycle stages, but the shipment size (the denominator of the ratio) continues to increase as the product progresses through the Introduction, Growth, and Maturity stages. The V/W ratio is therefore expected to peak in the Introduction stage, then decrease in the Growth and Maturity stages as large volumes are shipped, and could rise slightly in the decline stage as the volume declines. Therefore, using the V/W ratio, the flowchart implicitly represents product value and life cycle stage as determinants of transportation.

The flowchart then covers the case of low regulatory requirements. Perishability and value-to-weight ratio are considered in this case. If both perishability and the V/W ratio are low, the flowchart recommends the CTS, provided the company is primarily concerned about transportation and supply chain costs rather than its service level. The transportation modes adopted are sea, rail, or truck. In cases where service level is more significant than cost, the flowchart will lead the manager to the scenario in which at least one of perishability or V/W ratio is high. The question that arises in this instance is whether value-added services are necessary to support broader corporate goals, such as sustainability, resilience, and digitalisation. If the company does not require value-added services, the flowchart will direct the strategy of the established supply chain, as outlined in Part A. Under a firm's Agile or Responsive SCS, the FTS will provide the best alignment. FTS is typically based on air, truck, or intermodal modes due to their speed and flexibility. For an Efficient or Risk-Hedging SCS, the recommended transportation strategy is CTS, utilising modes such as sea, rail, or truck. If the company requires value-added services, the flowchart will help classify the TS that should be adopted, based on the SCS chosen earlier. In the case of an Agile/Responsive SCS, both FTS and VTS are suggested to be combined, and the transportation modes include air, truck, and intermodal. In the case of Efficient or Risk-Hedging SCSs, the appropriate TS is a blend of

CTS and VTS, where recommended modalities include sea, rail, and truck, supplemented by the required value-added services. Using this series of decisions, the flowchart provides transportation managers with a viable guideline for determining the proper TS to align with the chosen SCS.

To illustrate a real-world application of the TS-SCS alignment framework in practice, we examine the global distribution of Pfizer vaccines (Pfizer Inc., 2023). Consider the introductory or growth stages of the PLC for this product, where demand uncertainty is high and medium supply uncertainty is expected. According to Patr A of Figure 3, the Responsive SCS is a proper fit. To continue with Part B of the flowchart, the product has high regulatory requirements, leading decision-makers to MTS as the fundamental TS for vaccines. Considering other contextual factors, the product has high product value and density, and medium to high perishability. The company also needs high service levels for the distribution of the product, as well as value-added services, to support resilience and sustainability (in particular, social sustainability to provide vaccines for everyone needed around the world). Therefore, a combination of FTS and VTS transportation strategies is recommended to provide fast, flexible, and responsive transportation via air and temperature-controlled truck.

Overall, there is no single TS that applies to all supply chains. Instead, alignment will be based on ensuring that the salient features of each TS reinforce the strategic intent of the respective SCS. Misalignment happens where companies invest too much in flexibility or services in stable environments, and too little in speed and resilience in volatile environments. Contributions of this framework include: extension of the alignment theory to transportation as a strategic enabler, providing a systematic approach to studying TS-SCS fit; and formulating a taxonomy of four TSs, grounded in the mode choice literature, and mapping them against SCSs based on a set of several key decision criteria, offering a decision-making instrument for researchers and practitioners.

4 Illustrative case survey

This section demonstrates the applicability of the proposed conceptual framework using a representative survey study among leading international companies. The objective is not to offer broad empirical generalisations, but to demonstrate how the framework can be operationalized and how patterns of TS-SCS alignment in the real world can be realised in practice. Given the practical constraints of global executive surveys, not all thirteen decision criteria of our proposed framework are applied in the illustrative case survey. Instead, it focuses on a narrower group of six broadly accepted attributes of transportation services, namely cost, time, reliability, flexibility, modal control, and value-added services, which are central to the literature on freight transportation and can be compared across industries. This narrow scope ensures quality data and manageability of the respondents, without sacrificing the ability to draw meaningful conclusions about the alignment patterns. The extended thirteen conditions are still within the conceptual framework and offer a theoretical envelope to be tested empirically in future studies.

To maintain the paper's structure and readability, and avoid detraction from the conceptual focus of the study, the main body of the paper presents the introduction and results of the illustrative case study, i.e. Sections 4.1 and 4.2. The methodological procedures of the case study, including the data collection and survey design, the validity and reliability assessment of the survey tool and BWM data, and the calculation of attribute weights using the BWM, and assessment of the TS-SCS alignment for the illustrative case companies, are presented in Appendices A, B, C, and D, respectively.

4.1 Transportation service criteria for a transportation strategy

This section defines the transportation service criteria for setting up TSs. Taking into account studies by Arencibia et al. (2015), Ben-Akiva et al. (2008), Roso et al. (2009), Swafford et al. (2006), and Khakdaman et al. (2020), among all, we include three sets of criteria for identifying the configuration of transportation service: (i) the common criteria for choosing a transportation service, such as transportation cost, time and reliability, (ii) transportation modal control, as a criterion for observing whether firms consider specific transportation mode(s) in their TS or they have a service choice attitude, and (iii) criteria to observe how firms would like to change their TS adaptive to their business circumstances, such as transportation flexibility, and how value-adding operations beyond the main transportation service is considered in firm's TS, i.e. value-added services (VAS). The attributes are defined as follows:

- End-to-end cost is the total amount of money paid for shipping, for example, one TEU (20-foot container) from origin to destination.
- End-to-end transportation time is the duration from the shipment's first origin to its final destination.
- Reliability is the on-time delivery of freight/goods at the destination.
- Modal Control is the importance of having control over determining the mode of transportation by firms.
- Flexibility is the transportation service capability to effectively fulfil a shipper firm's required changes in service components before finalising the booking of the transportation service and while goods are on their way towards their destination. Examples include changing delivery time/location, shortening or extending lead times, aggregating or disaggregating volume/variety via warehouses or cross-docking terminals, and switching to low-carbon transportation modes, e.g. rail, to decrease the environmental carbon footprint of transportation operations.
- Value-added services (VAS) are ancillary services, including tracking and tracing, storage and handling, customs, and packaging, offered by the LSP beyond the main transportation service.

With the above configuration of TSs, we developed a TS-SCS alignment survey among international firms and evaluated the results as described in the Appendices. The following section reflects on the evaluation of the case study relevant to the proposed framework.

4.2 Reflection of the proposed framework in the illustrative case survey

Here, we map the illustrative case to the proposed conceptual framework, demonstrating how the TSs observed in practice can be used to illustrate the patterns of alignment that the proposed framework suggests. Illustrations in section 3 about the right alignment of TS with SCS suggest that more than one proper TS strategy might be needed for each SCS, depending on the nature of the industry, contextual factors, and dynamics of the business environment. In practice, industries with the same SCS apply different TSs to make the right alignment between their TS and SCS with the aim of minimising total supply chain cost. When a Fortune company adopts a responsive TS for an efficient SCS, this will improve the total supply chain landed cost for their specific industry, while when another company selects an efficient TS for their efficient SCS, they also seek to decrease the total landed cost of the supply chain via different configurations between production, transportation, and distribution operations. Using the proposed conceptual framework and data of the illustrative case survey, we identified four major TSs that are applied by major international supply chains to properly align their TS with SCS, as depicted in Figure 4. We arrived at these strategies considering three transportation service attributes that usually

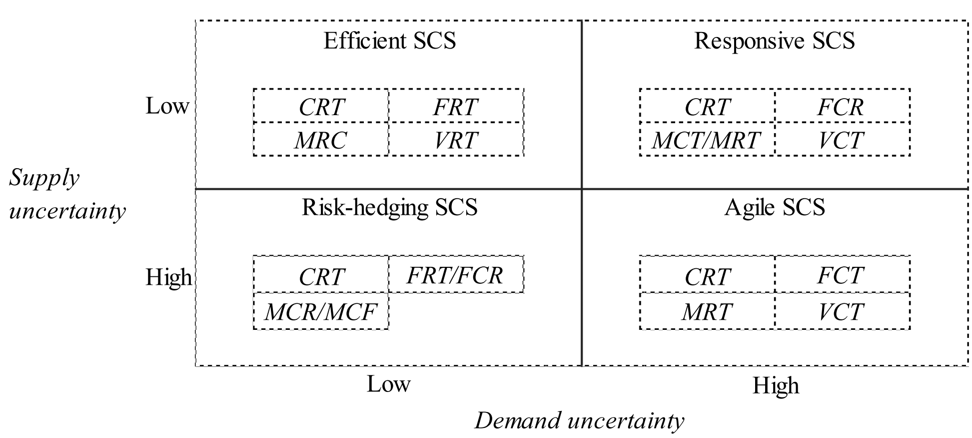

Figure 4. Right TSs for proper alignment with each SCS.

contribute to approximately 70% of the overall weight of a TS for every industry in each SCS, e.g. CRT represents a TS that Cost, Reliability, and Time form 70% of its total weight. Following this, we illustrate these TSs.

Cost-efficient, fast, and reliable transportation (CRT strategy): Many firms in our survey use this TS, which is equivalent to the CTS in our proposed framework. Firms with this TS mainly focus on minimising transportation costs while improving transportation time and reliability. For example, firms operating in the energy industry (see Table D1) apply a CRT strategy for their efficient SCS where 75% of the decision criteria weight in their TS is composed of transportation cost (i.e. criterion weight of 0.35), transportation reliability, and time. The consumer cyclicals industry is another case where firms follow a CRT strategy for their agile SCS.

Flexibility-oriented transportation (FRT and FCT/R strategies): A flexibility-oriented TS (equivalent to the FTS in our proposed framework) is applied when firms need to address different uncertainties within their end-to-end supply chain (i.e. demand fluctuations) by utilising capabilities of LSPs' flexible transportation services, such as changing transportation destination, increasing or decreasing transportation lead time, aggregation or disaggregation of shipment quantity, and so on. Mason and Nair (2013) report that LSPs' clients, e.g. shipper firms, seek flexibility in the logistics services as a valuable competency for addressing uncertainties in their competitive markets. TSs that consider the adaptability of transportation service components as a main decision criterion are getting more popular among firms (Khakdaman et al., 2020). We identified the following two main flexibility-oriented TSs among our case companies:

Flexible, reliable, and fast transportation (FRT): In this TS, the majority of the weight for the decision criteria is composed of transportation flexibility, time, and reliability, while cost-efficiency is among the least important decision factors. For instance, healthcare companies with an efficient SCS adopt an FRT strategy for the best alignment of their TS with SCS. Another example is the utilities industry, which applies the FRT strategy to mitigate different risks in its risk-hedging SCS. Firms with low demand uncertainty and high supply uncertainty (i.e. utilities industry) adopt a risk-hedging SCS to pool and share resources in their supply chain in order to share risks among supply chain actors when supply disruptions happen (Lee, 2002). Using an FRT strategy by firms in the utilities industry helps mitigate supply chain risk by, for example, consolidating (or deconsolidating) the quantity of a key component from alternative supply sources when the main supply source is disrupted.

Flexible, cost-efficient, and fast/reliable transportation (FCT/R): Firms adopting this TS have a stricter view of the costs of a flexible transportation service by including cost-efficiency besides flexibility and reliability (or time) as main decision criteria (i.e. at least 70% of criteria weight). For example, firms pursuing a responsive SCS for innovative products in the consumer cyclicals industry adopt an FCR strategy to respond to demand fluctuations via on-time and adaptive deliveries while maintaining minimum transportation costs. Another case is the telecommunications industry with agile SCS, which adopts an FCT strategy to address its demand and supply volatilities.

Modal-control-oriented transportation (MRT, MCT/R, and MCF strategies): While firms usually decide about transportation mode when asking LSPs to transport their goods (Tongzon, 2009), the inclusion of modal control as a primary decision criterion for developing TS reflects vital importance of modal control for some industries that need to avoid risks associated with losing control and visibility over transportation of their goods by LSPs (Khakdaman et al., 2020; Tsai et al., 2012). This TS is equivalent to the MTS in our proposed framework. We identified the following three main modal-control-oriented TSs:

Mode-specific, reliable, and fast transportation (MRT): Firms pursuing this TS need to utilise a reliable and fast transportation service operating within specific, pre-determined modes of transportation. As an illustration, to ensure safe transportation of some pharmaceutical products, healthcare companies adopting a responsive SCS need to determine the mode of transportation in advance. Other examples are supply chains operating with agile SCS in the industrials and basic materials industries.

*Mode-specific, cost-efficient, and fast/reliable transportation (MCT/R):*This TS is applied by industries that need to control transportation mode while considering transportation cost and time/reliability as typical attributes of a transportation service. Firms producing consumer non-cyclical products adopt the MCT/R strategy when pursuing both efficient and responsive SCSs. MCT/R is also applied by the consumer cyclicals industry when adopting an efficient SCS.

Mode-specific, cost-efficient, and flexible transportation (MCF): The MCF TS is applied when firms need to control transportation mode(s) and costs while favoring transportation flexibility to address supply chain uncertainties. Risk-hedging SCS is a good example of how several healthcare firms adopt an MCF strategy to mitigate operational risks along the supply chain.

VAS-oriented Transportation (VRT and VCT/R strategies): This TS is concerned mainly with industries that derive particular value from technological/operational value-added services, e.g. packaging, tracking and tracing, and storage and handling, aligning operations in their supply chain. This TS is equivalent to the VTS in our proposed framework. We identified the following two main VAS-oriented TSs:

VAS-oriented, reliable, and fast transportation (VRT): This TS belongs to firms that, apart from transportation reliability and time, value VASs as an effective attribute of their TS to align their supply chain operations. For instance, firms operating with industrial products in the context of efficient SCS are willing to apply VASs to track their freight from origin to destination or to package goods via LSPs' VAS services, while their goods are on the way toward the destination.

VAS-oriented, cost-efficient, and fast/reliable transportation (VCT/R): Firms with this TS seek a typical cost-efficient, reliable, and/or fast transportation while benefiting from value-added services. Two examples are firms operating with responsive SCS in the industrials sector and firms operating under an agile SCS in the utilities industry.

In summary, taking into account the preferences of leading supply chain firms to adopt a variety of TSs for each SCS shows that only a *customised* TS can provide the right alignment between TS and SCS, as also emphasised via the proposed conceptual framework. This customisation can take the shape of a focus on transportation costs, service flexibility, control of modality, and value-added services.

5 Implications, conclusions, and future research directions

5.1 Managerial implications

Aligning TS with SCS is crucial in the efficient and effective movement of products or services. The most important insight of our framework for managers is that TS needs to be strategically aligned with SCS by carefully considering the product characteristics, uncertainty, and broader sustainability, technology, and regulatory demands. The mismatch adds to expenses, compromises resiliency, and threatens customer satisfaction. A customised TS can properly fit with SCS, where managers consider the thirteen decision criteria in the proposed TS-SCS alignment framework. For example, as products move through different stages in their life cycle, (Cao & Folan, 2012), different TSs may be needed to handle each stage. In the introduction phase, where frequent product and process design changes happen, demand is uncertain, and relevant distribution channels are being established, a flexible and responsive TS could pave the way to help create demand, position the product in the market, and capture more customers' demand. In the growth stage, where product development is established, and production capacity increases relevant to a more established demand, companies need to enhance distribution channels using a fast, reliable, and flexible TS. In the maturity stage, where product development experiences few rapid changes to keep the company as innovative as possible and optimum production capacity is utilised, CTS, MTS, and VTS could be applied. In particular, the VTS could generate new value propositions in the market to improve companies' market share. In the decline phase, where sales started to decline due to market saturation, technological advances, or changing consumer preferences, companies may utilise phasing out promotions focusing mainly on CTS to cut costs. Overall, as product characteristics evolve across different product life cycle phases, adjusting TS to SCS ensures that market dynamics and demand shifts are addressed, facilitating timely yet cost-efficient delivery of products and services.

A better alignment of TS with SCS can also help address environmental, social and economic sustainability as one of the contemporary requirements and norms of societies and governments. All four categories of TSs suggested in section 3 could utilise different sustainability-oriented practices to secure a decent alignment with SCSs. For example, when firms apply MTS to align with their SCSs, they could use environmentally friendly transportation modes, e.g. rail, and green technologies, e.g. hybrid or electric vehicles, to reduce the transportation carbon footprint and improve energy efficiency. Firms can also embed sustainability requirements, such as temperature-controlled green cold chains or compliance with emission standards, directly into their contracts with LSPs, to ensure both environmental and regulatory fit. Applying Cost-efficient, fast, and reliable TSs could improve environmental and economic sustainability by utilising better route planning, maximising vehicle utilisation, and reducing fuel consumption. Modal shifts to lower-carbon transport where possible (e.g. short-sea shipping, rather than road transport, or utilising synchromodal transportation (Khakdaman et al., 2020)), carbon-accounting instruments to track the carbon impact of each shipment, and eco-driving programs on road freight fleets can also be part of these strategies.

FTS could enhance the economic sustainability of supply chains by: improving responsiveness to demand fluctuations, better synchronising transportation to inventory needs, lowering risks of transport disruptions and improving resilience, and increasing overall customer satisfaction. As FTSs improve supply chains' capability to address changes in the business environment (Khakdaman et al., 2022), they provide better communication and understanding of customers, employees, and local communities. This inclusively addresses their needs and leads to better social sustainability. Environmentally, the flexibility can also enable green logistics by enabling companies to dynamically switch to lower emission modes where possible (e.g. rail over road when shipments are not urgent, or employing synchromodal transportation (Khakdaman et al., 2020) for real-time switch between modes) or consolidating loads to minimise empty running and energy waste. Adopting new technologies, such as IoT, AI, and Blockchain, in VTSs can enhance the innovation and competitiveness of supply chains. Another application of VAS-oriented TSs is using green packaging offered by LSPs to reduce waste and improve recyclability, leading to the overall enhancement of environmental sustainability. VTSs can also allow LSPs to incorporate carbon-neutral services (e.g. offsetting programs, carbon reporting dashboards, or electrified last-mile delivery) into their value proposition, making sustainability an explicit component of service differentiation.

The framework can also enable LSPs to create differentiated service offerings that align with the strategic requirements of their clients instead of providing one-size-fits-all transport options. For instance, companies with an efficient SCS consider cost-efficiency and predictability; LSPs might counter this with consolidated rail or sea transport, bulk shipments, and basic tracking functionalities to increase reliability without increasing cost. Companies with a responsive SCS want speed and flexibility; LSPs can customise services via providing short lead-time contracts, air or truck priority capacity, and rerouting capability that scale with changes in demand. In the case of risk-hedging SCSs, supply failure is widespread, and the LSPs can offer multimodal continuity solutions like storage-linked transport, backup routes, and compliance-oriented contracts, which enable continuity even in fluctuating environments. Lastly, agile SCSs are typically characterised by high supply and demand volatility; LSPs can mitigate this by providing contracts to ensure rapid mode-switching, on-demand multimodal routing, synchromodal transportation, and carbon-neutral last-mile delivery, all powered by predictive visibility platforms. This type of service customisation places LSPs in a position beyond transactional carrier and more of a strategic partner, enabling clients to align their transportation and supply chain strategies.

5.2 Conclusions and future research directions

In this study, we investigated how the strategic fit between transportation strategy (TS) and supply chain strategy (SCS) could be achieved. We addressed this research gap by shifting the transportation concept out of its conventional operational context and conceptualising it as a strategic lever. In this regard, we have formulated a conceptual framework along with a practical decision-making flowchart that expands Lee (2002) SCSs, Efficient, Responsive, Risk-Hedging, and Agile, by mapping four introduced TSs, namely Cost-Oriented, Flexibility-Reliant, Modal-Control-Intensive, and Value-Enhanced, against four SCS types across 13 contextual decision criteria. We conducted a survey among Global Fortune 500 companies to demonstrate and explain how the framework works in practice with an illustrative case survey. The results showed that no universal right transportation approach applies to any type of supply chain. Rather, only customised TSs in line with contextual conditions can achieve alignment. We also found that misalignments do not necessarily indicate inefficiencies, and they can represent trade-offs between resilience, compliance, or customer satisfaction and strict cost minimisation.

This research has threefold contributions. First, it sharpens and broadens traditional supply chain models (Fisher, 1997; Lee, 2002) by explicitely incorporating TS as part of alignment theory, so that TS is no longer a post hoc consideration. Second, it proposes a conceptual framework and decsiosn-making tool based on the key contextual factors enabling researchers and practitioners to effectively align SCS withTS. Third, it offers practical implications to managers of shipper companies and LSPs to shape and adapt TSs to product families.

This study has limitations. First, the illustrative case example is grounded on a small number of six attributes as opposed to thirteen criteria demonstrated in our framework. The entire set of criteria should be empirically tested in future studies to deeper understand TS-SCS alignment. Second, we sampled mostly large multinational firms. Although this yielded important global insights, future studies need to examine alignment in SMEs, regional supply chains, and emerging economies, where constraints in resources could cause shifts in alignment patterns. Third, BWM was used to facilitate effective strategic preference elicitation but fails to capture dynamic changes over time. Longitudinal case research, simulation models, cluster analysis, or discrete choice experiments might be used in future studies to create a more dynamic perspective on alignment. Fourth, we did feature sustainability, resilience, and digitalisation in the conceptual framework, but these dimensions were not operationalized in the illustrative case. Future works might involve explicitly quantifying the impact of green logistics practices, resilience strategies, or digital technologies on TS–SCS fit.

Other avenues for research could include: studying how alignment evolves in the face of technological disruptions like AI-enabled logistics or blockchain-based visibility systems, or market disruption such as pandemics or geopolitical unrest, and therefore contributing to the development of dynamic models of alignment. Another direction is to consider interdependencies within functions of the supply chain, e.g. how transportation alignment can interact with procurement, production, or distribution strategies. Lastly, the potential exists to combine this framework with more general sustainability transition and organisational behaviour theories, to see how regulatory, environmental and social demands redefine meaning of alignment in global logistics.

Acknowledgements

The funding body will be acknowledged following peer review.

Author contributions

None.

Funding

This article is funded by the Nederlandse Organisatie voor Wetenschappelijk Onderzoek (grant number 438-13-214).

ORCID

Masoud Khakdaman 0000-0003-1656-2967
Jafar Rezaei 0000-0002-7407-9255
Lóránt Tavasszy 0000-0002-5164-2164

Data availability statement

The participants of this study did not give written consent for their data to be shared publicly, so due to the sensitive nature of the research, supporting data is unavailable.

References

Ahmadi, H. B., Kusi-Sarpong, S., & Rezaei, J. (2017). Assessing the social sustainability of supply chains using best worst method. *Resources, Conservation and Recycling*, *126*, 99–106. https://doi.org/10.1016/j.resconrec.2017.07.020

Alchemer. (2023). Alchemer online survey platform. accessed February 1, 2024, available at https://www.alchemer.com

Arencibia, A. I., Feo-Valero, M., García-Menéndez, L., & Román, C. (2015). Modelling mode choice for freight transportation using advanced choice experiments. *Transportation Research Part A: Policy and Practice*, *75*, 252–267.

Baker, P. (2004). Aligning distribution center operations to supply chain strategy. *The International Journal of Logistics Management*, *15*(1), 111–123. https://doi.org/10.1108/09574090410700266

Ben-Akiva, M., Bolduc, D., & Park, J. Q. (2008). Discrete choice analysis of shippers' preferences, *Recent Developments in Transportation Modelling: Lessons for the Freight Sector* (pp. 135–155). Emerald Group Publishing Limited. https://doi.org/10.1108/9781786359537-008

Bodendorf, F., Feilner, S., & Franke, J. (2024). How do joint ventures and non-equity strategic alliances impact the complexity of the supply chain and thus supply chain performance?. *Supply Chain Management: An International Journal*, *29*(4), 685–705. https://doi.org/10.1108/SCM-04-2023-0168

Bolis, S., & Maggi, R. (2003). Logistics strategy and transport service choices: an adaptive stated preference experiment. *Growth and Change*, *34*(4), 490–504. https://doi.org/10.1046/j.0017-4815.2003.00232.x

Cao, H., & Folan, P. (2012). Product life cycle: The evolution of a paradigm and literature review from 1950–2009. *Production Planning & Control*, *23*(8), 641–662. https://doi.org/10.1080/09537287.2011.577460

de Carvalho Borella, M. R, & Padula, A. D. (2010). Alignment between the supply, manufacturing and distribution strategies and the business strategy. *Journal of Operations and Supply Chain Management*, *3*(2), 44–60. https://doi.org/10.12660/joscmv3n2p44-60

Chopra, S., & Meindl, P. (2007). Supply chain management. Strategy, planning & operation. In. *the summa of management* (pp. 265–275). Gabler. https://doi.org/10.1007/978-3-8349-9320-5_22

Chorn, N. H. (1991). The 'alignment' theory: Creating strategic fit. *Management decision*, *29*(1), 20–24. https://doi.org/10.1108/EUM0000000000066

Christopher, M. (2000). The agile supply chain: Competing in volatile markets. *Industrial Marketing Management*, *29*(1), 37–44. https://doi.org/10.1016/S0019-8501(99)00110-8

Christopher, M., Peck, H., & Towill, D. (2006). A taxonomy for selecting global supply chain strategies. *The International Journal of Logistics Management*, *17*, 277–287. https://doi.org/10.1108/09574090610689998

Denham, F., Howieson, J., Solah, V., & Biswas, W. (2015). Environmental supply chain management in the seafood industry: Past, present and future approaches. *Journal of Cleaner Production*, *90*, 82–90. https://doi.org/10.1016/j.jclepro.2014.11.079

Díaz, J. T., Rojas, M. M., Franco, C. F., Velasquez Contreras, A. T., Bolivar, H., & Perez Gonzalez, J. F. (2015). Criteria for decision-making in transportation logistics function, *2015 International Conference on Industrial Engineering and Operations Management (IEOM)* (pp. 1–6). United Arab Emirates. https://doi.org/10.1109/IEOM.2015.7093776

Evangelista, P., Santoro, L., & Thomas, A. (2018). Environmental sustainability in third-party logistics service providers: A systematic literature review from 2000–2016. Sustainability, *10*(5), 1627. https://doi.org/10.3390/su10051627

Fartaj, S. R., Kabir, G., Eghujovbo, V., Ali, S. M., & Paul, S. K. (2020). Modeling transportation disruptions in the supply chain of automotive parts manufacturing company. *International Journal of Production Economics*, *222*, 107511. https://doi.org/10.1016/j.ijpe.2019.09.032

Feo-Valero, M., García-Menéndez, L., & Garrido-Hidalgo, R. (2011). Valuing freight transport time using transport demand modelling: A bibliographical review. *Transport Reviews*, *31*(5), 625–651. https://doi.org/10.1080/01441647.2011.564330

Fisher, M. L. (1997). What is the right supply chain for your product?. *Harvard business review*, *75*, 105–117.

Fortune magazine. (2023). List of global fortune 500 companies. accessed at December 5, 2025, available at http://fortune.com/global500/list

Goldratt, E. M., & Cox, Jeff (1986). *The goal: a process of ongoing improvement*. Routledge.

Goldsby, T. J., Hoang, T. T., Stank, T. P., & Bell, J. E. (2023). A modernized framework for transportation decision-making in a hyper-integrated global supply chain environment. *Transportation Journal*, *62*(1), 16–42. https://doi.org/10.5325/transportationj.62.1.0016

Green, K. W., Whitten, D., & Inman, R. A. (2008). The impact of logistics performance on organizational performance in a supply chain context. *Supply Chain Management: An International Journal*, *13*(4), 317–327. https://doi.org/10.1108/13598540810882206

Gupta, H., & Barua, M. K. (2017). Supplier selection among SMEs on the basis of their green innovation ability using BWM and fuzzy TOPSIS. *Journal of Cleaner Production*, *152*, 242–258. https://doi.org/10.1016/j.jclepro.2017.03.125

Haial, A., Berrado, A., & Benabbou, L. (2016). A framework for designing a transportation strategy: The case of a pharmaceuticals supply chain, *2016 3rd International Conference on Logistics Operations Management (GOL)*. 1–6. IEEE.

Haial, A., Benabbou, L., & Berrado, A. (2021). Designing a transportation-strategy decision-making process for a supply chain: Case of a pharmaceutical supply chain. *International Journal of Environmental Research and Public Health*, *18*(4), 2096.

Harris, G. A., Componation, P. J., & Farrington, P. A. (2010). An exploration of Fisher's framework for the alignment of supply chain strategy with product characteristics. *Engineering Management Journal*, *22*(4), 31–43. https://doi.org/10.1080/10429247.2010.11431877

Holter, A. R., Grant, D. B., Ritchie, J., & Shaw, N. (2008). A framework for purchasing transport services in small and medium size enterprises. *International Journal of Physical Distribution & Logistics Management*, *38*(1), 21–38. https://doi.org/10.1108/09600030810857193

Hossain, M. I., Talapatra, S., Saha, P., & Belal, H. M. (2025). From theory to practice: Leveraging digital twin technologies and supply chain disruption mitigation strategies for enhanced supply chain resilience with strategic fit in focus. *Global Journal of Flexible Systems Management*, *26*, 87–109. https://doi.org/10.1007/s40171-024-00424-w

Ivanov, D. (2020). Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case. *Transportation Research Part E: Logistics and Transportation Review*, *136*, 101922.

Jazairy, A. (2020). Aligning the purchase of green logistics practices between shippers and logistics service providers. *Transportation Research Part D: Transport and Environment*, *82*. 102305. https://doi.org/10.1016/j.trd.2020.102305

Joshi, M. P., Kathuria, R., & Porth, S. J. (2003). Alignment of strategic priorities and performance: an integration of operations and strategic management perspectives. *Journal of Operations Management*, *21*(3), 353–369. https://doi.org/10.1016/S0272-6963(03)00003-2

Kayikci, Y., Subramanian, N., & Bhatia, M. S. (2014). A sustainable transportation and logistics framework: Indicators and decision support system. *International Journal of Applied Logistics*, *5*(1), 1–22.

Kayikci, Y., Bartolacci, M. R., & LeBlanc, L. J. (2018). Identifying the key success factors in strategic alignment of transport collaboration using a hybrid Delphi-AHP, *Handbook of Research on Strategic Supply Chain Management in the Retail Industry* (pp. 1–24). IGI Global.

Ke, J. Y., Cho, W., & Su, H. (2025). Flying through uncertainty: Air transportation's impact on supply chain resilience and inventory efficiency. *Transportation Research Part E: Logistics and Transportation Review*, *197*, 104042. https://doi.org/10.1016/j.tre.2025.104042

Ke, J. Y. F., Windle, R. J., Han, C., & Britto, R. (2015). Aligning supply chain transportation strategy with industry characteristics. *International Journal of Physical Distribution & Logistics Management*, *45*(9/10), 837–860. https://doi.org/10.1108/IJPDLM-06-2014-0130

Keya, N., Anowar, S., Bhowmik, T., & Eluru, N. (2021). A joint framework for modeling freight mode and destination choice: Application to the US Commodity Flow Survey data. *Transportation Research Part E: Logistics and Transportation Review*, *146*, 102208. https://doi.org/10.1016/j.tre.2020.102208

Khakdaman, M., Rezaei, J., & Tavasszy, L. (2020). Shippers' willingness to delegate modal control in freight transportation. *Transportation Research Part E*, *141*, 102027. https://doi.org/10.1016/j.tre.2020.102027

Khakdaman, M., Rezaei, J., & Tavasszy, L. (2022). Shippers' willingness to use flexible transportation services. *Transportation Research Part A: Policy and Practice*, *160*, 1–20.

Kumar, A., Shrivastav, S. K., & Bhattacharyya, S. (2023). Measuring strategic fit using big data analytics in the automotive supply chain: A data source triangulation-based research. *International Journal of Productivity and Performance Management*, *72*(10), 2977–2999. https://doi.org/10.1108/IJPPM-11-2021-0672

Lagoudis, I. N., Lalwani, C. S., Naim, M. M., & King, J. (2002). Defining a conceptual model for high-speed vessels. *International Journal of Transport Management*, *1*(2), 69–78. https://doi.org/10.1016/S1471-4051(01)00007-6

Lee, H. L. (2002). Aligning supply chain strategies with product uncertainties. *California management review*, *44*(3), 105–119. https://doi.org/10.2307/41166135

Liang, F., Brunelli, M., & Rezaei, J. (2020). Consistency issues in the best worst method: Measurements and thresholds. *Omega*, *96*, 102175. https://doi.org/10.1016/j.omega.2019.102175

Logistics Quarterly magazine. (2023). List of main customers of top 40 global LSPs. Volume 16, Issue 3. accessed at December 5, 2025, available at http://logisticsquarterly.com/issues/16-3/3pl2011/

Mason, R., & Nair, R. (2013). Supply-side strategic flexibility: Understanding the drivers of logistics service provider responsiveness. *The International Journal of Logistics Management*, *24*(1), 38–62.

Mason, R., & Nair, R. (2013). Strategic flexibility capabilities in the container liner shipping sector. *Production Planning & Control*, *24*(7), 640–651. https://doi.org/10.1080/09537287.2012.659873

McGinnis, M. A. (1989). A comparative evaluation of freight transportation choice models. *Transportation Journal*, *29*(2), 36–46. https://www.jstor.org/stable/20713033

Ning, L., & Yao, D. (2023). The impact of digital transformation on supply chain capabilities and supply chain competitive performance. *Sustainability*, *15*(13), 10107. https://doi.org/10.3390/su151310107

Orcao, A. I., & Pérez, R. (2014). Transport and logistics in the Spanish fashion industry: A case study of Zara. *Tijdschrift voor Economische en Sociale Geografie*, *105*(4), 421–437.

Paul, A., Moktadir, M. A., & Paul, S. K. (2020). An innovative decision-making framework for evaluating transportation service providers based on sustainable criteria. *International Journal of Production Research*, *58*(24), 7334–7352. https://doi.org/10.1080/00207543.2019.1652779

Pellegrino, R., Costantino, N., & Tauro, D. (2021). The value of flexibility in mitigating supply chain transportation risks. *International Journal of Production Research*, *59*(20), 6252–6269. https://doi.org/10.1080/00207543.2020.1811417

Pettit, T. J., Fiksel, J., & Croxton, K. L. (2010). Ensuring supply chain resilience: Development of a conceptual framework. *Journal of Business Logistics*, *31*(1), 1–21. https://doi.org/10.1002/j.2158-1592.2010.tb00125.x

Pfizer Inc. (2023). U.S. Manufacturing and Distribution Fact Sheet. accessed at December 5, 2025, available at https://cdn.pfizer.com/pfizercom/COVID19_Vaccine_US_Distribution_Fact_Sheet_032023.pdf

Qi, Y., Boyer, K. K., & Zhao, X. (2009). Supply chain strategy, product characteristics, and performance impact: Evidence from Chinese manufacturers. *Decision Sciences*, *40*(4), 667–695. https://doi.org/10.1111/j.1540-5915.2009.00246.x

Qi, Y., Zhao, X., & Sheu, C. (2011). The impact of competitive strategy and supply chain strategy on business performance: The role of environmental uncertainty. *Decision Sciences*, *42*(2), 371–389. https://doi.org/10.1111/j.1540-5915.2011.00315.x

Randall, T., Morgan, R., & Morton, A. (2003). Efficient versus responsive supply chain choice: An empirical examination of influential factors. *Journal of Product Innovation Management*, *20*(6), 430–443. https://doi.org/10.1111/1540-5885.00041

Reis, V. (2014). Analysis of mode choice variables in short-distance intermodal freight transport using an agent-based model. *Transportation research part A: Policy and practice*, *61*, 100–120. https://doi.org/10.1016/j.tra.2014.01.002

Rezaei, J. (2015). Best–worst multi-criteria decision-making method. *Omega*, *53*, 49–57. https://doi.org/10.1016/j.omega.2014.11.009

Rezaei, J. (2016). Best-worst multi-criteria decision-making method: Some properties and a linear model. *Omega*, *64*, 126–130. https://doi.org/10.1016/j.omega.2015.12.001

Rezaei, J., Hemmes, A., & Tavasszy, L. (2017). Multi-criteria decision-making for complex bundling configurations in surface transportation of air freight. *Journal of Air Transport Management*, *61*, 95–105. https://doi.org/10.1016/j.jairtraman.2016.02.006

Rezaei, J., Nispeling, T., Sarkis, J., & Tavasszy, L. (2016). A supplier selection life cycle approach integrating traditional and environmental criteria using the best worst method. *Journal of Cleaner Production*, *135*, 577–588. https://doi.org/10.1016/j.jclepro.2016.06.125

Roso, V., Woxenius, J., & Lumsden, K. (2009). The dry port concept: connecting container seaports with the hinterland. *Journal of Transport Geography*, *17*(5), 338–345. https://doi.org/10.1016/j.jtrangeo.2008.10.008

Sanchez-Rodrigues, V., Potter, A, & Naim, M. M (2010). The impact of logistics uncertainty on sustainable transport operations. *International Journal of Physical Distribution & Logistics Management*, *40*, 61–83. https://doi.org/10.1108/09600031011018046

Sabherwal, R., Hirschheim, R., & Goles, T. (2001). The dynamics of alignment: Insights from a punctuated equilibrium model. *Organization science*, *12*(2), 179–197. https://doi.org/10.1287/orsc.12.2.179.10113

Sarkis, J. (2021). Supply chain sustainability: Learning from the COVID-19 pandemic. *International Journal of Operations & Production Management*, *41*(1), 63–73. https://doi.org/10.1108/IJOPM-08-2020-0568

Shinghal, N., & Fowkes, T. (2002). Freight mode choice and adaptive stated preferences. *Transportation Research Part E: Logistics and Transportation Review*, *38*(5), 367–378. https://doi.org/10.1016/S1366-5545(02)00012-1

Solanki, R., Agarwal, P., & Kumar, S. (2023). Value-to-weight ratio in freight transport mode choice: A multi-criteria perspective. In *2023 International Conference on Transport Modelling and Decision Systems (ICTMOD)*.

Stank, T. P., & Goldsby, T. J. (2000). A framework for transportation decision making in an integrated supply chain. *Supply Chain Management: An International Journal*, *5*(2), 71–78. https://doi.org/10.1108/13598540010319984

Sun, H., & Hong, C. (2002). The alignment between manufacturing and business strategies: Its influence on business performance. *Technovation*, *22*(11), 699–705. https://doi.org/10.1016/S0166-4972(01)00066-9

Swafford, P. M., Ghosh, S., & Murthy, N. N. (2006). A framework for assessing value chain agility. *International Journal of Operations & Production Management*, *26*(2), 118–140. https://doi.org/10.1108/01443570610641639

Thomson Reuters business classification. (2012). Accessed February, 1, 2020. https://financial. thomsonreuters.com/content/dam/openweb/documents/pdf/financial/trbc-fact-sheet.pdf

Tongzon, J. L. (2009). Port choice and freight forwarders. *Transportation Research Part E: Logistics and Transportation Review*, *45*(1), 186–195. https://doi.org/10.1016/j.tre.2008.02.004

Tsai, M. C., Lai, K. H., Lloyd, A. E., & Lin, H. J. (2012). The dark side of logistics outsourcing–unraveling the potential risks leading to failed relationships. *Transportation Research Part E: Logistics and Transportation Review*, *48*(1), 178–189. https://doi.org/10.1016/j.tre.2011.07.003

Venkatraman, N. (1989). The concept of fit in strategy research: Toward verbal and statistical correspondence. *Academy of Management Review*, *14*(3), 423–444. https://doi.org/10.2307/258177

Venkatraman, N., & Camillus, J. C. (1984). Exploring the concept of 'fit' in strategic management. *Academy of Management Review*, *9*(3), 513–525.

Wei, S., Xu, W., Guo, X., & Chen, X. (2023). How does business-IT alignment influence supply chain resilience? *Information & Management*, *60*(6), 103831. https://doi.org/10.1016/j.im.2023.103831

Wong, C. Y., Skipworth, H., Godsell, J., & Achimugu, N. (2012). Towards a theory of supply chain alignment enablers: A systematic literature review. *Supply Chain Management: An International Journal*, *17*(4), 419–437. https://doi.org/10.1108/13598541211246567

Xu, X. (2024). Teaching freight mode choice models new tricks using interpretable machine learning. *Future Transportation*, *4*, 1339273.

Zhang, A., Lam, J. S. L., & Huang, G. Q. (2014). Port strategy in the era of supply chain management: The case of Hong Kong. *Maritime Policy & Management*, *41*(4), 367–383. https://doi.org/10.1080/03088839.2013.863434

Appendicies

Appendix A. Survey design and data collection

We designed a web-based survey questionnaire using the Alchemer platform (Alchemer, 2023). The survey consists of several questions in two sections. The first section introduces the objective of our study and asks respondents about their sociodemographic information of the respondents (e.g. position, job function) and their company's operations (e.g. company's industry type, size (number of employees), annual revenue and product types; and so on). Then, we asked them to choose one of their products/materials and reveal the level of demand and supply uncertainty for that product. In the second section, we asked respondents to reflect their preferences for transportation service attributes based on the BWM method.

In order to make a comprehensive perspective about the alignment of TS with SCS, we chose to sample from international supply chains with strong operational influence on the global production and trade of goods, including firms with high overall revenues and firms that manage large freight flows. The former type of companies was identified via the Global Fortune 500 list (Fortune magazine, 2023). The latter category was found via the list of major customer firms of the 40 largest LSPs worldwide (Logistics Quarterly magazine, 2023). This magazine presents between 5 to 10 leading customer shippers for each LSP. 556 unique companies were identified by combining these lists. Then, we targeted top (c-level) and senior/middle-level managers who lead supply chain/logistics/transportation functions in these firms. We emailed the web-based survey to 2490 managers (e.g. vice-president of operations, director of logistics, head of supply chain). After three follow-up rounds, 324 usable responses were collected from 209 unique firms. This implies a response rate of 13% and 38% among individuals and companies, respectively. The demographics of respondent firms are depicted in Table A1.

Appendix B. Validity and reliability of the survey instrument and BWM data

The theoretical validity of the survey instrument was achieved by basing all the attributes on the established literature of SCS and transportation services. Demand and supply uncertainty measures were directly obtained from the typologies of SCS developed by Lee (2002), while transportation service attributes (cost, time, reliability, flexibility, modal control, and value-added services) were derived from the literature on TS and the freight mode choice (e.g. Arencibia et al., 2015; Khakdaman et al., 2020; Reis, 2014; Swafford et al., 2006). To ensure content validity, two academic professionals in the field of supply chain management and three top industry managers were involved in reviewing the draft questionnaire and provided feedback on how to improve the wording of the items and the sequence of questions. This ensures that the decision criteria adopted in the BWM capture dimensions that are considered to be strategically relevant in both academic and practice literature.

Reliability was evaluated in multiple ways. First, the factual and descriptive questions (e.g. size of firm, industry, annual revenue, respondent position) are based on objective information and do not imply issues of internal consistency. Second, for the reliability of the obtained criteria weights from BWM, we checked the consistency of individual experts' pairwise comparisons using the input-based consistency measure and the thresholds developed by Liang et al. (2020). Checking all the findings per individual expert, the input-based consistency ratio of 81 responses among our 323 is above the thresholds (hence, unacceptable). Thus, we excluded those 81 responses from our

Table A1. Profile of the respondents and their companies.

Respondent Position	%	Company size (#employees)	%	Annual Revenue	%	Economic sector	%
C-level/Top Management	21%	<99	4%	<$100 Mn	10%	Basic Materials	13%
Senior/Middle Management	79%	100–249	7%	$100–250 Mn	8%	Consumer Cyclicals	18%
		250–999	6%	$250 Mn-1 Bn	13%	Consumer Non-Cyclicals	21%
		1000–9999	19%	$1–10 Bn	19%	Energy	4%
		10000–49999	26%	$10–50 Bn	27%	Healthcare	12%
		>50000	38%	>$50 Bn	23%	Industrials	7%
						Technology	15%
						Telecom Services	9%
						Utilities	2%

analysis, which resulted in using 242 (sufficiently) consistent responses for further analysis. This ensures that the subsequent results are based on sufficiently reliable preference data.

While taking this step was essential to ensure methodological rigour, the omission of responses could raise potential bias. We thus analysed the excluded cases and noted that they were not concentrated in a single industry sector or SCS type, but were spread across the sample. This indicates that any inconsistencies in BWM comparisons were more likely attributed to each respondent's behaviour (e.g. time pressure or lack of attention during pairwise comparisons) rather than to any systematic differences in industries or strategy categories. The exclusion of the responses, therefore, is unlikely to skew the substantive findings. However, we recognise this as a possible limitation and recommend that, in the future, the antecedents of inconsistency between respondent groups may be examined to gain a better insight into cross-group differences in data quality and decision-making behaviour (see Liang et al., 2020; Rezaei et al., 2016; Rezaei, 2015).

Appendix C. Calculating attribute weights using the Best-Worst Method

To obtain the relative importance of the transportation service attributes in the strategy decisions of firms, we used the Best-Worst Method (BWM) (Rezaei, 2015). The reason why BWM was chosen instead of mainstream mode choice methods (discrete choice modelling) is that our study's focus is on strategic alignment rather than transactional mode selection. Discrete choice models are useful in predicting individual shipment-level decisions, but they demand extremely large data sets, are context-specific, and primarily measure operational-level behavioural preference. Conversely, we aim to identify the comparative strategic value of attributes (e.g. cost, time, reliability, flexibility, modal control, and VAS) in different industries and SCSs. BWM is cost-effective regarding data requirements, minimises the burden on respondents, and contains an inherent consistency ratio (Liang et al., 2020). This last property is particularly valuable in cross-industry surveys, where heterogeneous perspectives can increase inconsistency risks. Thus, BWM is more suitable for a survey targeting senior logistics and supply chain managers, who often have time limitations. BWM is increasingly applied in logistics and supply chain research (e.g. supplier selection (Gupta & Barua, 2017; Rezaei et al., 2016), transportation disruptions in the supply chain (Fartaj et al., 2020), supplier segmentation (Rezaei et al., 2016), LSP selection (Paul et al., 2020), sustainable supply chain (Ahmadi et al., 2017), optimal bundling configurations in ground transport of air freight (Rezaei et al., 2017), to name a few), which also justifies its usefullness. Simultaneously, the discrete choice models might be an additional method in future studies, specifically to confirm our conceptual model at the industry or shipment levels.

We applied BWM to identify the level of alignment between TS and SCS of international supply chains through finding the criteria weights of 323 responses in our study. In this study we use the linear BWM (Rezaei, 2016) as follows.

Step 1: Determine a set of n decision (or assessment) criteria $\{C_1, C_2, \ldots, C_n\}$.

Step 2: The decision-maker/expert selects the best criterion (e.g. the most important/influential one) and the worst criterion (e.g. the least important/influential one) among the available set of criteria identified in Step 1.

Step 3: The decision-maker/expert conducts pairwise comparisons between the best criterion and other criteria. To this end, the decision-maker applies a number between 1 and 9 (where 1 is 'equally important' and 9 is 'extremely more important') in order to determine preference of the best criterion over other criteria. This will result in the following vector:

$$A_B = (a_{B1}, \ a_{B2}, \ldots, a_{Bn}) \tag{1}$$

where a_{Bj} represents the preference of the best criterion C_B over criterion C_j, $j = 1, 2, \cdots, n$.

Step 4: The decision-maker/expert carries out pairwise comparisons between the other criteria and the worst criterion in a similar way to the third step using a number between 1 and 9. The resulting vector of this comparisons would be:

$$A_W = (a_{1W}, \ a_{2W}, \ldots, a_{nW})^T \tag{2}$$

where a_{jW} represents the preference of criterion C_j over the worst criterion C_W, $j = 1, 2, \cdots, n$.

Step 5: Determine the optimal weights of the criteria $(w_1^*, \ w_2^*, \ \ldots, \ w_n^*)$ and ξ^{L*} by minimising the maximum absolute differences $\{|w_B - a_{Bj}w_j| \text{ and } |w_j - a_{jW}w_W|\}$ via the following model:

$$\min \max_j \{|w_B - a_{Bj}w_j|, \ |w_j - a_{jW}w_W|\}$$

s.t.

$$\sum_j w_j = 1$$

$$w_j \geq 0, \quad for \quad all \quad j. \tag{3}$$

This model can be transferred to the following linear programming model:

$$\min \xi^L$$

s.t.

$$|w_B - a_{Bj} w_j| \leq \xi^L$$

$$|w_j - a_{jW} w_W| \leq$$

ξ^L

$$\sum_j w_j = 1$$

$$w\_j \geq 0, \quad for \quad all \quad j. \tag{4}$$

Solving this problem results in finding the optimal weights ($w_1^*, \ w_2^*, \ \ldots, \ w_n^*$) and ξ^{L*}.

Appendix D. Assessing TS-SCS alignment of the illustrative case companies

In this section, we assess the alignment of TS with SCS for the case companies against frameworks proposed by Lee (2002) (see Figure 1) and our proposed one (see Figure 2). To this end, we first obtained the weight of each transportation service attribute for each respondent using BWM. We then incorporated these weights in the context of four SCSs by calculating the average weight (geometric mean) for each service attribute relevant to each SCS, as shown in Table D1.

As shown in Figure 1 and Table D1, for products with low demand uncertainty, i.e. predictable demand (functional products), and low supply uncertainty, i.e. a stable process, an efficient SCS is the best match. Considering the same situation in Table D1, we expect to recognise an *efficient* TS, i.e. focusing mainly on minimising transportation costs, to be aligned with the efficient SCS. However, we see that transportation reliability and time are the most important decision criteria (i.e. they have the highest weights among all attributes) in determining the TS of companies in this group, while transportation cost is the third important criterion when these companies align their TS with their SCS. This mismatch between TS and SCS also exists for responsive and agile SCSs, where transportation cost is the second most important criterion after transportation reliability and transportation time, respectively.

These results, while counterintuitive, can be theoretically described using alignment theory and the Theory of Constraints. As a bottleneck, transportation reliability or timeliness can be rationally prioritised by firms over cost. Moreover, some deviations may present intended strategic decisions, e.g. prioritising customer satisfaction, resilience, or regulation. In contrast, others can be seen as an unintended inefficiency because of the processes that cannot be changed easily or long-term contractual obligations with LSPs, which do not allow firms to change their TS. Industry-specific contexts also reinforce this argument. For instance, in the case of efficient SCSs, healthcare companies prioritise reliability and timeliness because of the regulatory requirements and the perishable nature of medical products (Haial et al., 2016).

To better comprehend these misalignments with strong interpretations, we have incorporated further analysis to enhance the statistical rigour of the illustrative case. To determine the statistical significance of the observed differences among attributes of transportation services, we performed non-parametric hypothesis testing using the Kruskal-Wallis test. This is to make sure that small differences in numbers (e.g. a reliability weight of 0.199 and a cost weight of 0.192 for Efficient SCS in Table D1) are not taken at face value, but rather are justified (or not) by statistics.

Table D1. Assessment of TS and SCS alignment based on Lee's model.

	Demand uncertainty													
	Low (Functional products)							High (Innovative products)						
	Cost	Control	Flexibility	Reliability	Time	VAS	# Resps.	Cost	Control	Flexibility	ReliabIlity	Time	VAS	# Resps.
Supply uncertainty	0.192	0.142	0.133	0.253	0.199	0.082	51	0.196	0.153	0.143	0.228	0.192	0.088	40
	0.233	0.129	0.127	0.210	0.198	0.101	99	0.216	0.122	0.120	0.200	0.236	0.104	52

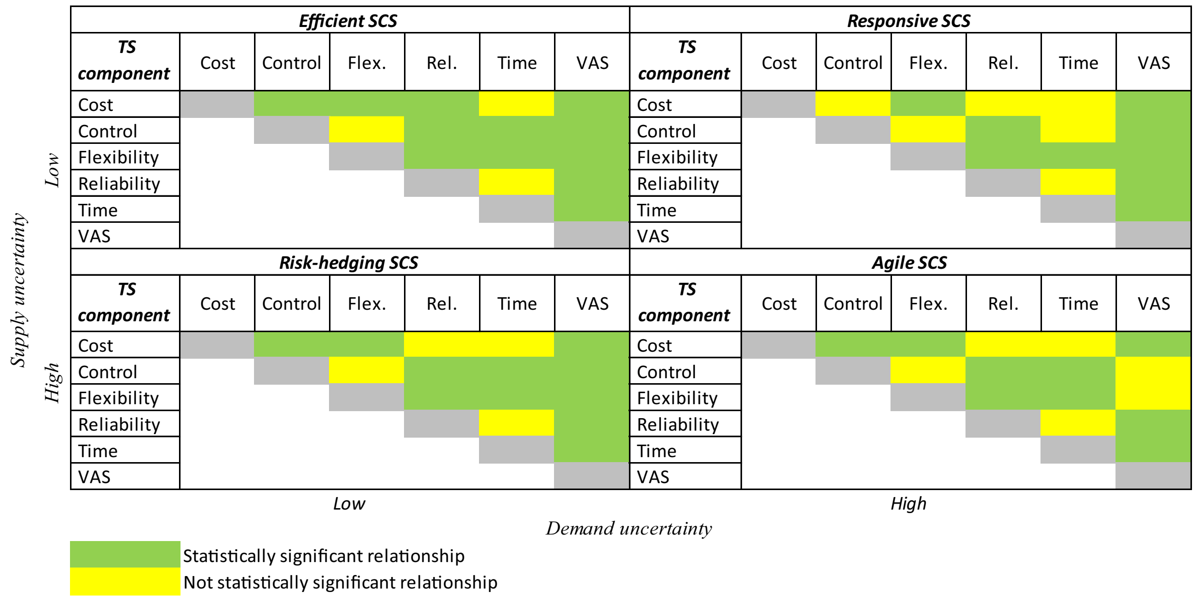

Figure D1. Summary of the results of pairwise comparison of TS components for each SCS.

Table D2. Results of pairwise comparison of TS components for each SCS.

SCS	Pairwise comparison of two attributes	Test statistic	*P*-value	SCS	Pairwise comparison of two attributes	Test statistic	*P*-value
Efficient SCS	Control & Cost	−1.707***	0.088	Responsive SCS	Control & Reliability	−2.791*	0.005
	Control & Reliability	−3.664*	<.001		Flexibility & Cost	1.765***	0.078
	Control & Time	−2.312**	0.021		Flexibility & Reliability	−3.369*	<.001
	Cost & Reliability	−1.957**	0.05		Flexibility & Time	−2.156**	0.031
	Flexibility & Cost	2.784*	0.005		VAS & Control	3.079*	0.002
	Flexibility & Reliability	−4.741*	<.001		VAS & Cost	4.267*	<.001
	Flexibility & Time	−3.388*	<.001		VAS & Flexibility	2.502**	0.012
	VAS & Control	4.588*	<.001		VAS & Reliability	5.87*	<.001
	VAS & Cost	6.295*	<.001		VAS & Time	4.657*	<.001
	VAS & Flexibility	3.511*	<.001		Control & Cost	−1.188	0.235
	VAS & Reliability	8.252*	<.001		Control & Time	−1.578	0.115
	VAS & Time	6.9*	<.001		Cost & Reliability	−1.604	0.109
	Cost & Time	−0.605	0.545		Cost & Time	−0.391	0.696
	Flexibility & Control	1.076	0.282		Flexibility & Control	0.577	0.564
	Time & Reliability	1.352	0.176		Time & Reliability	1.213	0.225
Risk-hedging SCS	Control & Cost	−4.788*	<.001	Agile SCS	Control & Cost	−3.226*	0.001
	Control & Reliability	−4.298*	<.001		Control & Reliability	−2.751*	0.006
	Control & Time	−3.682*	<.001		Control & Time	−3.732*	<.001
	Flexibility & Cost	5.001*	<.001		Flexibility & Cost	3.811*	<.001
	Flexibility & Reliability	−4.511*	<.001		Flexibility & Reliability	−3.335*	<.001
	Flexibility & Time	−3.895*	<.001		Flexibility & Time	−4.316*	<.001
	VAS & Control	3.469*	<.001		VAS & Cost	4.811*	<.001
	VAS & Cost	8.257*	<.001		VAS & Reliability	4.335*	<.001
	VAS & Flexibility	3.256*	0.001		VAS & Time	5.316*	<.001
	VAS & Reliability	7.767*	<.001		Cost & Time	−0.505	0.613
	VAS & Time	7.15*	<.001		Flexibility & Control	0.584	0.559
	Flexibility & Control	0.213	0.831		Reliability & Cost	0.475	0.635
	Reliability & Cost	0.49	0.624		Reliability & Time	−0.981	0.327
	Time & Cost	1.106	0.269		VAS & Control	1.584	0.113
	Time & Reliability	0.616	0.538		VAS & Flexibility	1	0.317

Note: $*p < 0.01$, $**p < 0.05$ and $***p < 0.1$ for statistical significance.

Figure D1 is the summary of pairwise comparisons of the attributes for each SCS. It uses the green colour to present the attributes (ex, cost vs. reliability, flexibility vs. time) with significantly dissimilar relative importance. As an example, in responsive SCS the control and flexibility (i.e. relative importance of 0.153 and 0.143 in Table D1) were found to be much less important than the reliability (i.e. relative importance of 0.228 in Table D1) in responsive supply chains (see the green colour of control and flexibility in the reliability column of Responsive SCS in Figure D1).

Table D2 contains the detailed information about the Kruskal-Wallis test statistics and *p*-values for all the pairwise comparisons between 6 TS components across the four SCSs. The findings imply that the majority of attribute

Table D3. Assessment of TS and SCS alignment based on Lee's model, taking into account industry characteristics.

			Demand uncertainty													
			Low (Functional products)							High (Innovative products)						
			Cost	Control	Flexibility	Reliability	Time	VAS	# Resps.	Cost	Control	Flexibility	Reliability	Time	VAS	# Resps.
Supply uncertainty	Low	Basic Materials	0.198	0.122	0.172	0.260	0.181	0.066	10	0.184	0.143	0.121	0.278	0.199	0.074	2
		Consumer Cyclicals	0.182	0.170	0.096	0.309	0.167	0.077	7	0.250	0.123	0.163	0.280	0.104	0.079	7
		Consumer Non-Cyclicals	0.202	0.216	0.113	0.235	0.164	0.069	8	0.175	0.193	0.143	0.142	0.270	0.077	9
		Energy	0.350	0.146	0.080	0.223	0.172	0.028	3							
		Healthcare	0.136	0.122	0.149	0.332	0.201	0.060	10	0.090	0.160	0.146	0.301	0.214	0.090	6
		Industrials	0.132	0.138	0.135	0.178	0.275	0.142	4	0.134	0.089	0.092	0.413	0.102	0.170	2
		Technology	0.192	0.096	0.146	0.203	0.203	0.161	6	0.223	0.162	0.149	0.151	0.171	0.143	7
		Telecommunications	0.270	0.097	0.110	0.115	0.332	0.076	3	0.252	0.138	0.134	0.236	0.204	0.035	7
	High	Basic Materials	0.210	0.120	0.102	0.226	0.234	0.107	17	0.110	0.127	0.106	0.380	0.161	0.115	2
		Consumer Cyclicals	0.237	0.125	0.109	0.198	0.196	0.135	17	0.211	0.100	0.112	0.202	0.295	0.081	13
		Consumer Non-Cyclicals	0.242	0.117	0.135	0.210	0.198	0.098	28	0.171	0.110	0.084	0.225	0.306	0.104	5
		Energy	0.172	0.101	0.098	0.234	0.285	0.110	7							
		Healthcare	0.313	0.211	0.144	0.138	0.141	0.053	8	0.174	0.128	0.111	0.342	0.154	0.090	5
		Industrials	0.213	0.202	0.160	0.228	0.128	0.070	6	0.165	0.166	0.102	0.200	0.207	0.160	4
		Technology	0.291	0.111	0.112	0.173	0.214	0.099	7	0.284	0.134	0.115	0.170	0.194	0.103	16
		Telecommunications	0.220	0.121	0.173	0.213	0.149	0.124	6	0.193	0.130	0.196	0.098	0.276	0.107	6
		Utilities	0.126	0.085	0.208	0.375	0.162	0.044	3	0.202	0.036	0.202	0.083	0.238	0.238	1

differences are statistically significant (i.e. 70% of the relationships (41 out of 60 pairwise attribute comparisons) and hence support the idea that firms focus on specific attributes according to their SCSs. As an example, transportation speed and reliability are statistically more important than modal control ($p < 0.001$) in Agile SCSs. This is indicative of the high emphasis the agile supply chains place on speed and reliability to meet volatile demand.

Refering to the identified misalignments illustrated before Figure D1, one can argue that these are not necessarily misalignments because transportation cost is always important for every SCS, even if it is an agile SCS, and transportation reliability is important for efficient SCSs. However, Ke et al. (2015) argue that to understand how TS could be aligned with SCS, industry characteristics as a vital factor should be taken into account. To this end, we investigate TS and SCS alignment in different industries based on the Thomson Reuters business classification (2012), which classified all industries into nine industry sectors. Since we already used this comprehensive industry classification in our survey design phase, we are able to investigate all industry sectors in our analysis, as shown in Table D3.

As can be seen in Table D3, some of the firms with efficient SCS have chosen a TS that is not necessarily cost-efficient (e.g. industries such as consumer non-cyclicals, healthcare, and industrials). As an illustration, the healthcare industry seeks a reliable, fast, and flexible TS (i.e. these three criteria compose almost 70% of the total criteria weight) and regards transportation cost as one of the least important factors for functional products in the context of efficient SCS. Taking the consumer non-cyclicals industry with efficient SCS into account, their preferred TS is mainly based on seeking transportation reliability since maintaining the efficient SCS needs optimal integration of production and distribution of materials/goods throughout the supply chain (Lee, 2002), which requires highly on-time transportation to enable implementing end-to-end tight production-distribution schedules. In another example, while based on the Fisher's framework, a common understanding in the supply chain community is that a responsive/agile SCS needs to have a fast, reliable and/or flexible TS for the best alignment of its end-to-end operations, Table D3, conversely, illustrates that firms with an innovative product and agile SCS apply a cost-efficient TS, i.e. technology and telecommunications industries. This shows that the TS approach of some industries towards alignment with SCS is not necessarily the same.

Although considering industry characteristics improves our understanding of how firms align TS with SCS, it also reveals several misalignments in real-world circumstances. A larger sample size per industry would increase the explanatory power and reliability of these findings and would provide a more solid empirical foundation to justify the given conceptual framework. Overall, the identified misalignments could stem from not considering the role that the 13 criteria of the proposed framework play in making proper decisions for TS-SCS alignment to address the complexities of the business environment.

Appendix D.1. The role of shipment size in the TS-SCS alignment of the case companies

In this section, we dig deeper into the analysis of TS and SCS alignment by incorporating shipment size as a key decision factor when firms devise their TS. Shipment size relates transportation/distribution operations to production operations when the firm's production strategy and TS need to be synchronised to better align with the overall SCS of the firm (Chopra & Meindl, 2007). For example, when a firm operates on an efficient SCS for some of its products, it may need to optimally and efficiently synchronise the flow of raw material, semi-finished products, and finished products among nodes of their supply chain network (e.g. suppliers, manufacturing plants, distribution centres, and retailers) in a way that each of these products arrives at the targeted node on the right time based on the overall integrated production-distribution plan of the supply chain. To achieve maximum efficiency, each node in the supply chain network needs to send/receive the planned shipment size on time via the LSP's transportation network. Considering the fact that many firms have more than one SCS due to their various product portfolios, the complexity of synchronising different shipment sizes with production and distribution plans will directly impact how firms devise their TSs.

In order to understand the impact of shipment size on choosing relevant TSs for each SCS, we used our dataset to incorporate two amounts of shipment sizes, i.e. below 25 TEU and above 25 TEU, as small and large shipment sizes into our framework for TS and SCS alignment. Table D4 shows how the TSs of supply chains are influenced by the amount of their shipment sizes when they operate within various SCSs. For example, taking into account the basic materials industry, while according to Table D4, they prefer a Cost-oriented TS for their Efficient SCS, when it comes to shipment sizes above 25 TEUs (see Table D4), their preference shifts to a flexibility-oriented TS to better align their TS with SCS. This can be done via, for example, synchronising their operations by distributing large shipment sizes into their supply chain network when they rely significantly on a flexibility-oriented TS by utilising their LSP's flexibility capability to change transportation service components such as destinations, lead times, and shipment volumes based on changes in their business circumstances. Similar shifts to a more flexibility-oriented TS for large shipment sizes can also be identified for the healthcare industry in the context of responsive SCS and the telecommunications industry in the context of risk-hedging SCS.

Shipment size can also have a great impact on a firm's TS alignment with SCS. For instance, a different TS is followed by the technology industry for small shipment sizes when operating with innovative products in the context of responsive SCS. While the technology industry achieves a responsive SCS through a modal-control-oriented TS for large shipment sizes, they prefer a VAS-oriented TS for small shipment sizes. This change in TS can reveal how the

Table D4. Assessment of TS-SCS alignment of the illustrative case considering industry characteristics and shipment size.

				Demand uncertainty													
				Low							High						
				Cost	Control	Flexibility	Reliability	Time	VAS	# Resps.	Cost	Control	Flexibility	Reliability	Time	VAS	# Resps.
Supply uncertainty	Low	Basic Materials	>25 TEU	0.172	0.130	0.340	0.162	0.127	0.069	2							
			<25 TEU	0.205	0.121	0.131	0.285	0.195	0.065	8	0.184	0.143	0.121	0.278	0.199	0.074	2
		Consumer Cyclicals	>25 TEU	0.302	0.258	0.111	0.077	0.194	0.058	3	0.278	0.078	0.238	0.261	0.079	0.067	3
			<25 TEU	0.092	0.104	0.084	0.482	0.147	0.091	4	0.230	0.157	0.107	0.294	0.123	0.089	4
		Consumer Non-Cyclicals	>25 TEU	0.424	0.204	0.088	0.123	0.123	0.039	1	0.163	0.180	0.177	0.129	0.264	0.087	7
			<25 TEU	0.171	0.218	0.117	0.251	0.170	0.074	7	0.214	0.240	0.022	0.189	0.292	0.043	2
		Energy	>25 TEU	0.362	0.114	0.078	0.228	0.188	0.030	2							
			<25 TEU	0.327	0.211	0.084	0.211	0.141	0.026	1							
		Healthcare	>25 TEU								0.051	0.129	0.199	0.325	0.188	0.108	3
			<25 TEU	0.136	0.122	0.149	0.332	0.201	0.060	10	0.129	0.190	0.093	0.276	0.239	0.072	3
		Industrials	>25 TEU	0.120	0.105	0.198	0.185	0.270	0.122	2	0.175	0.105	0.131	0.419	0.131	0.039	1
			<25 TEU	0.144	0.171	0.071	0.170	0.281	0.163	2	0.093	0.073	0.053	0.407	0.073	0.301	1
		Technology	>25 TEU								0.322	0.177	0.182	0.120	0.095	0.104	3
			<25 TEU	0.192	0.096	0.146	0.203	0.203	0.161	6	0.149	0.151	0.125	0.174	0.229	0.172	4
		Telecommu	>25 TEU	0.344	0.060	0.083	0.139	0.344	0.030	1	0.185	0.464	0.106	0.093	0.106	0.046	1
		nications	<25 TEU	0.233	0.115	0.123	0.103	0.326	0.100	2	0.263	0.084	0.139	0.260	0.220	0.033	6
	High	Basic Materials	>25 TEU	0.165	0.096	0.105	0.262	0.246	0.126	8							
			<25 TEU	0.250	0.141	0.100	0.195	0.224	0.090	9	0.110	0.127	0.106	0.380	0.161	0.115	2
		Consumer Cyclicals	>25 TEU	0.211	0.131	0.109	0.214	0.196	0.140	13	0.193	0.107	0.102	0.197	0.290	0.111	7
			<25 TEU	0.322	0.107	0.108	0.143	0.199	0.121	4	0.232	0.092	0.123	0.207	0.301	0.046	6
		Consumer	>25 TEU	0.216	0.113	0.155	0.170	0.214	0.133	11	0.182	0.119	0.086	0.186	0.308	0.119	4
		Non-Cyclicals	<25 TEU	0.260	0.119	0.122	0.236	0.188	0.075	17	0.127	0.076	0.076	0.381	0.297	0.042	1
		Energy	>25 TEU	0.137	0.100	0.089	0.264	0.249	0.161	4							
			<25 TEU	0.218	0.102	0.109	0.195	0.333	0.043	3							
		Healthcare	>25 TEU	0.325	0.234	0.169	0.090	0.111	0.072	4	0.219	0.146	0.146	0.109	0.340	0.040	1
			<25 TEU	0.302	0.188	0.119	0.186	0.171	0.034	4	0.163	0.124	0.103	0.400	0.108	0.103	4
		Industrials	>25 TEU	0.216	0.145	0.189	0.286	0.082	0.083	4							
			<25 TEU	0.207	0.316	0.101	0.111	0.222	0.044	2	0.165	0.166	0.102	0.200	0.207	0.160	4
		Technology	>25 TEU	0.213	0.048	0.128	0.091	0.128	0.392	1	0.269	0.134	0.122	0.152	0.210	0.113	6
			<25 TEU	0.304	0.121	0.110	0.187	0.229	0.050	6	0.294	0.133	0.111	0.181	0.185	0.097	10
		Telecommu	>25 TEU	0.216	0.128	0.258	0.098	0.192	0.107	3	0.166	0.141	0.125	0.095	0.331	0.142	4
		nications	<25 TEU	0.223	0.114	0.088	0.328	0.106	0.141	3	0.247	0.109	0.337	0.105	0.165	0.037	2
		Utilities	>25 TEU	0.126	0.085	0.208	0.375	0.162	0.044	3	0.202	0.036	0.202	0.083	0.238	0.238	1
			<25 TEU	0.172	0.130	0.340	0.162	0.127	0.069	2							

importance of determining transportation mode can be ignored when the shipment size is changed. While several other examples of the impact of shipment size on devising proper TS can be found in Table D4, there are also cases in which shipment size has a neutral role. For example, taking both consumer cyclicals and non-cyclicals industries into account, it seems that shipment size has almost no significant impact on TS when these industries experience high supply uncertainty no matter how much demand volatility they experience in the downstream of their supply chain (i.e. when they follow bot risk-hedging and agile SCSs). This could highlight a more static view to the alignment of TS with SCS relevant to the shipment size for particular industries. It should be noted that some identified misalignments can also be partly related to the constraints of the illustrative case design, which concentrated on a reduced set of core attributes instead of all thirteen decision criteria of the proposed conceptual frame. Ignorance of these contextual aspects (e.g. resilience, sustainability, regulatory pressure, or mode choice) may skew the relative importance of attributes and lead to the apparent mismatches.