

# Sustainable Business Models for last-mile delivery solutions: Beyond pilot implementation in Urban Freight Logistics

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## Abstract

Sustainable last-mile delivery solutions are increasingly tested in urban freight logistics to reduce emissions, congestion, and environmental impacts. Prominent measures include curbside management and the adoption of green vehicles such as cargo bikes, e-bikes, and electric vans, which directly address scarce urban curb space and the need to decarbonize delivery operations. Despite strong policy interest, many initiatives fail to move beyond pilot stages due to misaligned incentives, unclear value propositions, and weak long-term economic viability. This paper investigates how business model design influences the successful implementation and scaling of sustainable last-mile solutions. The preliminary results show that business models shape pilot configuration, stakeholder participation, and operational scalability. Therefore, it is necessary to integrate sustainability-related costs, higher operating expenses, infrastructure investments, and service redesign into viable revenue or cost-recovery mechanisms. Building on the secondary data collection and analysis, this study proposes a conceptual framework that links business model dimensions with the Multi-Level Perspective (MLP) to better understand sustainability transitions in urban freight systems. The framework explains how sustainable delivery innovations can evolve from temporary pilots to scalable long-term operations. The findings contribute to ongoing debates on urban freight planning within sustainable development agendas by clarifying how business model choices affect the integration of green vehicles, curbside management, and consolidation strategies into urban mobility plans, and by highlighting the importance of public-private partnerships in overcoming financial, operational, and regulatory barriers.

Keywords: Business models; urban freight; sustainable last mile logistics; curbside management; consolidation strategies

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## 1 Introduction

The operational landscape of last-mile logistics is defined by a fundamental conflict between rising consumer expectations and the stringent decarbonisation requirements imposed by the European Union. The Green Deal strategy (European Commission 2019) aims to reduce CO<sub>2</sub> emissions in the transport sector by 90% by 2050, which necessitates immediate and radical action: a 55% reduction in emissions from passenger cars and a 50% reduction in emissions from commercial vehicles by 2030, and in the long term – a complete ban on the registration of new non-emission vehicles by 2035. This stringent legal framework compounds intensifying market pressure, characterised by growing customer demands regarding speed, cost and flexibility of deliveries, as well as increasing reliance on free returns (Chamber of Electronic Economy and Gemius 2020). As a result, courier operators find themselves in a complex strategic dilemma, forced to simultaneously meet rising service quality standards and strictly adhere to some of the world's most ambitious environmental targets (van Loon et al. 2015; Iwan, Kijewska and Lemke 2016; Gatta et al. 2019; Buldeo, Verlinde and Macharis 2019).

One of the most visible ways of intervening in this field has been through funded projects that support experimentation in cities. Across programmes and calls, urban freight challenges such as congestion, emissions, inefficiency, and the pressure to improve last-mile operations have repeatedly been addressed through project-based initiatives, often with a strong pilot orientation. The existence of projects does not by itself reveal what has been learned from them, nor whether that learning has accumulated into broader change. While pilot projects may produce local evidence, operational experience, and stakeholder engagement, it remains difficult to see how such outcomes can contribute to changing the status quo in urban logistics.

Learning from pilots should not be equated with systemic change. Pilot projects can test technologies, operating models, and forms of collaboration, and they may succeed in demonstrating technical feasibility or local acceptance. However, this does not necessarily mean that they alter the dominant organization or become embedded in more durable practices (Herrera & MacAskill, 2021). The move from pilot to established practice depends not only on whether an intervention works, but on whether it becomes supported through legal, organizational, economic, and user-related conditions (Palacios-Argüello et al., 2025).

A sustainability transitions perspective offers a useful way of understanding this problem (Geels et al., 2019). From this viewpoint, pilot projects can be understood as niche experiments, that is, protected spaces in which alternatives to dominant practices are tested. Broader pressures such as climate goals, urban liveability concerns, digitalization, and the growth of e-commerce can be seen as part of the wider environment in which such experiments emerge. At the same time, these projects operate against a more stable regime characterized by established operational routines, governance arrangements, and incumbent business models. Transition research is useful here because it emphasizes that sustainability change does not arise from technology alone, but from interacting shifts in technologies, business models, behaviours, rules, and values (Kriukelyte et al., 2024).

This perspective is particularly relevant in urban logistics, where project-based innovation often encounters a system marked by fragmented responsibilities, multiple stakeholders, competing incentives, and the persistent dominance of established freight practices. Urban freight systems are shaped not only by infrastructure and technology, but also by regulatory frameworks, land-use patterns, actor constellations, and governance structures, which makes change difficult to attribute to any single intervention (Fischer & Persson, 2019). At the same time, recent work on sustainable business model innovation in last-mile logistics suggests that the long-term viability of new solutions depends not only on environmental performance, but also on how value creation, costs, and incentives are organized across actors (Kiba-Janiak et al., 2024; Kriukelyte et al., 2024, Liu et al., 2025).

Against this background, this paper examines EU-funded urban logistics projects as sites where pilot-based learning is produced and where the relationship between experimentation and more durable change can be explored. Rather than treating projects only as isolated demonstrations, the paper approaches them as part of a broader policy and transition dynamic in which repeated experimentation may or may not contribute to lasting transformation in urban logistics. More specifically, the paper asks whether project-based intervention in this field has mainly generated repeated local experimentation, or whether it has also contributed to learning that becomes carried forward into more durable urban logistics practices.

## **2 Theoretical approach: Sustainability transitions theory**

Sustainability Transitions Theory offers a useful perspective for analyzing how socio-technical systems, such as urban freight and logistics, undergo long-term changes toward more sustainable setups. These transitions go beyond simply replacing technology and involve fundamental changes in institutions, market structures, user habits, infrastructure, and governance (Hasani & Calugaru, 2025). In urban freight, this view is especially relevant, as shifting to sustainable last-mile delivery requires coordinated efforts among multiple stakeholders, including logistics providers, municipalities, technology suppliers, and customers (Cassiano et al., 2021).

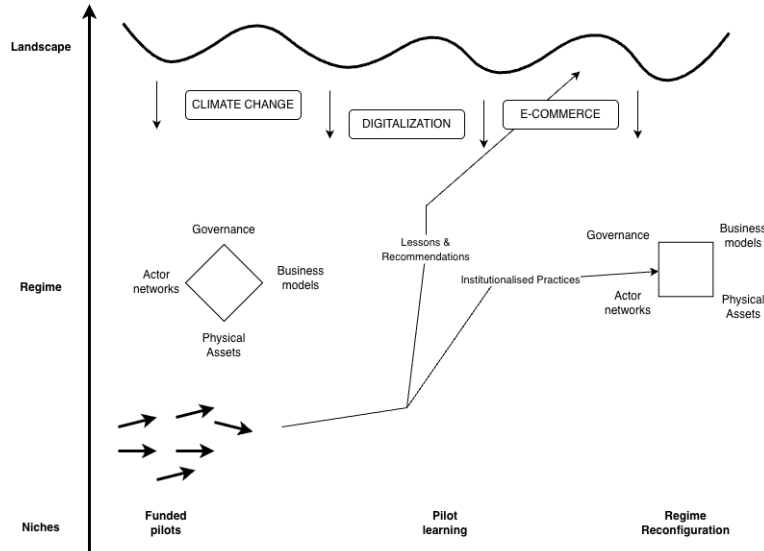
A key framework within this field is the Multi-Level Perspective (MLP) (Geels, 2002), which views transitions as the outcome of interactions across three analytical levels, niche, regime, and landscape. Figure 1 explains the multilevel perspective on sustainability transitions in urban freight systems. At the niche level (micro), protected spaces allow testing of innovative solutions such as cargo bikes, e-bikes, electric vans, consolidation strategies, and new curbside management practices and technologies. These pilot projects let actors explore new technologies, operational concepts, and business models with less market pressure (Benjelloun et al., 2010). According to Buerklend and Liedtke (2024), many of these solutions require new technical and organisational configurations. However, many such efforts remain at the pilot stage due to unclear value propositions, misaligned incentives, and limited cooperation among the stakeholders once the pilot ends (Palacios-Argüello et al., 2025).

At the regime level (meso), established urban freight systems are defined by dominant logistics practices, fossil-fuel-powered vehicle fleets, existing infrastructure, and institutionalized planning systems. These regimes are maintained by sunk investments, regulatory frameworks, and established stakeholder networks, which can slow the adoption and scaling of sustainable alternatives (Hasani & Calugaru, 2025). Notably, current business models in urban logistics often overlook sustainability-related costs or fail to account for the broader value of low-emission delivery options, thereby limiting their long-term economic sustainability.

At the landscape level (macro), larger external factors like climate policies, urban congestion, the rise of e-commerce, and society's demand for low-emission transport create opportunities for change. These pressures challenge existing regimes and motivate experimentation with sustainable delivery ideas (European Commission 2024). Yet landscape pressures alone are insufficient to create systemic change without feasible pathways for implementation and scaling.

Transitions occur when niche innovations align with landscape pressures and influence or reshape existing regimes (Geels & Schot, 2007). This process is complex and often contested, especially in urban freight systems where stakeholders have different incentives and risk perceptions (Hasani & Calugaru, 2025). Building on this view, this paper emphasizes the importance of business model design as a key yet often overlooked factor in sustainability transitions. Business models shape how value is created, delivered, and captured, influencing pilot setups, stakeholder involvement, and the potential to scale sustainable last-mile solutions (Macário et al, 2008; Quak et al., 2014).

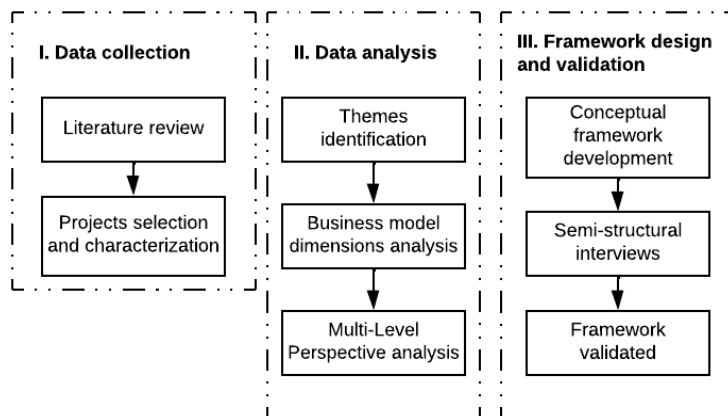
By considering economic, environmental, and governance factors, the transition perspective used here shows that successful scaling depends not just on technological feasibility, but also on aligning incentives, distributing costs and benefits fairly, and having effective public–private governance.



**Figure 1.** The multilevel perspective on sustainability transitions. Adapted from Geels et al., (2019)

### 3 Methodology

The methodology involves collecting both primary and secondary data to understand how business model design choices facilitate the alignment between niche sustainable last-mile delivery innovations and regime-level economic and institutional structures in urban freight transitions. A combination of within-case and cross-case analyses was employed, focusing on cities worldwide that have piloted sustainable last-mile solutions. Figure 2 shows the methodology for the study development.



**Figure 1.** Methodology scheme

#### 3.1 Data collection

The methodology involves gathering both primary and secondary data, including academic and grey literature, as well as semi-structured interviews. The initial search was conducted using Scopus and Web of Science, using

keywords such as “last mile solutions,” “urban freight pilots,” “business model,” “sustainability transitions theory,” “Multi-Level Perspective,” and “urban logistics.” The search was restricted to peer-reviewed journal articles published in English over the past 25 years, emphasizing important works like the Multi-Level Perspective (MLP) within Sustainability Transitions Theory, introduced by Geels (2002).

Regarding grey literature, Ploos van Amstel (2022) reports that, by 2022, the European Commission had funded more than 160 city logistics projects. Building on this, a sample of 30 international projects was identified through a systematic review of relevant project databases and institutional websites. For each project, data were collected on key characteristics, including funding schemes, project duration, stakeholder composition, and reported outcomes.

### *3.2 Data analysis*

After collecting secondary data, academic papers, and grey literature were analysed to identify the elements considered in business models and to examine urban freight transitions through the Multi-Level Perspective (MLP) using the framework of sustainability transitions theory.

First, the grey literature was systematically analysed to identify recurring patterns related to value creation, cost structures, stakeholder interactions, and implementation challenges. These insights were then structured along three key business model dimensions: economic, environmental, and governance. Each dimension captures critical aspects influencing the viability and scalability of sustainable last-mile solutions, including revenue mechanisms, sustainability performance, and stakeholder coordination.

Second, these empirically grounded dimensions were mapped onto the three analytical levels of the Multi-Level Perspective (niche, regime, and landscape) to examine how business model elements interact with broader socio-technical dynamics. This step enabled the identification of alignments and misalignments across levels, particularly with respect to financial viability, institutional constraints, and external policy pressures.

### *3.3 Framework design and validation*

Building on the primary data collection and analysis, this study develops a conceptual framework that links business model dimensions with the Multi-Level Perspective (MLP) to better understand sustainability transitions in urban freight systems. The framework is derived through an iterative process that combines insights from the reports of analysed pilot projects with established theoretical constructs from the sustainability transitions literature. The framework resulted in an integrative model that explains how business model design mediates transition processes. The proposed framework highlights how the alignment of economic, environmental, and governance dimensions across MLP levels influences the ability of sustainable urban freight innovations to move from pilot experimentation to scalable, long-term implementation.

To ensure the robustness and practical relevance of the proposed conceptual framework, a validation step will be conducted through semi-structured interviews, as the preliminary analysis of the secondary data revealed that only limited information was available regarding the underlying business models. This approach allows for the systematic assessment of the framework against real-world perspectives and experiences, particularly in complex and evolving domains such as sustainable urban freight transitions. The interviews will be conducted with a sample of key stakeholders involved in last-mile logistics and urban freight systems, including representatives from logistics service providers, municipal authorities, technology providers, and researchers. This selection ensured that insights reflect multiple perspectives across the socio-technical system and correspond to different roles within the Multi-Level Perspective (niche, regime, and landscape levels). The semi-structured format enabled a consistent discussion of core themes while allowing flexibility to explore context-specific experiences and emerging issues.

The interview guideline will be based on the conceptual framework and will focus on assessing (i) the relevance and completeness of the identified business model dimensions (economic, environmental, governance), (ii) the validity of their mapping across MLP levels, and (iii) the framework’s ability to explain barriers and enablers for scaling sustainable last-mile solutions. Special attention will be given to validating the role of business models as mediating mechanisms between niche experimentation and regime transformation under landscape pressures. Feedback from interviewees will be used to refine the framework by confirming key relationships, identifying missing elements, and clarifying causal mechanisms.

## **4 Preliminary results**

### *4.1 Understanding urban freight transitions through the Multi-Level Perspective (MLP)*

The analysis of pilot projects highlights the central role of cities as key actors operating across regime and landscape levels in sustainability transitions. At the regime level, municipalities shape the institutional and spatial conditions of urban freight through planning frameworks, curbside regulations, and infrastructure provision, which directly influence the feasibility of green vehicles adoption, curbside management, and consolidation strategies to improve urban freight logistics (Kercall et al., 2025). At the same time, cities are positioned at the interface with landscape pressures, such as climate targets, congestion challenges, and growing e-commerce demand, which create the need for systemic change (European Commission, 2019). The literature shows that cities actively mediate

between these levels by enabling niche experimentation while aligning it with broader policy objectives (i.e., Mission cities call from the European Commission) (European Commission, 2024). This confirms that urban sustainability transitions are strongly governed at the city level, where local authorities play a decisive role in connecting experimental solutions to long-term system transformation (Kercall et al., 2025).

At the niche level, the analysed pilots function as protected spaces for experimentation with both technological and organisational innovation (Schot & Geels, 2013). Green vehicles adoption, curbside management, and consolidation strategies are not only technical interventions but also vehicles for testing new business models, collaboration formats, and service designs. The niche experiments enable stakeholders to explore different configurations of value creation, including shared logistics operations, digital coordination platforms, and public-private partnerships (Benjelloun, 2010). However, the findings also reveal that many niche innovations remain unstable due to unclear value propositions and misaligned incentives among actors. This limits their ability to mature and challenge the existing regime, highlighting that successful niche development depends on viable business model design alongside technological feasibility.

From a regime perspective, the diffusion of these niche innovations into mainstream urban freight systems remains limited. The dominant regime is characterised by established logistics practices, incumbent actors, and cost-efficient diesel-based delivery models, which create strong path dependencies (Lehtonen, 2006; Obergassel, 2021). In fact, integrating green vehicles, curbside management practices, and consolidation strategies to improve urban freight logistics is hindered by misalignment with existing operational routines, a lack of standardisation, and insufficient incentives for logistics providers to adopt new solutions (Lindholm, 2010; Schliwa et al., 2015). While landscape pressures, such as decarbonisation policies and societal demand for sustainable delivery, create momentum for change, they have not yet sufficiently destabilised the regime to allow widespread adoption (Frank, 2025).

Finally, the Multi-Level Perspective (MLP) helped to clarify some of the complexities of the change and long-term implementation of sustainable last-mile delivery solutions. Across all three MLP levels, financial viability emerges as a critical condition for enabling transition dynamics (Björklund et al., 2017). At the niche level, pilots rely heavily on public funding to initiate experimentation but often struggle to transition toward self-sustaining operations (Buijs, 2024). At the regime level, prevailing market structures and cost logics do not adequately reward sustainability benefits, limiting the integration of higher-cost but lower-emission solutions. At the landscape level, increasing policy pressure for decarbonisation creates opportunities for redirecting financial flows, yet these signals are not consistently translated into stable investment conditions (Tavasszy et al., 2026). In conclusion, business models capable of aligning value creation and capture across actors, and supported by public-private governance arrangements, are essential to bridge this gap. This highlights that reconfiguring financial mechanisms is a key lever for enabling niche innovations to scale and ultimately transform the urban freight regime.

#### 4.2 Conceptual framework development

Table 1 illustrates how Business Model dimensions connect with the Multi-Level Perspective (MLP) in sustainable urban freight transitions. The preliminary findings show that sustainability transitions in urban freight depend on aligning economic, environmental, and governance dimensions across niche, regime, and landscape levels. Business models play a crucial role by organizing how value is created, measured, and shared among actors and levels. When such alignment occurs, niche innovations like green vehicles adoption, curbside management technologies, and consolidation strategies are more likely to expand and contribute to regime change. Conversely, persistent misalignments, especially in financial viability and incentive structures, often cause innovations to remain at the pilot stage despite strong landscape pressures for change.

Table 1. Alignment of Business Model dimensions across Multi-Level Perspective (MLP) in sustainable urban freight transitions.

	<b>Landscape (Macro)</b>	<b>Regime (Meso)</b>	<b>Niche (Micro)</b>
<i>Economic</i>	Climate policy pressure; weak translation into stable financial incentives	Cost-efficiency dominance; externalities not priced; structural disadvantage for green solutions	Experimental revenue models; public funding; incomplete cost-revenue alignment
<i>Environmental</i>	Decarbonization targets; societal pressure; increasing legitimacy of sustainable urban freight	Environmental value not central to decision-making; cost most important than sustainability	Strong sustainability value propositions; CO <sub>2</sub> reduction pilots; limited KPI standardization
<i>Governance</i>	Policy agendas (climate, urban mobility); cities translating pressure into action	Institutional rigidity; fragmented regulations; established actor networks	Public-private partnerships; pilot coordination; experimental collaboration

#### **Economic**

From a Multi-Level Perspective, the economic dimension reveals misalignments across niche, regime, and landscape levels that hinder the scaling of sustainable last-mile solutions. At the niche level, of green vehicles

adoption, curbside management practices, and consolidation strategies rely on experimental business models with diversified revenue streams, including service fees, subscriptions, and public funding. However, these models often remain unstable due to incomplete cost-revenue mechanisms and dependence on subsidies. At the regime level, dominant urban freight systems are structured around cost-efficient, high-volume delivery models that do not internalize sustainability-related costs, creating structural disadvantages for innovative solutions. This limits their competitiveness and integration into mainstream logistics operations. At the landscape level, increasing pressure from climate policies and sustainability agendas creates a need to reorient financial flows toward low-emission solutions. However, these pressures are not yet consistently translated into market conditions that ensure long-term financial sustainability.

#### ***Environmental***

The environmental dimension highlights how sustainability objectives are articulated and operationalized differently across MLP levels. At the niche level, pilot projects explicitly integrate environmental goals, such as emission reductions, improved air quality, and reduced congestion, into their value propositions, often using low-emission vehicles and consolidation strategies. However, KPI definition and measurement practices remain heterogeneous, and the monetization of environmental benefits is limited. At the regime level, environmental performance is not yet a primary driver of value creation, as existing logistics systems prioritize cost and efficiency over sustainability outcomes. This creates a gap between the environmental value generated by niche innovations and the criteria for adoption within the regime. At the landscape level, broader societal and political pressures, such as decarbonisation targets and public demand for sustainable urban logistics, reinforce the importance of environmental performance. Nevertheless, without robust mechanisms to translate these pressures into economic incentives or regulatory requirements, the environmental advantages of niche solutions remain insufficient to drive widespread regime change.

#### ***Governance***

The governance dimension illustrates how coordination and institutional alignment enable or constrain transition dynamics across levels. At the niche level, pilot projects depend on close collaboration among diverse actors, including municipalities, logistics providers, and technology partners, often organized through experimental governance arrangements such as public–private partnerships. At the regime level, established institutional frameworks, regulatory structures, and actor networks shape the conditions for scaling, often reinforcing existing practices and limiting flexibility for innovation. Misalignment between local regulations, operational practices, and stakeholder incentives can hinder the integration of green vehicles adoption, curbside management technologies, and consolidation strategies into standard logistics operations. At the landscape level, policy agendas related to climate change, urban sustainability, and digitalisation create overarching directionality for transition processes. In conclusion, cities play a crucial intermediary role in translating these landscape pressures into concrete regulatory and planning measures, thereby facilitating alignment between niche experimentation and regime transformation.

## **5 Expected results: Framework validation insights**

The validation of the conceptual framework through semi-structured expert interviews is expected to confirm the relevance of integrating business model dimensions with the Multi-Level Perspective (MLP) for analysing sustainability transitions in urban freight. The findings are anticipated to reinforce the role of business models as critical mediating mechanisms shaping the alignment among niche innovations, regime structures, and landscape pressures. In particular, the interviews are expected to validate that economic, environmental, and governance factors are not independent factors, but interdependent dimensions that jointly determine whether sustainable last-mile solutions can move beyond pilot stages.

From a theoretical perspective, the results are expected to contribute to sustainability transitions literature by extending the MLP framework to more explicitly account for business model dynamics. While traditional MLP applications emphasize technological innovation and institutional change, the validated framework is likely to demonstrate that mechanisms for value creation, capture, and distribution are central to transition processes. This highlights business models as a missing or underdeveloped link in explaining why many niche innovations (i.e., sustainable urban freight pilots) fail to scale despite favourable landscape pressures.

From a practical perspective, the validation is expected to generate actionable insights for industry stakeholders involved in urban freight logistics. The results will likely confirm that successful implementation depends on designing business models that align stakeholder incentives, distribute costs and benefits fairly, and incorporate sustainability impacts into value propositions. Practitioners may highlight the importance of revenue diversification, collaborative business models, and data-driven performance measurement (e.g., emissions and congestion KPIs) as key enablers for scalability. Furthermore, the findings are expected to underline the need for stronger coordination mechanisms among logistics providers, cities, and technology actors to reduce operational uncertainty and support long-term adoption.

From a policy perspective, the validation is expected to emphasize the crucial role of public authorities in enabling sustainability transitions. Interview insights will likely confirm that cities act as intermediaries between landscape pressures and local implementation, translating climate goals into regulatory frameworks, infrastructure provision, and financial support mechanisms. The results are expected to highlight that policy interventions, such as targeted subsidies, access regulations, standardisation efforts, and support for pilot replication, are essential to bridge the gap between experimentation and long-term implementation. Moreover, the framework is likely to demonstrate that effective policy design must go beyond technological support and explicitly address business model viability, including mechanisms to internalize environmental benefits and reduce financial risks for early adopters. Overall, the expected results of the framework validation will help to clarify whether achieving sustainable urban freight transitions requires a systemic alignment of business model innovation with multi-level dynamics.

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