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Tatjana Apanasevic * and Anna Fjällström

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Towards Sustainable Urban Freight: A Collaborative Business Model Framework for Last-Mile Consolidation Centres

Tatjana Apanasevic * and Anna Fjällström

RISE Research Institutes of Sweden, Isafjordsgatan 22, Box 1263, SE-164 29, Kista, Sweden

* Correspondence: tatjana.apanasevicl@ri.se; Tel.: +46 761 08 23 87

Abstract

Urban freight transport is responsible for creating negative transport externalities in the form of noise and congestion and has a significant environmental impact. One solution is to establish a freight consolidation centre, which could offer benefits such as shorter delivery distances, and fewer delivery routes. However, this would require collaboration between actors with conflicting interests and goals. In this study, we propose a collaborative business model framework for freight consolidation centres. This framework was tested through a pilot project in Gothenburg, using the principles of engaged scholarship. Our results show that last-mile consolidation significantly increases efficiency and enables sustainability gains to be achieved. However, a number of structural, economic and organisational barriers need to be addressed in order to realise the full benefit of the collaborative business model. There is a need for a deeper institualisation of new norms, procedures and policies in the business models of the individual actors involved.

Keywords: urban freight; freight consolidation centre; electric vehicles; hybrid electric vehicles; business model; collaborative business model

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1. Introduction

This article builds on a paper presented by the authors at the 38th International Electric Vehicle Symposium, held in Gothenburg on 15-18 June 2025, entitled "Towards a framework for a collaborative business model for a freight consolidation centre" [1].

Today, freight transport has a significant impact on the climate, accounting for 25 per cent of road transport emissions in the EU [2]. While urban freight transport fosters the economic development of a city, it also has a significant impact on the city's environmental goals, climate impact, air quality, road safety; it also generates noise and congestion, which are considered negative transport externalities [3–6]. For example, about 17 per cent of the traffic on the Gothenburg's Event Route (Evenemangsstråket) comprises goods transport, including vans and light trucks, as well as some heavy trucks [7]. In addition to the approximately 27 million kilometres travelled by cars within the zone, freight transport accounts for 5.5 million vehicle kilometres [7].

In order to become climate-neutral cities by 2050, municipalities are adopting ambitious climate goals and developing zero-emission plans. At the same time, municipalities seek to reduce traffic and noise to make urban areas more liveable for citizens. The transition to a climate-neutral, sustainable city requires a shift towards greener vehicles and the implementation of new logistics solutions that would help to mitigate the negative impacts of last-mile urban freight transport. One possible solution is to establish a number of last-mile consolidation and distribution nodes in or near urban neighbourhoods. Using electric vehicles (EVs) is also a prominent way of reducing environmental impact [8].

However, the overall system of urban freight logistics in the last mile is very complicated due to the involvement of multiple actors with conflicting interests and complex operating models. In this context, the deployment of such consolidation and distribution nodes poses a number of challenges. One challenge is the need for coordination and collaboration between logistics service providers (LSPs) and the other actors involved in order to implement and use this service. Despite the obvious benefits of collaboration, which are improved operational planning, reduced running of empty vehicles, increased capacity utilisation, and improved environmental conditions, achieving this can be difficult [5]. Another challenge is related to the need to combine both traditional and electrical vehicles for last-mile delivery, since LSPs managing traditional and electric fleets have different costs and prices [4]. This makes it difficult to develop a commonly accepted business model and can lead to internal competition [4].

Previous research on the freight industry "has only limited experience of collaboration <…> due to a highly competitive market and low revenue streams" [5] (p. 2). Furthermore, the literature focusing on business models used in urban freight transport is scarce, especially with a focus on the challenges posed by sustainability trends and electromobility [6,8]. A different approach to the business model is needed to promote collaboration between the involved actors and achieve sustainability goals, social and economic value [4]. Given these gaps in the literature, this study aims to propose a framework for a collaborative business model applicable to freight consolidation centres. In this study, we address the following research questions:

RQ1) What benefits and challenges does collaboration bring to stakeholders in the freight consolidation centre ecosystem?

RQ2) How can the collaborative component be conceptualised and included in the business canvas?

To answer these research questions, we conceptualise collaborative business models as outcome-based partnerships, in which all parties are mutually invested in the success of the common business model goals [9]. We extend the business model canvas [10] with additional building blocks, such as *Form/Models of collaboration*, *Price model with incentives*, and *Non-monetary benefits and value*. We also incorporate the design principles of vested agreements [9] when discussing all the key components of the business model. The proposed collaborative business model was tested in a pilot project for a freight consolidation centre, following the principles of engaged scholarship. We refine the proposed framework by addressing the need to further translate the benefits and value of collaboration into the business models of the actors involved. The findings presented in this paper are work in progress.

This study bridges the gap in the academic literature on urban freight logistics by proposing a framework for a collaborative business model for last-mile consolidation and distribution nodes. This study also extends academic literature by providing knowledge about the challenges of using a mix of traditional and electric vehicles for last mile delivery. Furthermore, this study contributes by proposing further insights into how the benefits of the collaborative business model can be translated into the tactics of each collaborating organisation. The study provides important guidelines for practitioners developing urban last-mile consolidation and distribution nodes. They can use the proposed collaborative business model framework as a practical tool.

In the next section, we provide a brief overview of the relevant academic literature, followed by a description of the conceptual background and the concept itself and the methodology used. Finally, we then present and discuss our findings and draw conclusions.

2. Related Work

In this section, we provide a brief overview of the literature on freight consolidation centres, collaboration and business models in freight logistics. It can be concluded that academic research in this area is rather scattered and fragmented and requires further investigation.

2.1. Freight Consolidation Centres

The academic literature discusses a Urban Consolidation Centre (UCC), which can be defined as logistics facilities that decouple long-distance and last-mile transport, typically located within urban areas that they serve whether it is a city centre, an entire town, or a specific location, and using vehicles designed for urban transport [8,9,11,12]. UCCs can be operated by one or multiple companies and facilitate the collection of goods from multiple shippers, their transshipment, and consolidation for last-mile delivery to goods receivers [12,13]. To achieve this, LSPs can split their supply chains into multiple tiers. This requires significant effort to synchronise goods and establish the necessary transportation infrastructure. For the purposes of this research, we use terms "freight consolidation centre" and "consolidation centre" interchangeably.

Benefits include a reduced environmental footprint through the use of greener electric vehicles for last-mile delivery [3,14,15]. Other benefits include fewer freight vehicles, less congestion and noise, and an improved quality of urban life [3,14]. Businesses receiving freight can benefit from fewer deliveries [16]. Logistics operators can benefit from reduced vehicle-kilometres and trips across the city, less time spent on congested roads or waiting at loading docks, the use of UCCs for storage and transhipment, shorter distances travelled, and less driving of empty vehicles [3,5,14,16].

However, UCCs may face challenges such as conflicting interests among the parties involved, unsustainable operations, low profitability, regulatory obstacles and difficulties in achieving economies of scale [3,14]. Furthermore, many city logistics initiatives focused primarily on the technical, environmental and operational feasibility, rather than business aspects [17].

2.2. Collaboration in Freight Logistics

The question of collaboration in transportation has been at the forefront of researchers' attention for a few decades. The importance of collaboration has gained substantial attention due to the increasing pressure on LSPs in the form of high levels of competition within the industry, inefficient load capacity usage and travel times due to road congestion, low margins, and a need to reduce the environmental impact and CO_2 emissions [5,18–20]. To meet these challenges and increase operational efficiency, a collaborative approach is needed in which all parties work towards the same objective, achieving better operational results and optimising objectives for everyone involved rather than focusing solely on individual benefits [20]. Literature on Collaborative Transportation Management (CTM) aims to address inefficiencies of the transportation planning and execution process through mathematical simulations of different models of collaboration [18,21].

Researchers [5,12,18] have identified three types of collaboration that are specific to the transport sector:

- Horizontal collaboration: this implies collaboration between two and more competing organisations at the same level of the logistics network and sharing information or resources. For example, this could involve synchronising operations to minimise the overall number of vehicles needed for urban transportation.
- Vertical collaboration involves "collaboration between two or more organisations acting at different levels of the logistics chain, such as a receiver, a shipper, and a carrier" [5] (p. 4). These actors share the responsibilities, resources and data. In this form of collaboration, LSPs can decompose transportation routes into multiple tiers, enabling each parter to serve one or more dedicated tiers.
- Lateral collaboration enables greater variation in combination and sharing of responsibility, resources and data both vertically and horizontally.

The coordinating structure for collaboration can be centralised, in which case decisions are made at a higher level and then synchronised at lower levels, or decentralised, in which case collaboration is based on consensus, agreement of objectives, indicators, and equality rules between partners [5]. Vargas et al. [5] summarise the following strategies or forms of collaboration in freight distribution:

1. Route scheduling/planning, which aims to optimise routes.
2. Backhauling, which aims to reduce empty running on return journey after a delivery.
3. Freight exchange, which involves matching freight demand and capacity.
4. Consolidation centres, which allow transport carriers to sort and consolidate goods, achieving high load volumes, and deliver them to the final destination using cleaner electrical vehicles.

5. Delivery and servicing plans aim to reduce the number of trips required when one organisation acts as the lead supplier for multiple organisations, thereby reducing the number of trips required to serve these premises or area.
6. Joint optimisation of vehicles and deports involves two or more fleets sharing a large proportion of their joint resources in order to optimise their service.

Vargas et al. [5] highlight the importance of collaboration and coordination within the freight industry to improve operational planning and reduce operational expenditure, empty running vehicles, and environmental impact, while increasing capacity utilisation. However, a neutral third party is needed to facilitate this collaboration. Nevertheless, due to high competition and low margins, the experience of collaboration in the industry is limited [5].

The role of actor collaboration is extensively discussed in the literature [3,5,14,22]. Xu et al. [23] use a platform economy approach to redefine partnerships in collaborative logistic networks, focusing on achieving win-win situations, enhanced efficiency, and lower costs. de Bok et al. [15] explore the implementation of a UCC and identify a key barrier: the unwillingness of involved participants (carriers, receivers and local authorities) to meet the financial costs of the UCC in return for the benefits that they receive. The research demonstrates that the largest reduction in vehicle kilometres can be achieved in scenarios involving full collaboration between the LSPs. Other identified barriers to collaboration include the need for significant collaboration to achieve data and assets sharing, businesses' reluctance to share data about their operations, legal barriers such as competition law, a lack of trust and common goals, and a lack of a fair rewording mechanism for collaboration [5]. Other barriers include load compatibility, which can restrict the ability to share loads, and unclear responsibilities for transport [5].

Sustainable solutions involve the integration of traditional and green transportation modes to address inefficiencies in the last-mile delivery, which is an important research gap [4]. Perboli and Rosano [4] highlight the potential for potential price wars and the need for strategic collaboration to maintain service quality and efficiency in the coexistence between traditional vehicles and green alternatives such as electric vehicles, bikes and cargo bikes. Macário et al. [24] observe that logistics operators have no incentive to engage with sustainable solutions, because the costs they are responsible for are partly supported by the whole society, as externalities. The researchers suggest that public regulation could incentivise sustainable logistics.

2.2. Business Models in Freight Logistics

It needs to be mentioned that academic research on urban freight transport, collaboration, and the business models used is rather limited, particularly due to the challenges posed by sustainability trends and electromobility [5,6,8]. A literature review reveals a gap in understanding of how traditional models can adapt to these challenges, emphasising the need for research to focus on sustainable and smart urban logistics solutions.

A number of researchers have analysed various aspects of business models for urban freight transport. Particular attention has been given to a comprehensive analyses of cost structures and revenue streams [25,26]. Additionally, Björklund and Gustafsson [14] identify critical factors for viable business models in UCCs, such as scalability, continuous development, and innovative service offerings.

Vargas et al. [5] propose a framework for a freight collaborative business model, emphasising the importance of operational coordination and revenue sharing to improve efficiency and reduce environmental impact. Vargas et al. [22] further elaborate on a gain-sharing model for collaborating logistics operators in terms of operations, economics and benefits.

Another critical research area is the financial viability of last-mile urban logistics. Adaptable business models and the critical mass are necessary for long-term sustainability [14,27]. Strategies for economic sustainability include value-added services and alternative revenue streams. These strategies include joint freight strategies, cost-efficient solutions, and value-based services, such as selling storage space and warehousing, as well as reverse logistics or backhauling [3,16].

The use of electric vehicles in the logistics domain sets additional challenges. The high upfront cost, lack of charging infrastructure, and instability of electricity prices make their use less attractive [8].

3. Conceptual Background

In this section, we provide an overview of the theoretical background. Specifically, we discuss the concepts of business models, collaboration, and sustainable business models, as well as collaborative outsourcing. This is followed by our proposal for a framework for collaborative business models.

3.1. The Business Model Concept: An Overview

The concept of a business model first emerged during the e-commerce and internet-based service boom [28–30]. A business model concept is usually used to articulate how an organisation creates, delivers, and captures value from a product, service, or technology [29,31–33].

Although widely used, the concept remains ambiguous and complex in its nature as it is strongly related to business strategy, innovation management, and supply chain [34]. This is reflected in the ways how business model was conceptualised by different authors. For example, a business model can be described as: (i) a mediating device between technology and economic value [31]; (ii) a narrative that explains how an enterprise operates [32]; (iii) the logic of a firm, the way it operates and how it creates value and delivers it to customers [33,35]; (iv) a conceptual tool [36]; or (v) a detailed conceptualisation of a enterprise's strategy [37]. However, the core emphasis remains on value creation and capture monetary value using certain resources and capabilities [28,30–32,36,38].

It needs to be noted that, while cross-organisational collaboration with key partners is a key component of the business model, the concept has predominantly been focused on the logics of a single firm [30]. Zott and Amitt [39] argue that a business model is a combination of interdependent activities that extend beyond boundaries of the focal firm and embed it in its environment; moreover, Zott et al. [40] highlight the importance of value creation in networks.

3.2. Collaboration and Collaborative Business Model

Collaboration is a complex process involving a number of steps. Glasbergen [41] has analysed the literature on collaboration and synthesised a concept of the Ladder of Partnership Activity (see Table 1). This concept shows how collaboration evolves over time, beginning with the establishment of trust and building collaborative advantage through the development of shared visions and goals. The ladder further presupposes that each successive step requires a higher degree of interdependence—in terms of resources, decision-making capacity and risk-sharing—between public, private, and civil actors. The concept also suggests that greater joint investment in assets leads to greater interdependence among the actors.

Table 1. The Ladder of Partnership Activity (based on [41]).

Level	Description
Level 1.	**Building trust**. Trust is built over time. The process must be managed by a set of rules ensuring security, equity and fairness, and it must be supported by positive experience.
Level 2	**Exploring collaborative advantage.** Each of the parties can connect its own interests with common goals, a shared vision, and clear mandates.
Level 3	**Constituting a rule system.** Structures, roles, and rules are established, agreements are written to regulate responsibilities; and a neutral coordinator is appointed.
Level 4	**Changing a market.** Joint decisions are translated into action, results are measured, and the parties learn from the process. A follow-up plan is developed and data is shared openly for continuous improvement.

Level 5	**Changing the political order.** A partnership is established as part of governance, creating new regulations, policies, and norms, and securing long-term financing.

Currently emerging social and environmental challenges, such as climate change, environmental degradation, rapid digitalisation, and other disruptions transform and change all levels of society and business activities and call for systemic sustainable solutions [34,42,43]. These solutions cannot be provided by an individual actor and require cross-sector collaboration where value is created and captured in collaboration with external stakeholders. This is a reason why the concept of collaborative business model attracts more attention in the recent academic research.

There is a notable research stream elaborating collaboration aspects within the concept of "sustainable business models" or "business models for sustainability" [42–46]. These types of business models focus on the transformation and reorganisation of value chains by addressing how to enable circular resource flows and, by doing so, reduce the negative impacts for environment and society [44]. In this way, sustainable business models move beyond the creation of economic and customer value. They represent a paradigm shift from traditional business models driven solely by economic and financial value creation towards models that also create non-monetary social and environmental value [43,44,47].

Another solid stream of research is focused on alliances and inter-organisational collaboration [9,48,49]. For example, de Man and Luvison [48] synthesise the literature on alliances and identify three types of collaborative business model. Depending on how they approach value creation, capture, and delivery, these collaborative business models can focus on sharing, specialisation, or allocation. Operationalisation of each business model type requires a specific approach to managing incentives, building relationships, accountability, the role of top-level management and reporting. Kringelum and Fredriksen [34] examine the establishment of collaborative business models as a process of negotiation, commitment and execution steps, identifying three key considerations: the scope of collaboration and alignment between value creation and capture; the level of organisation required for coordination and cooperation; and the contextual environment of the collaboration including roles and prevailing norms.

The involvement of multiple stakeholders in collaborative business models increases complexity and requires careful consideration of the diverse, and sometimes conflicting, goals of the participating actors [42].

Cross-sector collaboration is affected by multiple factors, including the form of collaboration, its evolution over time, and the impact of a wide range of individual, organisational, and contextual factors [42,50,51]. Moreover, organisations often face significant challenges when aligning their internal procedures and day-to-day practices with the articulated partnership aspirations [42].

3.3. The Concept of Collaborative Outsourcing

From an implementation-oriented standpoint, the collaborative outsourcing framework proposed by Vitasek et al.'s [9] reflects the critical success factors of successful collaboration. We therefore adapt and incorporate its core principles into our proposed collaborative business model framework, which is why we present it in more details below.

The framework for collaborative outsourcing – also referred as *vested outsourcing* – is conceptualised as "a systematic, collaborative outsourcing relationship in which companies and service providers become "vested," or mutually committed to each other's success, creating a long-term win-win relationship based on achieving mutual determined goals" [9] (p. 6). Instead of prescribing detailed transactions, vested agreements articulate a limited set of shared, measurable outcomes and then grant the service provider the autonomy to determine *how* those outcomes are achieved [9].

The five interlocking design principles that underpin vested outsourcing are as follows:

1. *Focus on outcomes rather than transactions.* Traditional transaction-based agreements prioritise risk aversion, liability-limitations, and the lowest possible cost. In contrast, the *Vested model*

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encourages continuous improvement and innovation by rewarding actual outcomes, such as improved customer service, efficiency gains, and reduced CO_2 emissions [9]. This implies mapping and documenting an outsourcing business model and the development of a shared vision that will guide actors during their collaboration.

2. Governing the *what* instead of the *how*. A Statement of Objectives (SOO), which describes intended results, not tasks, replaces traditional prescriptive contracts [9]. This approach gives suppliers the freedom to optimise their processes and technologies, and encourages continuous innovation, development and improvements. Collaborative SOOs enable business model actors to pursue objectives that are more complex than those in traditional models. Furthermore, business actors gain the ability to adapt and reconfigure resources to secure a sustainable competitive advantage and innovate to achieve new competitive positions.
3. *Setting clear and measurable joint goals*. A limited number of high-level Key Performance Indicators (KPIs), directly aligned with the shared vision, are monitored through an integrated performance management system. Using formative KPIs instead of quantitative ones allows the business model actors to adapt to changes over time.
4. *Designing a pricing and incentive model that balances cost and service*. This model combines a baseline fee (e.g., per transaction) with outcome-based incentives (known as "gain-share"), ensuring mutual benefits from efficiency gains and revenue growth [9]. This approach is labelled "*What's in it for We*." The *pricing* principle requires that the incentive model, cost, value and service are balanced fairly or equally. If these factors are unclear, it will be difficult to forecast the expected business model results.
5. *Steering through insight rather than oversight*. A flexible governance architecture encompasses *relationship governance* (shared policies, culture and behavioural norms), *transformation governance* (continuous improvement and innovation), *exit and entry governance* (a pre-emptive plan for potential disengagement and engagement), and compliance with regulatory or market-specific requirements [9].

It needs to be mentioned that establishing governance mechanisms among collaborating actors representing different sectors or industries is essential for the long-term success of both the business model and the collaboration, as emphasised by Zott and Amitt [39] and subsequent research [34,41].

3.4. Proposal of a Framework for a Collaborative Business Model

The business model canvas [36] is the most popular tool used for developing a business model. It consists of nine building blocks: key partners, key activities, key resources, value proposition, customer relationships, channels, customer segments, cost structure and revenue streams.

For our proposed framework for a collaborative business model, we extend the original nine blocks of the canvas to include a few additional elements.

Following the framework of a freight collaborative business model [5], we added a block called ***Forms/Model of collaboration***. Taking the example of freight industry, this block covers aspects such as the forms of physical collaboration (e.g., horizontal, vertical or lateral) and collaboration strategies (e.g., backhauling, freight exchanges, consolidation centres, and joint optimisation) (see Figure 1).

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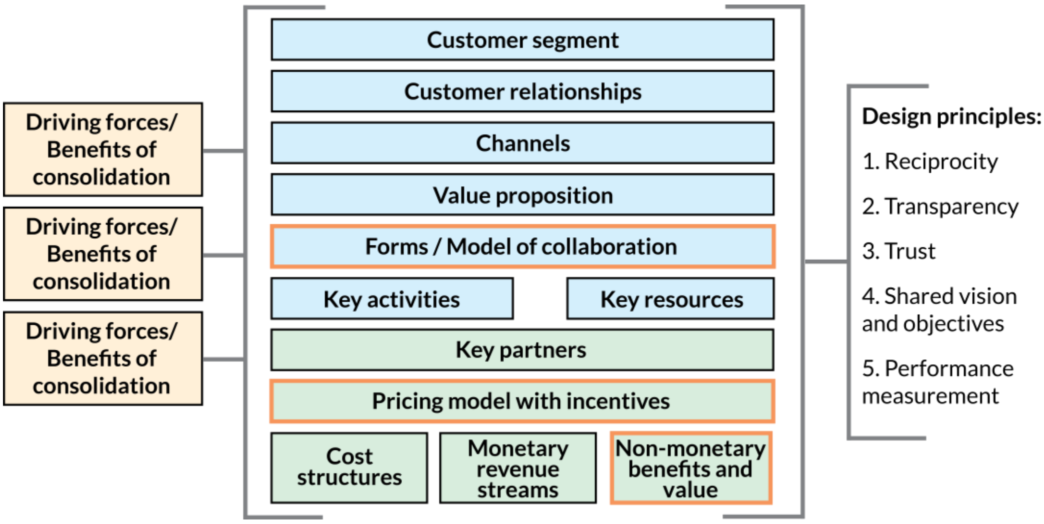

Figure 1. Conceptual framework of a collaborative business model.

One of the key elements of a collaborative model is the ***Price model with incentives***. It refers to the fourth principle of vested agreement [9] and involves setting a pricing and incentives model that gives a fair and balanced cost and gain distribution among involved stakeholders. Development of structures that both share risks, cost and value should encourage the right behaviours in order to develop, change and promote the ability of the parties to innovate, create new values and change together. This contributes to encourage actors to exceed expectations and continuously contribute to the common goals and objectives of the collaborative business model.

Building on the literature focused on the sustainable business models, we divide the original building block Revenue Streams in two elements:

- ***Monetary revenue streams*** which are related to earnings from a service activities [10]. Taking the example of a freight consolidation centre, monetary revenue streams are driven from this centre's business activities and increased efficiency (saved time, shorter distances travelled, and reduced empty vehicles trip) [3,5,14,16].
- ***Non-monetary benefits and value*** are related to societal and environmental social benefits [43,44,47]. When applied to a freight consolidation centre, the examples of such non-monetary benefits and value are reduced environmental footprint, reduced noise, and reduced congestion [3,14].

Building on the framework for collaborative outsourcing [9] and literature on collaboration, we propose the following ***design principles*** or ***success factors*** for collaboration. They should be considered when discussing the key components of the collaborative business model:

1. **Reciprocity:** Reciprocity lies at the heart of collaboration [48,49]. Business relationships should be built on a foundation of mutual benefit, ensuring that all involved parties benefit from the relationship and considering each party's unique circumstances [5,9]. However, this does not mean that the benefits should be shared equally; rather, each party should receive fair reward for investing in the relationship [5,9,20,41]. Additionally, these rewards do not necessarily need to be monetary; they may take the form of non-monetary benefits and value and have a long-term orientation, rather than a short-term one [20]. This creates a strong incentive for involved parties to continuously improve and optimise collaboration towards shared goals.
2. **Transparency:** Transparency is crucial in collaborative contracts. By sharing information, data, and processes openly [46], parties can establish a stronger foundation of trust and understanding, which is necessary to manage uncertainties and create joint strategies to overcome challenges.
3. **Trust:** Trust is a basic prerequisite [41,49]. Trust is not given automatically but built over time through consistent and reliable behavior from parties involved [41]. Established pricing fairness,

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transparency and considering circumstances of each actor involved ultimately contributes to building trust [5,9]. Building and maintaining a high level of trust is a pre-requisite for effective collaboration and innovation in the collaborative business model framework.

4. **Shared vision and objectives:** The parties should collaborate to establish and agree on shared long-term goals and visions [5,9,41]. This will ensure that all efforts are focused on achieving these goals, and that the parties are working together on complex objectives.
5. **Performance measurement:** Formative and quantitative performance metrics (KPIs) are important to objectively assess the success of the collaboration. These metrics must be designed to encourage the right behaviours and support common goals [5,9].

4. Materials and Methods

4.1. Methodology

The findings presented in this article are a work in progress resulting from a qualitative approach based on the principles of engaged scholarship [52], spanning a period of approximately two years. Engaged scholarship is defined as "a participative form of research for obtaining the different perspectives of key stakeholders (researchers, users, clients, sponsors, and practitioners) in studying complex problems" [52] (p. 9). There are four different ways in which engaged scholarship can be applied. For the purposes of this research, we have chosen collaborative research, which enables the co-production and co-creation of knowledge.

To obtain the perspectives of the key stakeholders involved in a freight consolidation centre, we collaborated with two logistics operators, two goods receivers, a municipality, and a science park representing a neutral platform for collaboration and innovation in transport and logistics. Data was generated through:

1. A series of three-hour workshops, during which different aspects and success factors of the collaborative business model were discussed. These workshops were held on a monthly basis between April 2024 and January 2025.
2. An individual semi-structured interview with a science park representative involved in negotiating a pilot project agreement for a freight consolidation centre. The interview questions were related to the details of the pilot contract agreements and conditions.
3. Shorter, biweekly online project meetings to discuss progress and results.
4. Project progress information shared at quarterly project consortium meetings.
5. Project partner interviews to understand strategic and tactic objectives.

The authors have synthesised the knowledge gained through the engaged scholarship to develop and test the concept of a collaborative business model for a freight consolidation centre.

4.2. Data Analysis

To conceptualise a collaborative business model, we mapped the key actors in the freight consolidation centre ecosystem, their roles and the relationships between them. During the workshops, we collected insights from the key actors regarding their current business models, existing services, value propositions, pricing models, existing partners as well as other requirements connected to the freight and transportation domain.

We also held dedicated workshops to discuss our conceptualised design principles for the collaborative business model (i.e. reciprocity, transparency, trust, shared vision and objectives, and performance measurement) with the key actors. These insights were analysed and summarised to contribute to the development of the collaborative business model framework. Furthermore, we summarised the results from the pilot project. Our findings are presented in the Section 4.

4.3. Description of the Project's Test Pilot

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The aim of the REDIG project is to create a system demonstration for the ecosystem required for a fossil-free, open and scalable logistics system for a freight consolidation centre serving the Event Route (Evenemangsstråket). This district of Gothenburg has a high concentration of event venues, museums, exhibition centres, and arenas. Due to new construction and an increase in business tenants, the number of businesses in the area is expected to increase in the future. This will lead to consequences, such as increased transport and freight needs, congestion, CO_2 emissions, and noise.

To test such a logistics solution, the project implemented a small-scale pilot of a freight consolidation centre using fossil-free last-mile transport with a start in April 2025 with an expected duration of one year. The core collaborative strategy of the centre is to optimise logistics processes through freight consolidation, while also seeking to reduce the number of truck deliveries by 30 per cent. The pilot provides an opportunity to share insights and experiences that could be used to improve and scale up logistics in the future. Particular interest lies in understanding how different stakeholders should collaborate around a freight consolidation centre, the benefits that can be achieved, and how these can be strengthened and extended to include more actors.

The business network around the freight consolidation centre pilot includes the following actors (see Figure 2):

1. ***Shippers / Suppliers of goods***: The pilot started with five to six suppliers of goods that are representing the business-to-business (B2B) and intra-business segments, who send goods to their customers.
2. Two logistics operators:

Logistics Operator A manages an electric fleet and is responsible for transporting different types of goods. However, the electric vehicle fleet required a significant investment, resulting in higher operating costs and service prices compared to a traditional fleet operator (in our case, Logistic Operator B).

Logistics Operator B is a traditional fleet manager. This actor generally provides transport and logistics services and can transport all goods except food.

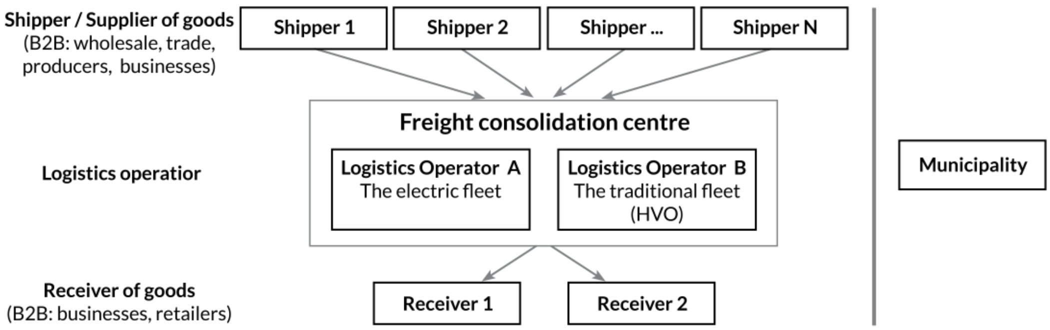

Figure 2. Business network of freight consolidation centre in REDIG pilot.

3. The two receivers of goods are large Event Route actors representing the B2B and intra-business segments. These actors are located very close to each other geographically.

Receiver 1 is an event organisation that runs a variety of activities, including entertainment, hotels, and restaurants. At certain times of the year, this actor runs entertainment activities daily and requires a large supply of seasonal goods. At other times, the organisation is closed. It is a municipality-owned organisation.

Receiver 2 is also an event organisation that runs many different activities, including entertainment, hotels, theatres, restaurants, exhibition and meeting facilities. This organisation requires the delivery of large quantities of event supplies/goods, but not on a daily basis. This receiver has no storage space for goods.

4. ***The Municipality of the City of Gothenburg*** is an important actor in this ecosystem. Its seeks to achieve zero environmental emissions and to make the city more attractive for its citizens. This

actor is responsible for setting regulations and requirements for transport and logistics services in different parts of the city.

Initially, the idea behind the pilot was that both logistics operators would be involved in the freight consolidation centre. Goods were to be delivered at night, during off-peak times. This collaboration was seen as essential for operating the consolidation centre, enabling it to be further scaled up and opened to other logistics operators.

As discussed during the initial stage of the project, the expected **benefits** of the freight consolidation centre are as follows:

- Potential to reduce transport costs over time by consolidating transport, optimising logistics processes, and organising logistics flows more efficiently, leading to time savings, an increased load factor of vehicles, and greater LSPs efficiency.
- Improved routines are needed for collaboration and optimised logistics processes.
- The environmental impact in terms of both CO_2 emissions, congestion, and noise can be reduced by using more sustainable electric vehicles and reducing the number of routes.
- The initial costs can be high, considering the investments required for electric vehicles.
- Consolidated CO_2 emissions reports were discussed as an added-value service for receiving companies.
- By centralising deliveries at a freight consolidation centre, more space can be freed up at receiving companies, which is particularly valuable for businesses that need the space for other purposes.

5. Results

The pilot is scheduled to take place between April 2025 and April 2026. Here, we present the interim results from the first six months of the pilot. The implemented services include terminal service, consolidation, and last-mile delivery. Additional services include handling returns (e.g., empty pallets) and short-term storage, enabling receivers to obtain better prices for large volumes of goods.

During this period, the number of suppliers shipping their goods through the consolidation centre increased from five or six to 60, with three of these providing most goods. Deliveries from the consolidation centre to the receivers were scheduled for two days a week during off-peak hours (unmanned night deliveries), and this is approaching a third day. During this time, a total of 576 deliveries were made to the consolidation centre and 68 last-mile deliveries from the consolidation centre to the receivers. This meant that the incoming flow of goods was consolidated by 88 per cent, saving 508 delivery trips. This made the receivers' internal logistics more efficient. The ongoing work is focused on identifying additional receivers located in close proximity to the existing ones.

However, **certain challenges** have arose during the negotiation process for the temporary pilot agreement, as well as during the pilot period.

Protective behaviour. A significant challenge was obtaining permission to consolidate transport with one of the largest wholesale shippers of goods. Discussions with this actor took time, and they eventually decided not to participate in the consolidation. This delayed the negotiation process and resulted in a significant change to the pilot, as this wholesale shipper was a large supplier that had initially been planned to participate in the pilot.

Competition. An unexpected competitive situation arose when the same wholesale shipper of goods showed interest in taking on the function of a freight consolidation centre, which challenged the existing distribution of role where Logistics Operator A and Logistics Operator B were intended to act as the main centres.

Increase in service price due to electric vehicles. There were some economic challenges, particularly with regards to the use of electric vehicles as part of the pilot. Logistics Operator A advocated the use of an electric vehicle to increase the environmental benefits. However, the cost of the transport service was higher than what Receiver 1 and Receiver 2 were initially willing to pay.

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Their financial situation, including ongoing restructuring and cost constraints, influenced their decision.

Directing deliveries to the consolidation centre. Due to hygiene requirements, Logistics Operator B could not handle food. This is why the facilities of Logistics Operator A were used as the consolidation centre for the pilot. This resulted in the practical challenge of ensuring that all deliveries were routed to the address of this freight consolidation centre. However, sometimes deliveries were shipped directly to the receivers or were shipped to the consolidation centre too late to be delivered to the receivers in time. This challenge is related to lock-in in the existing business relationships. Extensive dissemination of information and coordination with all parties was required to avoid misunderstandings and delays.

A lack of integration between the IT systems. A lack of integration between the IT systems of the receivers and Logistics Operator A is causing issues. The logistics operator does not know which goods will be shipped, when they will be shipped, or who has ordered them. Parcels are often received without order numbers or labels because the necessary information gets lost in IT systems along the value chain. Management of the goods flow is handled manually via chat with the receivers, which is time consuming and increases the operator's workload and costs.

Unknown goods delivery time for businesses. There is uncertainty about goods delivery time, when the supplier reports that the good have been sent and delivered, but not received by the organisation. Due to uncertainty about delivery times, some businesses started ordering goods well in advance or asked if they could order them directly. It is also difficult to handle last minute orders, because there might not be place for them in the delivery truck.

Low volumes / low load factor. After a half a year of the running pilot, volumes of goods remained an issue despite significantly increased number of shippers, with two delivery days.

Pricing. Pricing is based on the number of pallets used by each receiver. In this case, everyone benefits from everyone's volumes. However, the pilot receivers are too different in terms of volumes and size of packages that this pricing model penalises the receiver generating more goods volumes. An additional price increase arises if a receiver generates more driving hours than goods volumes. Furthermore, participating in the pilot incurs an additional cost for both receivers because the shipping price is already included in the goods' prices under their existing delivery agreements.

Sourcing and procurement process. Receiver 1 is a municipal corporation where only a part of the sourcing and procurement is administrated by the corporation itself whereof the major part of the sourcing and procurement is handled by the municipality. This leads to two challenges in adopting to a new sourcing and procurement process. First, the length of the contract is normally four to eight years and secondly, Receiver 1 has to convince another organisation to make changes in current and new contracts.

Adjustment to new routines. For the pilot to work effectively, all actors involved had to adapt and adjust their existing routines, which proved challenging in practice. Sometimes it was a pallet consisting of mixed packages; sometimes packages were sorted incorrectly and could be delivered to a wrong receiver; if it was a week with a holiday, there were deviations in delivery times. All this led to uncertainty and complains. Proper procedures are required to solve these issues and create trust.

Management of a consolidation centre outside the pilot in long-term perspective. When discussing the future development of the pilot, the project stakeholders considered various alternatives for the management and operation of a consolidation centre. It could be managed by one or a few collaborating logistics operators or by receivers. However, the need to disclose sensitive operational data was seen as an obstacle. The parties agreed that introducing an independent third party would be the optimal solution.

Summarising, the interim results demonstrate that a freight consolidation centre can significantly reduce the number of delivery trips and improve logistics efficiency, demonstrating clear environmental and operational benefits. However, the pilot also revealed major challenges, including pricing imbalances, low goods volumes, the need for IT integration and proper freight handling processes, and issues linked to existing contracts and routines. These findings highlight the

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high potential of consolidation, but emphasise that its long-term success depends on improved coordination, fair pricing and cost-sharing mechanisms, and an appropriate governance structure.

6. Discussion and Conclusions

Opportunities and challenges related to the collaboration of stakeholders around the freight consolidation centre and conceptualisation of the collaborative component in the business model were investigated in this research. Analysis of the results highlights the significant efficiency and sustainability gains enabled by coordinated last-mile consolidation, as well as the structural, economic and organisational barriers that complicate implementation. This is discussed below.

6.1. Benefits and Challenges of Collaboration in the Context of a Freight Consolidation Centre

The core function of freight consolidation centres is collaboration needed to consolidate freight from local shippers and good suppliers and distribute it within a specific area of a city. This research is based on the experience gained during the project pilot of a freight consolidation centre, implemented within the REDIG project in the City of Gothenburg. We have explored the benefits and challenges that collaboration around such a freight consolidation centre brings to its stakeholders (addressing our RQ1).

Two logistics operators participated in the project: one managing a traditional fleet, and the other managing an electric fleet. The expected benefits of collaboration for both operators were time savings, increased efficiency, shorter distances travelled, and an increased load factor of vehicles. The pilot results showed the potential to significantly increase efficiency and decrease the number of last-mile delivery routes (in this case by 88 per cent) when delivering from the consolidation centre to receivers. The logistic operators save time by delivering goods twice a week. Deliveries are made during off-peak hours, meaning that the drivers do not waste time in traffic or waiting for their turn at receivers' loading docks. This is in line with the findings of previous research [3,5,16].

The reduction in last-mile deliveries from the consolidation centre coupled with fewer off-peak goods deliveries and a use of more sustainable vehicles, addresses a number of social and non-monetary effects. These include reduced CO_2 emissions, noise, and congestion, as well as increased attractivity of the city, which support previous research [3,15]. Reflecting these non-monetary social and environmental value in the business model connects our concept to sustainable business models [43,44,47]. The last-mile delivery industry is highly competitive and generates low margins. Some researchers [24] have noticed that LSPs have low incentives to engage with sustainable solutions. However, one way to encourage them to do so might be finding a way to reflect non-monetary social and environmental value in organisational reports. Another way is for the municipality to use policy and regulation as an instrument.

Due to the optimisation of delivery routes, the urban freight receivers experienced fewer deliveries, which resulted in improved internal logistics. This was perceived as a benefit, which is consistent with previous research [16].

Several researchers have emphasised the importance of added-value services for the sustainability of consolidation centres [3,16]. The pilot provided added-value services, such as warehousing and reverse logistics for empty pallets, solving the storage space issue experienced by the receivers. Furthermore, the manager of the freight consolidation centre has a potential to generate a consolidated yearly CO_2 emissions report based on the number of deliveries and routes, saving the receivers time and money.

We have also identified some challenges related to collaboration within the context of a freight consolidation centre. The REDIG project focuses entirely on questions of collaboration. However, we observed competition between stakeholders during the pilot.

Combining and mixing the services of traditional and electric fleets proved to be very challenging, as the operational costs and prices of the electric fleet operators are much higher, than those of traditional fleet operators. There was a hesitation of logistic operators about considering their interests in a fair way, which challenged collaborative efforts. Therefore, including electric vehicles

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alongside traditional vehicles when developing a business model for a freight consolidation centre therefore presents new challenges for collaboration. This confirms and further elaborates findings of the previous research [4,8].

Achieving a critical mass is necessary for the long-term suitability of a consolidation centre [14,27]. This is evident in the pilot. Due to the small scale of the pilot, load factor and low goods volumes remain a problem.

In addition, it was challenging for participants of the pilot to adapt existing work routines and processes for the context of a consolidation centre, which confirms findings of research focused on sustainable business models [42]. This is an even greater challenge for municipal organisations, whose activities are more strictly regulated by the public procurement and long-term contracts. These actors are locked into their existing agreements, contracts and business models, which can be difficult to change due to certain industry operating traditions, industry culture, conflicting interests, and different perceptions of processes. This way, our research highlights the additional challenge that arise from public-private collaboration around a consolidation centre.

The pilot demonstrated the importance of integrating the IT systems of receivers and logistics operators, as well as establishing proper procedures for handling goods orders throughout the entire value chain. Otherwise, additional manual work outside IT-systems is required, which increases costs and delivery uncertainties.

Summarising our findings from the pilot, the identified **driving forces and benefits of consolidation** are optimisation of the flow of goods, saving time, reducing empty running, and increasing the load factor of the vehicles, which is in line with previous research [3,5,14,16]. The description of business model building blocks is summarised in Table 2. In the table, we also make a proposal for a possible solution for the future consolidation centre, additionally marked "*For a future service*".

Table 2. A collaborative business model for a freight consolidation centre.

Business model building block	Description
Value Proposition	**For LSPs:** Optimisation of the flow of goods, saving time, reducing empty running, and increasing the load factor of the vehicles. Fair distribution of revenue streams and costs.
	For receivers: Improved efficiency of receivers' internal logistics due to fewer deliveries. Reversed logistics of empty pallets. Warehousing: offering storage space to receivers. Generation of a yearly CO_2 emissions report.
	For city and municipality: More attractive city, less congestion, noise, and CO_2 emissions.
Customer Segment	B2B sector: large and small goods receivers including businesses, hotels, retailers.
Customer Relationship	Close relationship between collaborating actors to provide an optimum service. **For a future service**: Managed by an independent third party.
Channels	Integrated IT systems or an integrated common digital platform, mobile app, webpage.
Key Partners	**For the pilot**: Logistics operators sharing resources and consolidating freight. Suppliers of goods. Municipality regulating, supporting and planning traffic in the city.
	For a future service: An independent third party managing the consolidation centre and ensuring long-term sustainable collaboration between different partners.
Key Activities	Terminal consolidating freight from different goods suppliers for last-mile delivery.

	Delivering goods in off-peak time (unmanned night deliveries). Short-term storage service for receivers. Collecting empty pallets for reversed logistics.
Key Resources	Logistics terminal, traditional and electric fleets, personnel. Digital platform or integrated IT systems of receivers and LSPs.
Forms / Model of collaboration	Vertical lateral collaboration between operators and receivers for the pilot, which could take any form after the pilot is over. Collaboration strategy: Consolidation centre, route planning, joint optimisation of routes, backhauling.
Pricing model with incentives	**For the pilot**: Pricing is based on the number of pallets used by each receiver.
	For a future service: Pricing should be based on the share of contribution to monetary and non-monetary value as well as share of costs.
Cost structures	Fixed costs: facilities, infrastructure, fleet (vehicles, trucks), IT-systems. Operational costs: administration, personnel, transport running costs (fuel, electricity, maintenance, repair, fees, insurance), facility running costs (utilities, maintenance), package handling reverse logistics.
Monetary revenue streams	Service price. Short-term storage service. Yearly CO_2 emissions report. Reversed logistics (including more options, e.g., empty aluminium cans and PET bottles).
Non-monetary benefits and value	More attractive city, less congestion, noise, and CO_2 emissions. Indirect benefits for receivers: more efficient internal logistics, more free space.

6.2. Proposal for Further Development of the Framework of a Collaborative Business Model for a Freight Consolidation Centre

We have conceptualised a collaborative business model and incorporated a collaboration component into the business canvas in the form of design principles or success factors (addressing our RQ2). However, based on our findings, the challenges observed and lessons learnt, we can see that the process of establishing partnership and building mutual trust requires time.

We also conclude that in order for collaboration to reach a higher level in the context of a freight consolidation centre, an organisational change is needed. Based on Glasbergen [41], this implies a need for deeper institutionalisation of new norms, procedures, policies and even regulations between collaborating actors in both the overarching collaborative and individual business models. This process involves increasing the interdependence of resources, decision making, and risk sharing between public, private and civil society actors.

This means that the proposed framework needs to be further elaborated (see Figure 3). The collaborative business model for a freight consolidation centre can be seen as an umbrella business model for a diverse constellation of actors collaborating to provide and receive services. At the same time, all the partners involved have their own business models, diverse and sometimes conflicting interests, different industry operation traditions, norms, and routines.

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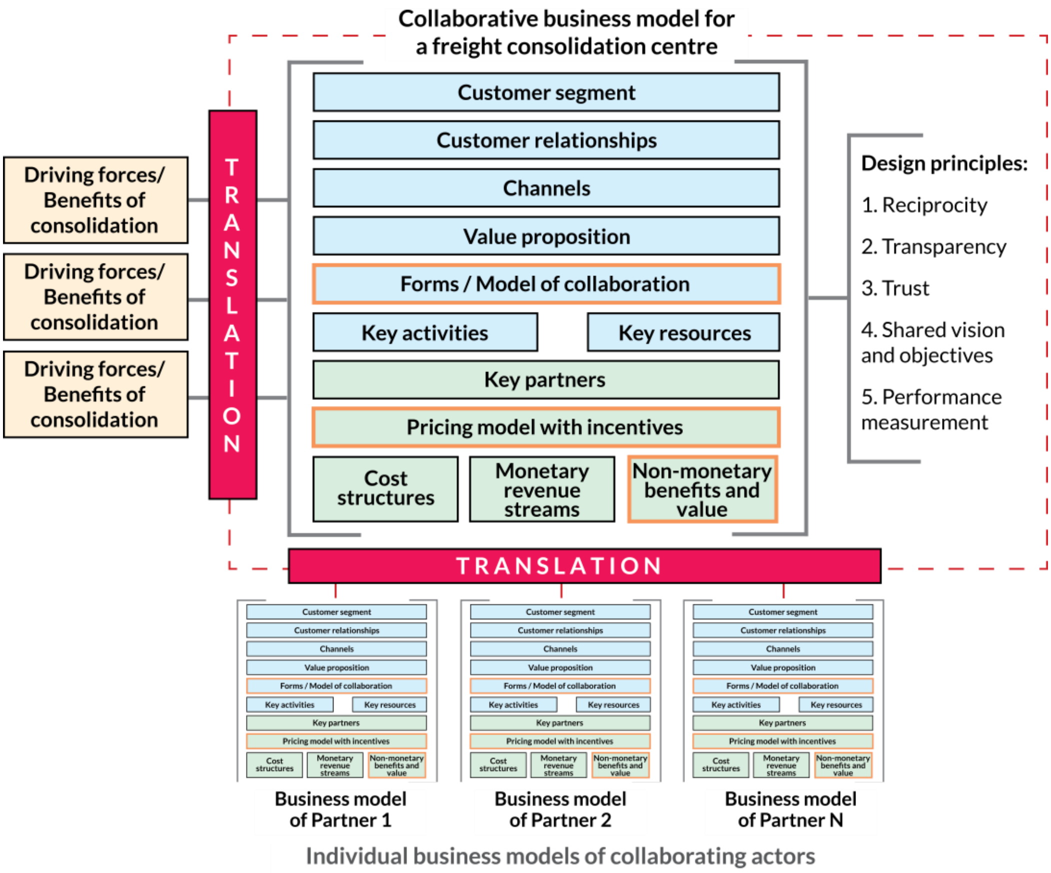

Figure 3. Elaborated framework of a collaborative business model for a freight consolidation centre.

In order to reach true co-creation of a collaborative business model, a neutral third party is needed to orchestrate and coordinate the collaboration of the different actors [5,22]. In addition, collaboration of these diverse actors requires not only clarifying each actor's roles, responsibilities, or actions, but also institutionalisation of routines and norms across both the collaborative business model of freight consolidation centre and individual business models of the actors involved [41]. In order to move towards this level of collaboration, it is necessary to translate the monetary and non-monetary gains of the collaborative business model for a freight consolidation centre into the business models of the individual actors.

We propose to make such a translation using Lund FBL model for innovation ecosystem portfolio tracking [53]. The FBL zone model (see Figure 4) illustrates these co-existing logics through three integrated processes: roles, delivery and results. The model describes a scale of collaboration ranging from an individual organisation to a constellation of actors. The tactics, results and outcomes will change as you moving along the scale. The ability to effectively translate the co-owned business model across different zones is crucial for ultimately achieving empowerment, agency, and implementation within the organisation. This process involves a structured progression from individual ownership and control to fully shared ownership and co-creative agency. A structured approach to translating results and effects is required to ensure that they are clearly articulated and aligned with the organisation's goals and strategy.

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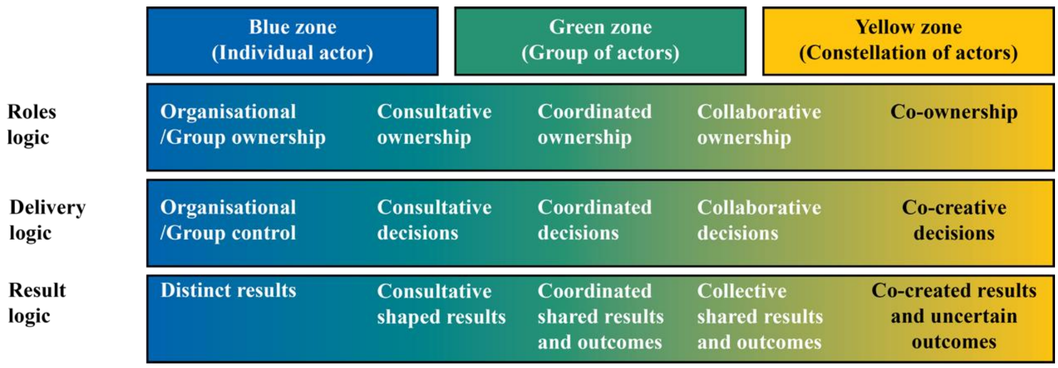

Figure 4. The FBL zone model [53].

For this translation to be effective, the results and impacts of the collaborative business model must be articulated in a way that clearly demonstrates how and through which mechanisms it contributes to each participating organisation's goals and strategy. This requires not only specifying the expected outcomes but also an understanding of the underlying mechanisms and drivers that generate them. In practice, the collaborative business model must be translated into tactics in each organisation. The overarching objectives, value proposition and outcomes therefore need to be granulated and explicitly linked to benefit results, performance, and outcomes of each organisation involved.

In Figure 5, we provide an example of such a translation between the Yellow and Green zones applied to the collaborative business model of the REDIG freight consolidation centre. However, a more detailed translation is the subject of further research and conceptualisation.

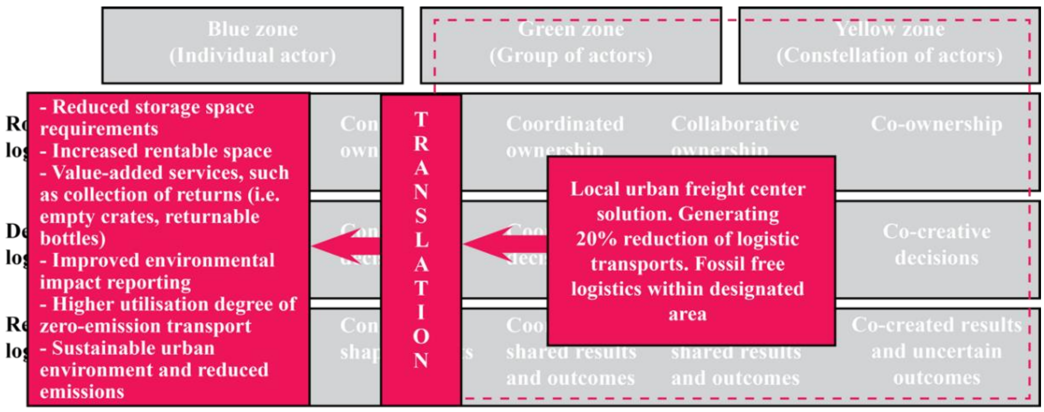

Figure 5. Example of translation explaining the REDIG freight consolidation centre use case.

6.3. Contribution, Practical Implications, Limitations and Further Research

This study makes several theoretical contributions to existing research on last-mile urban freight logistics. Firstly, it explores the benefits and challenges of collaboration among different actors of ecosystem of a freight consolidation centre, and how this collaboration could be strengthened by the overarching business model.

Secondly, we propose a conceptual framework for a collaborative business model for a freight consolidation centre, which incorporated five success factors: (i) reciprocity; (ii) transparency; (iii) trust; (iv) shared vision and objectives; and (v) performance measurement. This framework has been tested and further refined based on the findings of this study. We also propose a further research direction into how the benefits of the overarching business model can be translated into the benefits for the individual business models of the actors involved and institutionalised within their organisations.

Thirdly, our research addresses the identified research gap concerning the coexistence of traditional and electric fleets by examining issues and challenges observed in the pilot project. Our findings suggest that a fair monetary and non-monetary gain sharing mechanism should be incorporated into the overarching business model and then further distributed amongst the involved actors.

This study has important practical implications for practitioners working in the last-mile urban freight logistics. The proposed framework of collaborative business model can be used as a tool when developing business models for services requiring collaboration between actors representing different industries. One of the most important insights is that time is needed for collaboration to take off.

Another practical observation is that an electric fleet requires a substantial investment and has higher operational costs. Hence, from a broader perspective, when society aims to achieve zero environmental impact, the important discussion should focus on questions such as: who should take the cost of the transition to more environmentally friendly transport for last mile urban freight, given the low revenues in this sector?

A major limitation of this paper is that it is only considers findings from a small-scale pilot. This could influence and bias the results of this study. Future work could examine collaboration trends and business model development in a wider array of urban freight consolidation centres.

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Abbreviations

The following abbreviations are used in this manuscript:

EV	Electric Vehicle
LSP	Logistics Service Provider
UCC	Urban Consolidation Centre
CTM	Collaborative Transport Management
SOO	Statement of Objectives
KPI	Key Performance Indicators
B2B	Business-to-Business

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