

## RESEARCH ARTICLE OPEN ACCESS

# Chain-Level Business Model Patterns for the Green Logistics Transition

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**Received:** 23 November 2025 | **Revised:** 3 February 2026 | **Accepted:** 10 February 2026

**Keywords:** business model | decarbonisation | logistic chain | pattern | sustainability

## ABSTRACT

Sustainability transitions in freight transport increasingly depend on coordinated changes across entire logistics networks, not just within individual firms. This study investigates how business-model change unfolds across a multimodal European logistics chain engaged in reducing transport-related emissions. Drawing on 10 semistructured interviews and five multistakeholder workshops, the analysis identifies seven chain-level business-model patterns that structure how value is proposed, created and captured during the green transition. These patterns encompass beyond-compliance decarbonisation commitments, the integration of digital and physical services, fleet-level carbon-attribute allocation, collaborative value sharing practices, risk-sharing arrangements, green-tier service differentiation and cost-balancing mechanisms. Together, they demonstrate that environmental performance improvements emerge not from isolated organisational initiatives but from coordinated, networked business-model configurations grounded in verified emissions data and chain-level alignment. The results highlight the strategic importance of ecosystem collaboration, demonstrating how firms can co-shape the transition to climate-neutral logistics through network-level business-model innovation.

## 1 | Introduction

Transport and logistics are undergoing profound transformation as firms confront intensifying pressures to reduce greenhouse-gas emissions and meet rapidly evolving sustainability expectations. In the European Union, transport has become the largest emitting sector, placing freight logistics at the centre of corporate climate strategies and regulatory action.<sup>1</sup> Scholars highlight that reductions in emissions require not only technological upgrades—such as alternative fuels, electrification and digital monitoring systems—but also changes in the underlying business-model logic governing how value is created, delivered and captured across interdependent actors (Boons and Lüdeke-Freund 2013; Bocken et al. 2014; Geissdoerfer et al. 2017). Regulatory developments including the Corporate Sustainability Reporting Directive, FuelEU Maritime and strengthened Scope 3 requirements have intensified pressures

for accurate emissions accounting, verified data, transparency and cross-firm coordination (Dechezleprêtre et al. 2022).

Consequently, logistics chains are starting to see business-model innovation as a central mechanism in the green transition (Schaltegger et al. 2016; Lind and Melander 2023). Given that emissions reductions in logistics depend on coordinated action among multiple cargo owners, road hauliers and shippers, the challenge is inherently systemic. However, business-model research has primarily examined sustainability transitions at the level of individual firms, leaving a limited understanding of how decarbonisation unfolds across multimodal logistics chains where value-creation is inherently distributed.

To address this gap, the present study investigates the business-model patterns through which cargo owners, shipping companies and road hauliers collectively reconfigure

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their value-proposition, value-creation architecture and value-capture mechanisms in response to the green transition. Accordingly, this study examines the following research question: How do interdependent organisations in a logistics chain reconfigure their business models during the green transition?

Taken together, this study advances Business Strategy and the Environment literature by reframing decarbonisation as a networked business-model configuration challenge rather than a firm-level optimisation task. Conceptually, we introduce chain-level business-model patterns as a midrange construct that links firm-level sustainable business-model archetypes with ecosystem-level transition processes. Empirically, we provide an embedded, multimodal case that shows how decarbonisation unfolds across an integrated road–sea logistics chain operating under tightening EU regulation. Managerially and strategically, we demonstrate how firms can orchestrate ecosystem change through shared emissions data, verified reporting standards, value- and risk-sharing arrangements and coinvestment models that enable aligned green transformation across the chain.

## 2 | Literature Review

### 2.1 | Business Models

Business models describe how organisations create, deliver and capture value (Teece 2010; Osterwalder et al. 2005). Business models are commonly conceptualised through three interdependent dimensions: value proposition, value creation and value capture (Bocken et al. 2014). The value proposition articulates the offering and its relevance to customer needs; value creation encompasses the resources, capabilities, activities and partnerships required to deliver this offering (Amit and Zott 2001); and value capture refers to the mechanisms—pricing logics, revenue structures and cost architectures—through which organisations retain a share of the value generated (Teece 2010).

Sustainability-oriented business model research extends this foundation by embedding environmental and social goals within the value architecture of the firm (Boons and Lüdeke-Freund 2013; Schaltegger et al. 2016). Competitiveness is increasingly viewed as the alignment of economic viability with long-term societal benefit (Bocken et al. 2014), which requires firms to develop new capabilities, relational structures and governance arrangements (Mehrabani et al. 2025). In this view, value is not created solely for customers or shareholders but for a wider set of stakeholders, including ecosystems and communities.

Business models are dynamic; that is, organisations are innovating and making changes to the business-model in response to technological advances, regulatory pressures, shifting customer expectations and environmental constraints (Pohle and Chapman 2006; Lindgardt et al. 2012; Bucherer et al. 2012; Marolt et al. 2018). Business-model innovation can involve incremental adjustments or more fundamental reconfigurations to the business-model logic (Saebi et al. 2017; Eriksson et al. 2021).

Innovating business models frequently requires changes in organisational configuration as well as alignment with partners, networks and ecosystems that provide complementary resources

and legitimacy (Coviello et al. 2024; Heikkilä et al. 2018; Piaskowska et al. 2021). This transformation often takes the form of networked business models, in which value-proposition, creation and capture are distributed across interdependent organisations (Palo and Tähtinen 2013; Lind and Melander 2023; Heikkilä et al. 2014). Such transitions are cumulative processes involving iterative learning, capability building and interorganisational alignment (Brown et al. 2025; Jansen et al. 2023; Mula et al. 2024).

Recent scholarship increasingly views business model innovation as the recombination of recurring configuration logics, commonly conceptualised as business model patterns (Gassmann and Frankenberger 2014; Lüdeke-Freund et al. 2019). A business model pattern represents a repeatable structural solution to a strategic, technological or environmental challenge—a midrange construct between abstract archetypes and firm-specific models. Pattern research in sustainability has expanded rapidly, resulting in extensive catalogues such as the sustainable patterns of Lüdeke-Freund et al. (2018, 2024) and the patterns synthesised by Schroedel (2023). Circular economy studies similarly identify pattern families—such as repair, reuse, remanufacturing and recycling—through which organisations structure regenerative value flows (Lüdeke-Freund et al. 2019).

Despite this progress, existing literature mainly focuses on firm-level patterns. They provide limited understanding of how business model configurations operate in networked settings, where multiple actors jointly shape value creation and value capture. This is a critical omission in logistics, a domain where sustainability performance depends on coordination across interdependent organisations rather than on isolated firm-level initiatives.

Building on this gap, the present study conceptualises a business model pattern as a recurring configuration logic through which multiple actors align their value proposition, value creation and value capture in response to sustainability transitions.

### 2.2 | Business Model Innovation in Green Logistics Transition

Historically, transport has been dominated by logics of cost efficiency and reliability, often prioritising short-term optimisation over long-term environmental performance (Baştuğ and Yercan 2021; Ellram et al. 2022; Davis-Sramek et al. 2020). However, recent green logistics scholarship demonstrates that sustainability-oriented innovation in freight transport is closely intertwined with business model change (Bendig et al. 2023; Bertelè et al. 2024). The expansion of sustainability regulation and stakeholder expectations is increasing the importance of environmental issues. Urban and last-mile logistics research highlights models that enable electric vehicle adoption and platform-based coordination, such as waste-based fuel models (Sxoinaraki and Panou 2017), green courier aggregators (Doguchaeva et al. 2022) and service architectures like last-mile-as-a-service (Correia et al. 2021). Studies of sustainable systems and reverse logistics extend this perspective to online distribution, circular flows and waste reduction (Donner and de Vries 2023; Wit and Pylak 2020). Circular economy logistics research further identifies business model structures that enable

resource recirculation and closed-loop systems (Lüdeke-Freund et al. 2019).

These threads of literature collectively show that greener logistics requires adjustments in business models. However, they examine business model innovation predominantly within single organisations or discrete logistics segments such as urban freight, last-mile delivery or reverse flows. Studies engaging broader supply-chain perspectives—such as Aldakhil et al. (2018) and Melkonyan et al. (2019)—acknowledge systemic coordination challenges but still do not conceptualise business model innovation as a cross-organisational configuration problem. Moreover, although the above literature provides important insights, it does not conceptualise these configurations as patterns that explain how business models evolve collectively across interdependent organisations.

This research gap is increasingly significant as decarbonisation in freight transport requires forms of business model innovation that span shipping companies, road hauliers and cargo owners. Chain-level transformation cannot be explained by firm-centric archetypes or isolated business-model changes. Instead, it requires understanding business model patterns through which multiple actors jointly reconfigure their value proposition, value-creation architecture and value-capture mechanisms.

The present study addresses this need by identifying chain-level business-model patterns that characterise the greening of a multimodal European logistics chain and by showing how these patterns structure collective value proposition, creation and capture in sustainability transitions.

### 3 | Research Method

This study adopts a qualitative, multiactor case design suited to examining how business-model configurations evolve across interdependent organisations. The empirical focus is the green-transport chain of a specific industrial product, analysed as an embedded case (Farquhar 2012; Yin 2018). The chain spans both upstream and downstream multimodal transport: Upstream sea transport is operated by BulkShipCo, whereas downstream delivery begins with land transport by RoadLogCo from the cargo owner IndustryCo's premises, continues with short-sea shipping by ShortSeaCo and ends with final land transport by RoadLogCo to the customer. To investigate how these actors develop greener delivery options and reconfigure their business models, a qualitative study (Creswell and Creswell Báez 2021; Silverman 2021; Hartley 2004) was conducted between November 2023 and October 2025.

This transport chain provides a strategically relevant context for studying networked business-model reconfiguration. The participating organisations are early adopters and first movers in logistics decarbonisation, operating in a regulation-intensive environment shaped by EU climate legislation and verified emissions-reporting requirements. The chain spans a multiactor network requiring cross-organisational coordination to achieve measurable emissions reductions. In addition, the actors exhibit relatively high digital maturity. These characteristics make the case well suited for examining how interdependent firms

configure value proposition as well as value creation and capture during sustainability transitions.

The data collection was conducted as part of a broader research project aimed at identifying emission-reduction opportunities in multimodal transport chains. Data collection was guided by the principle of theoretical saturation. Altogether, it comprised 10 semistructured interviews and five multistakeholder workshops involving representatives from all organisations in the transport chain. Participants held diverse senior or boundary-spanning roles (such as sustainability directors, heads of logistics and supply chain development, digitalisation, sales, operations and business intelligence managers), enabling them to reflect on business-model interactions beyond their own organisational boundaries. As data collection progressed, recurring configuration logics related to emissions allocation, digital-physical integration, value sharing and pricing repeatedly emerged across actors and were corroborated in multistakeholder workshops, indicating that the core chain-level business-model patterns had been sufficiently captured despite the limited number of interviews.

The first two workshops enabled the research team to map the logistics chain, understand the organisational context and identify preliminary issues for further examination. These insights informed the first-stage interview framework, which focused on emission-reduction goals, customer expectations regarding emissions data and the role of certified and data-driven solutions in offering greener transport services. The second interview stage explored how the green transition affects pricing structures, business-model design and interorganisational collaboration within logistics networks.

Following the interviews, a third workshop was held in which companies articulated their decarbonisation ambitions and discussed shared challenges and potential solutions. In the fourth workshop, the researchers presented the seven emergent business-model patterns and invited feedback from chain participants. The final workshop gathered additional reflections and examined whether recent postponements to EU CO<sub>2</sub>-reduction targets had influenced the companies' ambitions; participants reported that their decarbonisation targets remained unchanged and joint activities to reduce logistics-related emissions continue.

All interviews were conducted online (via MS Teams or Zoom), recorded and transcribed—except for one interview where detailed notes were taken due to technical issues. Interview duration ranged from 25 to 60 min and workshops from 1 to 3 h. The final dataset consists of approximately 104 pages of interview transcripts and 30 pages of workshop notes. The material was analysed using thematic analysis (Creswell and Creswell Báez 2021; Lochmiller 2021; Rapley 2021), involving iterative coding, grouping and refinement of codes into themes and subthemes.

The analysis proceeded in stages. First, open coding was conducted to identify practices, capabilities, decision logics and coordination mechanisms relevant to decarbonisation. Second, the codes were iteratively grouped into themes and further into business model patterns, which illustrated business-model

**TABLE 1** | Coding structure: From codes to themes to business-model patterns.

Example codes (data fragments)	Themes (axial coding)	Business model patterns
‘We need structured, unified reporting’. ‘Verification prevents greenwashing’. ‘We want to be ahead of regulation’.	Commitment to climate action; compliance and incentives; enhanced value proposition through regulatory alignment	Beyond-compliance decarbonisation
‘Transparency is key for everything’. ‘Portal shows voyage-level emissions’. ‘Customers praise the portal as a value-added service’.	Solutions for emissions tracking; building trust; transparency of data	Integrated digital–physical service architecture
‘It does not matter which ship reduces emissions’. ‘We sell the green capacity we have’. ‘Fleet-level data is more realistic’.	Carbon-attribute allocation; fleet-level accounting; mass balance approach	Fleet-level emission allocation
‘Virtual arrival saves fuel and emissions’. ‘We share bunker savings 50/50’. ‘You cannot decarbonise alone’.	Cocreation of value; sharing value; collaborative optimisation	Value-sharing partnerships
‘Big investments are always a funding challenge’. ‘We built charging places for partners’. ‘Someone has to move first—but not alone’.	Shared investment; long-term contracting; risk-sharing; infrastructure codevelopment	Risk-sharing and coinvestment models
‘This is a premium product—accepted by customers’. ‘We now offer green service tiers’. ‘Customers want fossil-free deliveries tracked’.	Market value; green-tier differentiation; willingness- to-pay; verified emissions as commercial asset	Green-premium and tiered service models
‘We may subsidise green services via other means’. ‘Some route costs must be blended’. ‘Green transport must remain affordable’.	Cost allocation; cross-subsidisation; transition-phase pricing logic	Cost-balancing mechanisms

configuration logics shared across actors. The patterns were validated in the last two final stakeholder workshops involving representatives from all participating organisations. The resulting seven chain-level business-model patterns reflect recurring configurations that cut across firm boundaries and modes of transport. Table 1 summarises the coding structure linking empirical codes to themes and the resulting business-model patterns.

To enhance reliability, multiple researchers were involved in coding, interpretation and validation. Triangulation across interviews, internal company material and workshop discussions strengthened the robustness of the findings. The analytical process emphasised configurational reasoning—seeking patterns linking value proposition, value-creation structures and value-capture mechanisms—consistent with contemporary business-model research.

#### 4 | Findings: Chain-Level Business Model Patterns in the Green Transition

In response to our research question, we identify seven chain-level business-model patterns that constitute recurring configuration logics for decarbonisation. These patterns describe how shipping companies, road hauliers and the cargo owner

collectively reconfigure their value proposition, value-creation architecture and value-capture mechanisms in response to regulatory, technological and customer pressures. The patterns do not emerge from isolated organisational initiatives but from cross-actor alignment around verified emissions data, digital-physical system integration, collaborative optimisation and new pricing and cost-allocation logics.

Before detailing each pattern, we introduce the overarching dynamics that characterise the chain’s transition context. The findings confirm that the logistics chain operates in a regulation-intensive environment. Participants identified 25 regulation and voluntary initiatives addressing greenhouse-gas emissions across different phases of the transport chain. Most notably, these included the EU Emissions Trading System, FuelEU-type fuel intensity and decarbonisation obligations, renewable energy directive and emissions reporting requirements (Solakivi et al. 2026). Together with increasing customer requirements, these regulatory pressures act as key external drivers shaping the observed business-model patterns.

At the same time, across actors, sustainability has become a differentiating element of business strategy rather than merely a compliance obligation. As the IndustryCo noted, ‘Sustainability is the way to stand out ... customers want their own brand tied

to a fossil-free value chain'. Freight carriers similarly reported that environmental performance strengthens customer relationships: 'Our client is proud to work with us ... they promote us better than we can ever do ourselves'. Such statements underscore that decarbonisation is not only a compliance response but also a source of competitive positioning and interfirm legitimacy within the logistics ecosystem.

The sections below present the seven patterns, each describing a recurring business model configuration that connects value proposition, value-creation practices and value-capture mechanisms.

#### 4.1 | Beyond-Compliance Decarbonisation

Actors across the chain increasingly treat verified emissions data as the foundation for both operational decisions and commercial positioning. Regulation initially triggered measurement efforts, but firms now aim to stay ahead of formal requirements, using structured, ISO-aligned data 'to avoid fake or greenwashing claims' and to demonstrate credible progress towards zero-carbon goals. Verified reporting enables the IndustryCo to demand chain-level transparency and to frame logistics as part of its own sustainability promise to customers.

This pattern reflects a shift from compliance as a minimum requirement to decarbonisation as a strategic commitment. Third-party verification and transparent communication allow actors to signal that they are moving faster than regulation, strengthening legitimacy and trust. The IndustryCo expects that such leadership will 'stand out in the market' and become 'both environmentally and economically the best choice'. In this way, emissions data evolve from a regulatory artefact into a relational asset and integral element of the joint value proposition.

#### 4.2 | Digital-Physical Service Integration

Digitalisation is evolving from a support function into an integrated service architecture that underpins reliability, transparency and low-carbon value creation. BulkShipCo and RoadLogCo have developed customer portals and real-time emissions dashboards that allow clients to analyse transport performance at shipment and voyage level. BulkShipCo, for example, offers a simulation tool that shows the effect of alternative fuels: 'We provide the data in the portal for customers to analyse further ... including the emission reduction if, for example, 20% or 30% bio-blend were used'.

These portals have become relational assets. BulkShipCo reports that customers 'praise the portal as a value-added service not commonly offered', whereas IndustryCo notes that clients are 'really expecting fossil-free transportation from the mills' and want it tracked through verified data. As one BulkShipCo manager put it, 'transparency is the key for everything ... the more transparent we can report and show the data, the better way forward'. However, not all partners are equally advanced—ShortSeaCo still relies mainly on spreadsheets but emphasises

that 'transparency in how emissions are calculated and reported adds credibility'.

Across the chain, the digital layer is becoming part of the product. It increases switching costs, builds trust and deepens customer relationships by embedding emission visibility into the core service. Integrated digital-physical service architectures also provide the data infrastructure for other patterns, including fleet-level emission allocation, green-premium offerings and collaborative optimisation.

#### 4.3 | Fleet-Level Emission Allocation (Book-and-Claim Logic)

Several actors, particularly in maritime transport, are experimenting with ways to treat verified emission reductions as allocatable attributes rather than fixed properties of individual voyages. Discussions focus on fleet-level accounting and book-and-claim systems that decouple where low-carbon fuels are physically used from where their environmental benefits are commercially assigned. ShortSeaCo summarised this logic by stating that 'it doesn't matter whether the emission reduction is made on this ship or on another ship, as long as it is done'.

In this pattern, the value proposition shifts from promising that a given shipment is transported on a specific low-carbon vessel to offering access to a pool of certified low-emission capacity. In principle, this also opens possibilities to certify surplus reductions—such as those generated by smaller vessels outside the EU ETS—as carbon credits that could be allocated to other freight operations. Interviewees stressed that these ideas remain at an early, exploratory stage, but they illustrate how operators are beginning to integrate carbon-attribute allocation into their business-model thinking.

At the same time, actors recognise the risks. If book-and-claim systems are not governed transparently and backed by robust verification, customers may question whether purchased attributes correspond to real, additional reductions. Fleet-level allocation therefore requires credible standards and communication to avoid undermining trust in low-carbon logistics offerings.

#### 4.4 | Value-Sharing Partnerships

A central value-creation pattern in the chain is the emergence of value-sharing partnerships, in which environmental and economic benefits are distributed across actors rather than captured by a single firm. This is particularly visible in BulkShipCo's deployment of Virtual Arrival, an operational optimisation method that aligns vessel speed with actual berth availability to avoid unnecessary high-speed sailing and anchorage waiting. According to BulkShipCo, adopting Virtual Arrival has reduced emissions by around 24% compared with conventional sailing patterns.

Crucially, the cost savings from reduced fuel consumption are shared: BulkShipCo describes contract clauses that split bunker savings '50/50', which 'incentivises clients to adopt greener practices'. Virtual Arrival thus converts operational optimisation

into jointly captured cost reductions, reinforcing the willingness of cargo owners and carriers to participate in greener arrangements. Beyond this specific case, similar value-sharing dynamics appear in jointly used digital systems, shared data for optimisation and collaborative pilot projects.

In this pattern, the business-model logic shifts from bilateral price negotiations to cocreated value bundles, where both emissions and cost savings become subjects of joint design. Value-sharing partnerships therefore function as a mechanism through which actors align incentives and scale operational innovations that support decarbonisation.

#### 4.5 | Risk-Sharing and Coinvestment Models

Because green transport relies on capital-intensive assets such as alternative-fuel vessels, charging infrastructure and electric trucks, risk-sharing has become a core business-model mechanism. IndustryCo interviewees stressed that few logistics providers can justify these investments alone. RoadLogCo highlighted combined barriers of vehicle cost, range limitations and underdeveloped infrastructure: ‘The cost of electric trucks and their limited range, coupled with underdeveloped charging infrastructure, are significant barriers ... to building a more sustainable supply chain’.

To mitigate this, IndustryCo has invested in charging stations at its mills and makes them available to transport partners. A IndustryCo representative emphasised the importance of long-term collaboration: ‘You need very good partners ... you need long-term contracts to ensure investments. We have built charging places for trucks, which requires upfront investments and cooperation across stakeholders’. RoadLogCo echoed that ‘charging infrastructure is crucial’, noting that development involves customers, logistics providers and energy companies and that a ‘well-developed network is key’. Access to customer-provided charging during loading and unloading was seen as vital for aligning daily work with charging needs.

Similar risk-sharing logics appear in maritime investments. BulkShipCo described that ‘big investments are always a funding challenge’, especially for a company that ‘cannot spend 200 million just by ourselves’, making partnerships essential for funding fossil-free vessels and biofuel adoption. Across these examples, coinvestment, long-term contracting and infrastructure sharing distribute financial and operational risks, enabling earlier adoption of green technologies than would be possible for individual firms.

#### 4.6 | Green-Premium and Tiered Service Models

Verified emissions data and digital transparency enable the emergence of green-premium and tiered service models. IndustryCo observes growing momentum for differentiated low-emission services, arguing that ‘this is the perfect timing, and the market will help us’, with green transport expected to increase product attractiveness and attention. During the study period, ShortSeaCo launched a new green service, and collectively, all logistics partners now offer low-emission options on at least some routes.

These offerings rely on the ability to document and communicate reduced emissions. IndustryCo reported informing customers that fossil-free logistics constitute ‘a premium product’ and that ‘this concept is accepted’. BulkShipCo similarly noted that it ‘might be able to fetch some premium for that environmental friendliness’. In this pattern, decarbonisation becomes an explicit revenue logic: Customers willing to pay more can access verifiably lower emission transport, and providers can capture part of the value created by their investments.

At the same time, customers increasingly expect end-to-end solutions rather than isolated green segments. As one IndustryCo manager noted, ‘you need the whole chain to be emission-free ... the customer is looking for the end-to-end solution—not one part’. This expectation motivates actors to think in terms of green corridors and chain-level offerings, even as price-driven tendering and cost competition still constrain the scope for widespread premium pricing.

#### 4.7 | Cost-Balancing Mechanisms

The higher operational and investment costs associated with cleaner fuels and technologies create pressure on margins, leading actors to explore cost-balancing mechanisms in their business models. ShortSeaCo, for instance, suggested a form of cross-subsidisation in which part of the additional cost of green options is distributed across the broader customer base: ‘If we want to promote green transport, we could distribute part of the cost to other customers who don’t opt for green services’.

In this pattern, value-capture involves designing pricing structures, customer segmentation and cost-allocation rules that make greener options economically viable without rendering services unaffordable or uncompetitive. Interviewees acknowledged that such mechanisms carry risks: Subsidising green transport may cause price-sensitive customers to consider switching to another logistics service provider if they perceive cross-subsidies as unfair.

Nevertheless, cost-balancing mechanisms are emerging as a pragmatic response to the current cost differential between conventional and low-carbon transport. They enable firms to keep greener services on offer while the cost of technologies and fuels gradually declines, thereby supporting a managed, chain-level transition rather than an all-or-nothing shift.

#### 4.8 | Summary: Business Model Transformation Across the Chain

To clarify how these patterns reflect business model transformation rather than isolated operational actions, we mapped each empirical pattern onto the core business model components of value proposition, value creation and value capture. Table 2 summarises how each pattern represents a distinct configuration logic through which actors across the multimodal transport chain reconfigure their business models in response to the green transition.

**TABLE 2** | Business model patterns across value proposition, value creation and value capture.

Business model pattern	Value proposition	Value creation	Value capture
1. Beyond-compliance decarbonisation	Offers credible, certified low-carbon transport supported by verified emission data	Establishes unified data processes and transparent reporting routines	Enhances legitimacy and trust; strengthens long-term customer relationships; reduces perceived risk
2. Digital–physical service integration	Hybrid offering combining physical transport with digital tracking, emission dashboards and data services	Deploys digital infrastructures enabling real-time measurement and optimisation	Creates relational lock-in; supports outcome-based contracting; enables premium pricing for enhanced transparency
3. Fleet-level emission allocation	Provides access to low-emission transport irrespective of specific vessel/truck behaviour	Coordinates fleet-level optimisation; reorganises where emission reductions are generated and allocated	Enables emerging carbon-attribute or credit-based revenue models; supports differentiated service tiers
4. Value-sharing partnerships	Offers shared economic and environmental benefits (e.g., virtual arrival) as part of the customer value	Collaborative optimisation of speed, routing, utilisation and joint data use	Distributes cost savings (e.g., 50/50 energy savings); reinforces long-term contracting and cobenefit logic
5. Risk-sharing and coinvestment models	Positions green transport as a stable, long-term proposition, supported by jointly developed infrastructure	Coinvestment in charging, vessels, alternative fuels; alignment of operational capabilities across partners	Reduces individual capital exposure; stabilises revenue streams; lowers adoption barriers for green technologies
6. Green-premium and tiered service models	Offers fossil-free or low-emission transport as a distinct premium service tier	Builds the digital and operational foundation for service differentiation	Tests willingness-to-pay; captures value from decarbonisation; enables tiered pricing
7. Cost-balancing mechanisms	Provides scalable green options through differentiated pricing and cost-allocation structures	Aligns operational choices, customer segmentation, and cost structures to sustain greener offerings	Introduces cross-subsidisation, selective cost allocation and pricing mechanisms that distribute green costs across customers

## 5 | Discussion

This study demonstrates that decarbonisation in freight transport is not merely a technological or operational adjustment but requires the introduction of new business model patterns across multimodal logistics chains. The findings show that within logistics ecosystems, no single organisation can meaningfully decarbonise in isolation. Instead, emission performance emerges from a web of interdependent activities, shared infrastructures and relational arrangements spanning multiple actors. Consequently, business-model innovation in the green transition takes the form of a networked strategic process in which firms collectively reshape value propositions, as well as value creation and value capture mechanisms.

The seven business-model patterns identified in this study reflect emerging configuration logics through which firms compete and collaborate in low-carbon logistics markets. Although

the seven business-model patterns are analytically distinct, the empirical findings show that they are highly interdependent and typically enacted in combination as part of broader chain-level business-model reconfigurations.

Patterns such as beyond-compliance decarbonisation, digital–physical service integration and fleet-level emission allocation illustrate how firms are developing new ways to position themselves, differentiate service offerings and strengthen relationships with sustainability-oriented customers. Importantly, these patterns unfold through shared data infrastructures and aligned reporting practices and coordinated investment and pricing arrangements that extend beyond organisational boundaries. This suggests that competitive advantage in the green transition increasingly depends on a firm's ability to participate in and align with network-level configurations that support credible environmental performance.

## 5.1 | Strategic Coordination and Market-Facing Value

A central insight from this study is that decarbonisation requires greater relational alignment and strategic coordination across logistics actors, while simultaneously reshaping how value is defined and offered to the market. Verified emissions data, collaborative value sharing (e.g., virtual arrival) and risk sharing arrangements all strengthen relational ties and reduce uncertainty between cargo owners, road hauliers and shipping companies. These mechanisms enable chain-level transparency and foster trust—key relational assets in industrial markets, particularly where environmental performance increasingly influences supplier selection.

At the same time, respondents emphasised that customers increasingly expect verified, voyage-level emissions data and access to fossil-free or low-emission service options. Green-tier offerings, cost-balancing mechanisms and carbon-attribute allocation enable firms to respond to heterogeneous customer preferences while gradually shaping demand for low-carbon logistics services. Such pricing and service innovations reflect broader strategic shifts in industrial markets, where environmental attributes are becoming integral to value propositions.

## 5.2 | Interdependence of Chain-Level Business Model Patterns

The interdependence among the identified patterns is most visible in how certain patterns enable or stabilise others. For example, fleet-level emission allocation only becomes more meaningful when supported by shared digital–physical service architectures that generate verified, comparable emissions data across actors. Without such infrastructures, the allocation of emission reductions would remain contested and lack credibility for customers and regulators.

Similarly, green-premium and tiered service models should build on beyond-compliance decarbonisation commitments and transparent reporting practices to justify price differentiation. In the absence of credible data and shared standards, premium low-emission services risk being perceived as symbolic rather than substantive. At the same time, these premium offerings create commercial incentives that help justify investments in digital systems, alternative fuels and low-emission assets.

Risk-sharing and coinvestment models further enable commitment to these by reducing the financial uncertainty associated with green investments. Long-term contracting, shared infrastructure and joint investments enable decarbonisation pathways that would be difficult for individual actors to pursue alone. Cost-balancing mechanisms complement these arrangements by distributing the additional costs of low-emission solutions during the transition phase, helping to maintain affordability while greener technologies mature.

Importantly, these patterns cannot be understood as operational collaboration tactics alone. Although collaboration is a necessary condition for decarbonisation in logistics, the empirical

findings show that the identified business-model patterns reconfigure more fundamental aspects of how logistics services are defined, governed and monetised across the chain. They reshape what is offered to customers (e.g., verified low-emission services rather than undifferentiated transport), how value creation is organised and governed across interdependent firms (e.g., shared data infrastructures, joint optimisation and risk-sharing arrangements) and how economic value and costs are allocated over time (e.g., premium pricing, cost-balancing and fleet-level emission allocation). It is this joint redefinition of offering, governance and value capture—rather than collaboration per se—that characterises the observed changes as chain-level business-model configurations.

## 5.3 | Theoretical Contributions

Theoretically, this study extends business-model research by articulating how sustainability transitions unfold through networked configuration patterns, rather than through isolated firm-level innovations. Whereas prior work conceptualises sustainable business models primarily at the firm level—typically through archetypes such as stewardship, efficiency or circular resource flows (Bocken et al. 2014; Boons and Lüdeke-Freund 2013)—the present findings show that decarbonisation in multimodal logistics requires networked and interdependent business model transformations. By identifying chain-level business-model patterns, this study offers a midrange theoretical framework that explains how interdependent organisations collectively reshape value propositions, value-creation architectures and value-capture mechanisms in response to environmental pressures. This contributes to the ongoing development of business-model theory by highlighting the importance of interorganisational alignment, shared capabilities and cross-actor coordination in sustainability transitions.

A systematic comparison with the existing business model patterns (Gassmann and Frankenberger 2014; Schroedel 2023) confirms this novelty: Although several of the identified patterns show partial resemblance to generic logics such as revenue sharing, digitisation or performance-based contracting, the patterns found in this study incorporate verified emission data, fleet-level carbon allocation, collaborative decarbonisation investments or cost-balancing mechanisms for green services. Existing pattern literature also does not address how multiple firms jointly adapt their business model components in response to shared sustainability pressures. The seven patterns observed here thus represent new recombinations of business model logic that emerge specifically from the requirements and constraints of multimodal green logistics.

The findings also contribute to the literature on networked business models by conceptualising and empirically grounding seven chain-level business-model patterns. Prior research characterises networked business models as configurations in which value proposition, creation and capture are distributed across interdependent organisations (Palo and Tähtinen 2013; Lind and Melander 2023; Heikkilä et al. 2014). Although past research has established the theoretical foundations for understanding such distributed configurations, it offers limited

insight into how these transformations materialise in practice during sustainability transitions. This study addresses this gap by providing a pattern-based account of network-level business-model innovation. The multimodal green logistics case demonstrates how firms collectively innovate business model response to decarbonisation pressures—thereby extending prior perspectives on dynamic, interorganisational business-model evolution (Coviello et al. 2024; Piaskowska et al. 2021; Jansen et al. 2023; Mula et al. 2024; Brown et al. 2025).

Taken together, these theoretical implications show that sustainability-oriented business model transformation in logistics does not follow the linear, firm-centric pathways commonly described in existing literature. Instead, it evolves through multiactor configuration patterns that progressively align economic and environmental value across the transport chain. This contributes new insight into the mechanisms through which business models adapt within complex industrial ecosystems undergoing systemic sustainability transitions.

## 5.4 | Managerial Implications

The findings offer several strategic implications for managers seeking to navigate the green transition in multimodal logistics chains. First, managers should approach decarbonisation as a strategic transformation rather than an operational adjustment. Verified emissions data, shared reporting formats and transparent digital platforms form the foundation for credible low-carbon offerings. Firms that invest early in these infrastructures strengthen their strategic positioning and become preferred partners for customers with ambitious sustainability goals. Digital transparency also raises switching costs and deepens customer relationships by embedding data-driven collaboration into everyday operations.

Second, the patterns identified in this study highlight the value of strategic coordination across logistics ecosystems. Business-model transformation in freight transport requires alignment between cargo owners, road hauliers and shipping companies. Managers may prioritise relational practices that build trust and reduce uncertainty: shared emissions-reduction targets, value sharing agreements (e.g., virtual arrival) and risk-sharing mechanisms. These mechanisms enhance collective decision-making, lower the perceived risks of adopting new technologies and accelerate alignment across the chain.

Third, managers should recognise that chain-level business-model innovation must often be navigated in contexts characterised by multiple standards and regulatory frameworks. In the studied case, firms differed in whether they applied tank-to-wheel or well-to-wheel approaches and in whether they reported CO<sub>2</sub> or CO<sub>2</sub>-equivalent emissions. These challenges were further compounded by differences between EU regulatory requirements and the methodologies promoted by voluntary first-mover coalitions and science-based target initiatives, as well as by the fact that regulatory frameworks differ across transport modes. As companies participated simultaneously in regulatory compliance processes and multiple pilot projects—such as those linked to emerging digital product passport initiatives—these

differences required substantial alignment efforts. The findings suggest that chain-level business-model innovation relies not only on technical measurement capabilities but also on iterative standard-setting and coordination processes through which firms negotiate and harmonise calculation practices across overlapping regulatory, voluntary and modal regimes over time.

Fourth, the results underscore the need to cultivate new strategic capabilities that enable participation in low-carbon logistics. These include the ability to use digital emissions tools to enhance service offerings, to adopt fleet-level carbon-attribute allocation and to design green-tier or sustainability-linked pricing structures. Such capabilities support differentiated value propositions that respond to customer expectations for verifiable sustainability performance. Firms that proactively develop these capabilities gain an advantage in emerging green logistics markets, shaping customer expectations and influencing the trajectory of market development.

Fifth, managers should consider risk-sharing and coinvestment arrangements as essential components of their strategy. Investments in charging infrastructure, alternative fuels and new vessels or vehicles are too significant for many organisations to undertake alone. Long-term contracts, cofunding models and shared asset use distribute risks and create stable conditions for scaling low-carbon solutions. These arrangements enable firms to engage in strategic experimentation—testing new technologies and service models while reducing exposure to uncertainty.

Finally, managers should recognise the importance of ecosystem orchestration in driving sustainable logistics. The seven patterns identified here function as transition enablers that can be deliberately combined into a coordinated decarbonisation strategy. Firms that take an active orchestration role—by convening partners, shaping data sharing practices or piloting collaborative solutions—can influence the direction of the ecosystem and strengthen their long-term competitive position. By moving beyond isolated initiatives and adopting a chain-level perspective, managers can accelerate environmental performance improvements while building resilient, future-ready business models.

## 6 | Conclusions

Building on empirical data from a European multimodal transport chain, the paper identifies seven green business model patterns that articulate how interdependent actors reshape value proposition, value creation and value capture in response to the green transition. These patterns do not represent complete business models; rather, they constitute configuration logics through which firms align environmental objectives with operational and commercial viability.

The findings extend sustainability-oriented business-model research by revealing how strategic innovation emerges through interorganisational configuration logics that span the freight transport chain. The patterns identified here illuminate how firms build new strategic capabilities, strengthen relational ties and cocreate emissions reductions through reporting practices, value sharing agreements and collaborative investment decisions. They also illustrate how the green transition reshapes

industrial markets: Environmental attributes become central to value propositions, digital transparency becomes a differentiating asset and collaborative arrangements become necessary for scaling low-carbon technologies.

For managers, the results emphasise the importance of adopting a chain-level perspective when designing decarbonisation strategies. Firms that invest early in verified emissions data, develop collaborative optimisation routines and participate in coinvestment models are better positioned to meet customer expectations, reduce uncertainty and shape the evolution of green logistics markets. By orchestrating or actively contributing to ecosystem-wide alignment, organisations can strengthen both their environmental performance and their long-term competitive position.

This study's conclusions are based on a single, embedded case, representing early adopters within the European logistics context. Thus, these findings reflect a European, regulation-intensive logistics environment and early adopter firms with mature digital infrastructures. Future research could extend this work through comparative multicase studies across different sectors, geographic regions or regulatory environments. Such research would help assess the transferability of the identified patterns and explore how variations in digital maturity, organisational structure or policy context shape chain-level business-model transformation. Nonetheless, the present findings highlight the critical role of networked business-model innovation in advancing climate-neutral logistics and offer a foundation for understanding how industrial ecosystems can transition towards sustainable transport futures.

### Acknowledgements

This research was conducted as part of the *GreenConnect: Connecting green transition to competitive advantage in transport solutions* project, cofunded by Business Finland, participating companies and the University of Turku. The author is thankful to Kristel Edelman and Riikka Franzén for their valuable assistance in supporting the data collection process and to interviewees and workshop participants for their valuable insights and contributions. Open access publishing facilitated by Turun yliopisto, as part of the Wiley - FinELib agreement.

### Funding

This work was supported by Business Finland.

### Conflicts of Interest

The author declares no conflicts of interest.

### Endnotes

<sup>1</sup> <https://www.statista.com/statistics/1171183/ghg-emissions-sector-european-union-eu/>.

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