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**Financial Feasibility of Circular Urban Food
Surplus Logistics Systems:
A Scenario-Based Break-Even Analysis**

Supervisor

Prof. Andrea Tunì

Candidate

Yigit Onel

Abstract

Urban food systems generate substantial edible surplus due to demand uncertainty, time pressure, and coordination challenges in wholesale markets. While circular economy principles encourage keeping edible food in use rather than treating it as waste, many redistribution initiatives struggle to achieve financial sustainability. Environmental and social impact alone do not guarantee long-term operational viability.

This thesis examines how a circular food-surplus logistics system can be designed to remain both environmentally impactful and economically sustainable. The research was conducted in collaboration with WECO Impresa Sociale, using their operational infrastructure and real delivery data from the Turin wholesale market (CAAT).

The study follows a two-stage approach. First, seventeen urban food-surplus initiatives were comparatively analysed to identify different revenue structures (donation-based, hybrid, and commercial). Second, a case-based financial model was developed using annualised delivery data, operational cost structures, and wholesale market prices relevant to the Turin case study. Three alternative revenue scenarios were constructed and tested through break-even analysis. These include a hybrid model that combines fixed subscription fees with basket-based commissions (Scenario A), a volume-dependent model that applies tiered commissions based on delivery weight (Scenario B), and a differentiated pricing model that utilizes cross-subsidization between commercial and social stakeholders (Scenario C).

The results indicate that financial sustainability depends primarily on the pricing structure and the share of commercial customers rather than operational capacity. Among the models, Scenario A performed best, offering the most resilient architecture by securing fixed operational costs through subscriptions while incentivizing growth via value-based commissions. Ultimately, this hybrid revenue architecture proved most decisive in achieving long-term financial viability and operational autonomy."

By combining real practitioner data with structured financial modelling, this study provides a practical framework for designing financially viable circular food-surplus logistics systems in urban environments.

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Their practitioner collaboration has been fundamental in bridging theoretical modelling with real-world application.

AI Statement

This thesis has utilized ChatGPT-4 (OpenAI) as a supportive tool for structural organization, grammar refinement, and the formatting of academic references. Specifically, the AI was used to ensure consistency in citation styles and to improve the linguistic clarity of the technical descriptions.

All conceptual frameworks, financial modeling logic, scenario developments, and empirical analysis data were independently developed by the author. The author remains fully responsible for the accuracy, originality, and academic integrity of the final document.

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Chapter 1 – Introduction

1.1 Background

1.1.1 Urbanisation and the Transformation of Food Logistics

Urbanisation is profoundly reshaping contemporary food systems, altering how food is produced, distributed, and consumed. As cities continue to concentrate population and economic activity, food demand becomes increasingly dense, fragmented, and time-sensitive (Morganti & Gonzalez-Feliu, 2015). Urban food logistics must therefore operate within compressed delivery windows, strict access regulations, and limited road capacity, while simultaneously meeting rising expectations for freshness, reliability, and service quality (Allen et al., 2012). Decisions taken upstream—at the level of production, wholesale, and aggregation—cascade downstream into the last mile, amplifying their effects on urban distribution efficiency.

Within this context, food surplus emerges as a structural outcome of urban food markets rather than an exceptional failure (Garrone et al., 2014). In this thesis, food surplus is defined as edible, safe food products that remain unsold within the trading window but remain fit for human consumption (Papargyropoulou et al., 2014). Such surplus typically results from demand uncertainty, order cancellations, cosmetic or sizing standards, broken case packs, late inbound shipments, price fluctuations near market close, and uneven demand across vendors (De Steur et al., 2016). Crucially, surplus becomes food waste only when time constraints prevent its timely reallocation to a suitable receiver.

Fruit-and-vegetable wholesale markets play a central role in this dynamic. In most metropolitan areas, they function as hubs for daily aggregation and redistribution, concentrating flows from producers and distributors and distributing products to restaurants, independent retailers, street markets, and food-service platforms throughout the day. Their operational characteristics—high throughput, time pressure, and rapid re-grading and dispatch—make them both primary sources of urban food deliveries and points where surplus systematically accumulates (Ciccullo et al., 2021).

1.1.2 Environmental, Economic, and Social Impacts of Urban Food-Logistics Systems

Urban food logistics systems generate significant environmental, economic, and social impacts. Environmentally, frequent and fragmented deliveries in dense urban contexts can intensify resource use and emissions, particularly when distribution flows are poorly coordinated. (Savelsbergh & Van Woensel, 2016) High delivery frequencies, limited accessibility, and time-sensitive distribution requirements can increase per-unit emissions and contribute to systemic inefficiencies across the logistics system.

From an economic perspective, inefficiencies manifest as high last-mile delivery costs, unpredictable shrinkage, and underutilised assets. (Strotmann et al., 2017) Wholesalers often bear disposal costs and reputational risks associated with discarding edible products, while restaurants face volatility in availability and pricing. Logistics operators absorb the costs of failed deliveries and empty return trips, while municipalities incur downstream expenses for waste collection, treatment, and congestion. Collectively, these inefficiencies erode value across the system despite ongoing unmet demand.

Socially, the persistence of food surplus alongside food-access challenges highlights a structural mismatch between supply and demand. While edible food is discarded due to logistical and time constraints, urban populations continue to experience unequal access to fresh, affordable food. Addressing this mismatch requires not only redistribution initiatives but also logistics systems capable of operating reliably within narrow time windows and under stringent coordination requirements (Morganti & Gonzalez-Feliu, 2015).

1.1.3 The Circular Economy as a Response to Urban Food-System Pressures

In response to these pressures, the circular economy has gained prominence as a strategic framework for rethinking urban food systems. Rather than managing waste downstream, circular approaches prioritise prevention by keeping resources at their highest possible value for as long as possible (Geissdoerfer et al., 2017). Applied to food systems, this logic translates into an operational hierarchy that places edible-first redistribution at the top, followed by discounted resale, ingredient upcycling, and, only as a last resort, bio-valorisation (Ellen MacArthur Foundation, 2013). The objective is not merely to recover value from waste, but to prevent the loss of edible food through better coordination, timing, and logistics design (Bocken et al., 2016).

Operationalising circular economy principles in urban food logistics requires more than normative commitments. It depends on aligned incentives, clear governance arrangements, and fit-for-purpose logistics solutions. (Kirchherr et al., 2017) Fixed collection windows, rapid consolidation, reliable cold-chain checkpoints, lightweight digital visibility of available surplus, and clearly defined responsibilities for food safety and quality are essential enablers of repeatable circular loops. When effectively implemented, such configurations can reduce per-unit emissions, retain economic value for multiple actors, and expand timely access to fresh food in cities.

Within this evolving landscape, the integration of circular economy principles into urban food logistics represents both a significant challenge and a strategic opportunity. Understanding how circular logistics loops can be designed, implemented, and evaluated at the operational level is therefore critical for advancing more sustainable, resilient, and inclusive urban food systems.

1.2 Definition of the problem and research gaps in circular food logistics

This research is guided by a central question that addresses the challenge of translating circular economy principles into operationally and economically viable logistics solutions within urban food-distribution systems. While circular approaches to food systems are widely promoted as a means to reduce waste and environmental impact, their implementation at the firm level requires business models that can function under real-world constraints, including cost sensitivity, time pressure, and fragmented demand.

The main research question of this thesis is:

- **How can circular logistics solutions be designed and implemented within urban food-distribution systems to keep edible food surplus in circulation while maintaining operational feasibility and economic efficiency?**

This overarching question is articulated through the following sub-research questions:

- **How can an economically viable circular logistics model be structured to enable edible-first surplus redistribution within an urban food system?**
- **Which cost drivers and revenue mechanisms most influence the financial sustainability of circular urban food-logistics operations at the firm level?**
- **Under which operational conditions can a circular logistics model remain feasible and scalable within existing urban food-distribution networks?**

These questions reflect the inherent tension between circular-economy objectives and the operational realities faced by logistics operators and food-service actors. Keeping edible surplus in circulation is not solely a matter of social or environmental commitment; it depends on the design of logistics processes, pricing mechanisms, and coordination structures that enable the daily repetition of circular loops without compromising economic viability (Morganti, E., & Gonzalez-Feliu, J. , 2015).

By focusing on the economic and operational design of circular logistics models, this thesis positions logistics not as a secondary support function but as a central enabler of circular food systems. The research, therefore, seeks to contribute to both academic and managerial discussions by demonstrating how circular principles can be embedded into practical, firm-level logistics configurations.

1.3 Structure of the Thesis

This thesis is structured into five chapters, each addressing a specific component of the research problem and collectively contributing to the development and evaluation of a circular logistics model for urban food systems.

Chapter 1 introduces the research context and frames the problem of circular logistics within urban food-distribution systems. It outlines the study's motivation, defines the research questions, and clarifies the thesis's conceptual and analytical focus.

Chapter 2 reviews the relevant academic literature on circular economy principles, circular business models, and urban logistics, with a specific focus on food systems. This chapter synthesises existing frameworks on circular supply chains, surplus management, and urban food logistics, culminating in a conceptual framework that integrates circular business models with logistics design in the food sector.

Chapter 3 describes the research methodology adopted in the thesis. It explains the research design, data-collection process, and analytical criteria used to evaluate circular logistics use cases. Particular attention is given to the development of an analytical framework and performance indicators to assess the economic and operational viability of circular urban food-logistics solutions.

Chapter 4 presents the study's empirical analysis and results. Based on the selected case, this chapter reports the structure of the proposed circular logistics model and analyses its operational and economic performance under different scenarios. The results highlight key cost drivers, revenue mechanisms, and logistical conditions that influence the feasibility of edible-first surplus redistribution in an urban context.

Chapter 5 discusses the findings in relation to the existing literature and the research questions. It examines the managerial and policy implications of the proposed circular logistics model and reflects on its scalability and replicability in other urban food systems. The chapter concludes by summarising the thesis's main contributions and outlining directions for future research and concludes the thesis by summarising the main findings of the analysis.

Chapter 2 – Literature Review

2.1 The Circular Economy: Conceptual and Economic Foundations

The Circular Economy (CE) has emerged as one of the most influential sustainability paradigms of the last decade. It proposes a systemic alternative to the dominant linear economic model, which is traditionally characterised by a “take–make–dispose” logic. In linear systems, resources are extracted, transformed into products, consumed, and ultimately discarded as waste. This model assumes material abundance, externalises environmental costs, and treats value destruction at end-of-life as structurally inevitable (Geissdoerfer et al., 2017).

In contrast, the Circular Economy reframes economic activity as a regenerative system in which material flows are intentionally designed to remain within productive cycles for as long as possible (Ellen MacArthur Foundation, 2013). Rather than minimising waste at the margin, CE seeks to eliminate the very concept of waste through restorative and regenerative design (McDonough & Braungart, 2002). This shift represents not only an environmental ambition but a reconfiguration of how value is created, preserved, and circulated within economic systems.

Although the term “Circular Economy” gained policy traction primarily in the 2010s, its intellectual foundations are rooted in earlier theoretical traditions. Industrial Ecology conceptualised industrial systems as analogous to natural ecosystems, in which waste from one process becomes an input to another (Frosch & Gallopoulos, 1989). This systems-level thinking introduced the concept of closed material loops and industrial symbiosis, demonstrating that material efficiency could be enhanced through inter-organisational coordination.

Similarly, the Cradle-to-Cradle framework advanced the principle that “waste equals food,” arguing that products should be designed for perpetual cycling within biological or technical metabolisms (McDonough & Braungart, 2002). Rather than focusing solely on end-of-life recycling, this approach emphasised upstream design integrity and material health.

Perhaps most directly connected to contemporary Circular Business Models is Stahel's (2010) concept of the Performance Economy. Stahel proposed shifting from ownership-based production systems to service-oriented provision, in which firms sell performance rather than products. Such models incentivise durability, repairability, and extended product life, aligning economic incentives with value retention. Unlike earlier environmental-efficiency paradigms, the Performance Economy explicitly integrates economic motivation into circular logic.

Across these intellectual streams, CE converges around the principle of value retention. Circular strategies can be categorised by how they preserve material and economic value, including closing loops (recycling and recovery), slowing loops (reuse, repair, remanufacturing), narrowing loops (resource-efficiency improvements), and intensifying loops (increased utilisation rates) (Bocken et al., 2016). Importantly, these strategies are not economically equivalent. Recycling often recovers material mass but may degrade functional value, whereas reuse and remanufacturing preserve higher levels of embedded labour, energy, and economic worth (Stahel, 2010).

This distinction is critical for understanding the economic implications of circularity. While circular strategies are widely promoted for their environmental benefits, their financial viability depends on effective mechanisms of value capture. Environmental circularity does not automatically translate into economic sustainability (Lüdeke-Freund et al., 2019). As Geissdoerfer et al. (2017) note, CE represents a regenerative system in theory, but its implementation at the firm level requires new organisational and revenue structures capable of sustaining operational costs.

The Circular Economy can be analysed across multiple levels, including the micro (firm and product), meso (industrial networks), and macro (cities and regions) scales (Kirchherr et al., 2017). Urban systems have become particularly relevant arenas for circular experimentation, especially in areas such as food systems, reverse logistics, and resource recovery infrastructures (Morganti & Gonzalez-Feliu, 2015). However, while policy discourse frequently highlights the transformative potential of circular urban systems, empirical evidence regarding their economic performance remains fragmented (Korhonen et al., 2018).

Despite its normative appeal, the Circular Economy has also been criticised for conceptual ambiguity and definitional heterogeneity (Kirchherr et al., 2017). The term encompasses a broad spectrum of interpretations, ranging from resource-efficiency strategies to systemic socio-economic transformation. Moreover, many circular initiatives demonstrate environmental value creation without necessarily achieving stable revenue generation or long-term financial autonomy. However, the opposite case also exists, where initiatives may achieve financial success without fully delivering the intended environmental or social outcomes.

This tension between environmental ambition and economic implementation is particularly evident in urban circular systems, which are characterised by high logistical complexity and limited monetised flows. Circularity may enhance resource efficiency and reduce waste, yet its sustainability at the operational level ultimately depends on structurally coherent revenue mechanisms.

At the macro level, this structural challenge is reflected in persistent trends of rising global material extraction despite the growing diffusion of circular economy discourse, as illustrated in Figure 2.1.

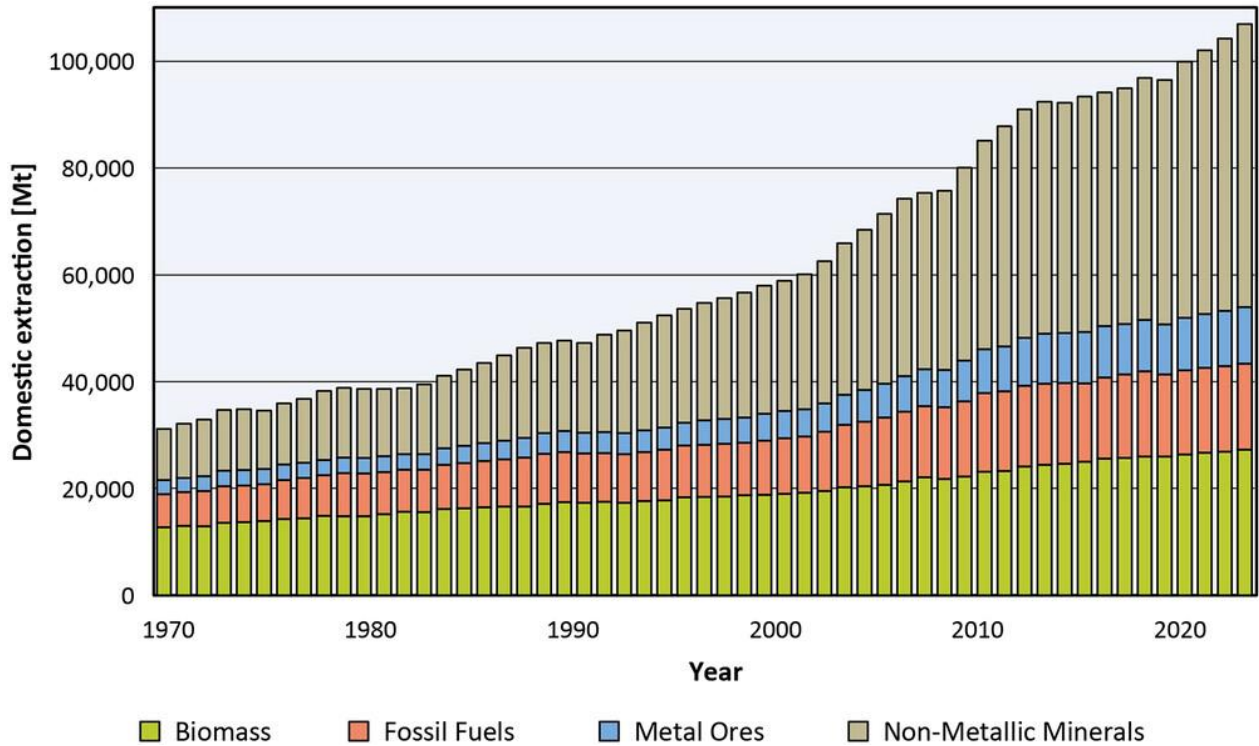


Figure 2.1. Global Material Extraction Source: Schandl et al. (2024)

Figure 2.1 presents the evolution of global material extraction by major resource categories between 1970 and 2022. Despite the growing diffusion of Circular Economy discourse and increasing policy commitments worldwide, total material extraction has continued to rise substantially over the past five decades, also driven by the increasing world population. Particularly pronounced is the expansion of non-metallic minerals, largely associated with construction and infrastructure growth, alongside sustained increases in biomass and fossil fuel extraction.

These trends indicate that macro-level structural decoupling between economic activity and material throughput remains limited. (Schandl et al., 2024) While circular strategies may improve recovery rates or resource efficiency at the micro level, aggregate material demand continues to expand in absolute terms (Korhonen et al., 2018). This observation does not invalidate the principles of circularity; rather, it underscores the importance of designing economically viable operational models that can function under real market conditions.

Instead, it requires structurally coherent business configurations that align environmental objectives with financially sustainable revenue mechanisms. (Lüdeke-Freund et al., 2019) The following section, therefore, examines

Circular Business Models as the organisational expression of circular principles and explores how value creation can be translated into effective value capture.

The economic viability of circular systems, therefore, cannot be assumed; it must be deliberately designed. Understanding how value is captured, monetised, and redistributed within circular configurations becomes essential, paving the way for the analysis of specific revenue models in Section 2.2.

2.2 Circular Business Models (CBMs) and Value Capture Mechanisms

Circular Economy principles are practically relevant only when translated into firm-level organisational architectures capable of sustaining operational activity. Circular Business Models (CBMs) represent the structural mechanism through which circular value creation is transformed into economically viable value capture (Lüdeke-Freund et al., 2019). While the broader Circular Economy discourse focuses on systemic resource loops, CBMs address the micro-level configuration of activities, partnerships, cost structures, and revenue streams that enable such loops to function in real market conditions (Zucchella & Previtali, 2019).

Recent research emphasises that circularity cannot be reduced to product design or waste recovery strategies; rather, it requires a reconfiguration of business-model logic (Geissdoerfer et al., 2020). CBMs differ from linear models in that they prioritise value retention over throughput expansion and resource productivity over extraction intensity (Bocken et al., 2016). However, the environmental ambition of circular models does not inherently guarantee financial viability. A persistent challenge in the literature concerns the misalignment between value creation and value capture (Oghazi & Mostaghel, 2018).

Bocken et al. (2016) identify multiple circular strategies—such as closing loops, slowing loops, narrowing loops, and intensifying loops—each associated with distinct economic implications. More recent contributions extend this typology by highlighting platform-based circular models, performance-based service models, and hybrid revenue configurations that combine commercial and social objectives (Urbinati et al., 2017; Pieroni et al., 2019).

A central analytical distinction concerns the separation between value-creation and value-capture mechanisms. Value creation in circular systems may manifest through avoided waste, emission reductions, social inclusion, or improved resource efficiency. However, value capture depends on monetisation structures—such as subscription fees, commissions, service contracts, cross-subsidisation schemes, or performance-based pricing (Tukker, 2015). Without coherent revenue mechanisms, circular initiatives risk remaining dependent on subsidies or philanthropic funding (Santa-Maria et al., 2021).

Recent empirical studies demonstrate that scalability in circular systems is strongly linked to revenue architecture rather than technological capability (Ranta et al., 2021). In particular, hybrid circular models—combining market-based transactions with social or environmental objectives—have been identified as structurally promising but financially fragile. (Davies & Chambers, 2018; Salvador et al., 2020). These models often face tensions between mission preservation and revenue optimisation.

In the context of food systems, this tension becomes particularly pronounced. Edible-first surplus redistribution preserves high embedded value yet generates limited direct revenue when structured primarily as a donation. (Garrone et al., 2014). Consequently, designing financially autonomous circular logistics models requires deliberate attention to pricing structures, commission rates, and break-even thresholds (Morganti & Gonzalez-Feliu, 2015).

This structural gap between environmental value generation and economic sustainability underpins the scenario-based revenue modelling approach developed in this thesis. By explicitly focusing on revenue mechanisms and break-even logic, the study contributes to the emerging literature on the financial feasibility of circular business configurations in urban food systems.

To synthesise the above discussion, Figure 2.2 conceptually illustrates the structural misalignment between environmental value creation and revenue-based value capture in circular food systems. The figure provides a simplified representation of the financial sustainability tension that characterises many hybrid circular initiatives and motivates the break-even modelling approach developed in this thesis.

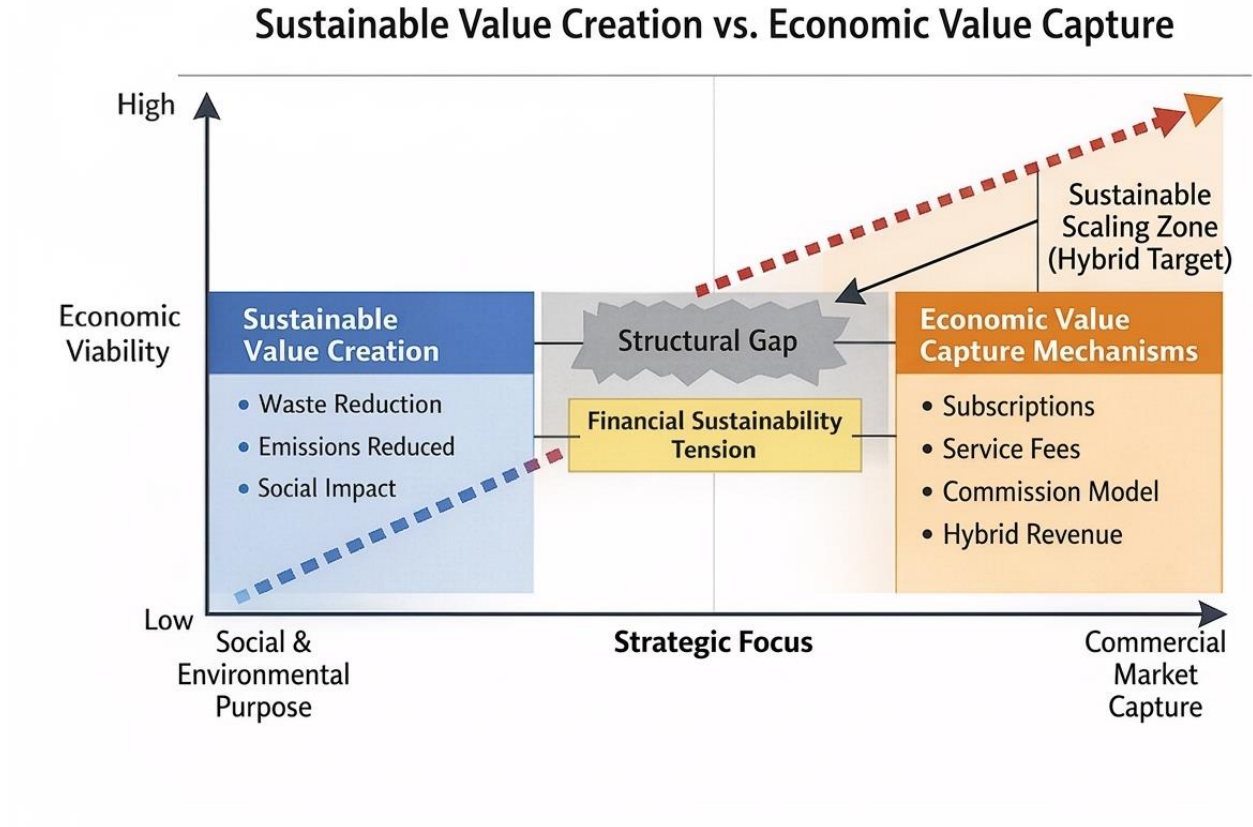


Figure 2.2. Sustainable Value Creation vs. Economic Value Capture. Source: Author's own elaboration.

Figure 2.2 presents a two-dimensional analytical representation of the structural tension between sustainable value creation and economic value capture in circular food systems. The horizontal axis (X-axis) represents Strategic Focus, moving from a primary Social & Environmental Purpose toward Commercial Market Capture. This dimension tracks the transition of a circular initiative from purely impact-driven activities toward the integration of monetized income streams. The vertical axis (Y-axis) represents Economic Viability, reflecting the financial strength and self-sufficiency of the operational model.

On the left-hand side of the diagram, the Sustainable Value Creation zone—comprising waste reduction, emissions savings, and social impact—often operates under low or unstable revenue structures. The central "Structural Gap" represents the core financial sustainability challenge: the tension between achieving significant environmental/social impact and the lack of sufficient value-capture mechanisms. Without a clear revenue architecture, initiatives in this zone remain financially fragile.

The top-right quadrant, identified as the Sustainable Scaling Zone (Hybrid Target), represents the strategic objective of this research. This is a configuration where high sustainable value creation is matched by high economic viability. The dotted upward trajectory, labelled "Break-Even Model", symbolises the analytical path of aligning social purpose with economic sustainability through structured revenue modelling. In this thesis, break-even analysis is employed as a formal tool to determine the minimum operational and pricing conditions under which circular surplus redistribution can reach this target zone, ensuring long-term viability without compromising its environmental or social mission.

The conceptual tension illustrated in Figure 2.2 highlights that circular business models cannot rely solely on environmental legitimacy. Financial sustainability requires explicit revenue architecture design—such as the hybrid or commission-based models explored in this study—to bridge the structural gap. Consequently, understanding the economic resilience of these systems becomes essential. Section 2.3, therefore, examines the specific financial sustainability mechanisms and break-even logic that act as the structural determinants of long-term circular viability.

2.3 Financial Sustainability and Revenue Structures in Circular Systems

While circular economy principles emphasise resource efficiency, environmental regeneration, and social value creation, financial sustainability remains one of the most persistent structural challenges faced by circular initiatives. Numerous studies have highlighted the discrepancy between environmental impact generation and monetised revenue flows, particularly in sectors characterised by high coordination costs and low-margin transactions (Korhonen et al., 2018; Ranta et al., 2021).

Circular systems frequently generate substantial environmental value through waste reduction, emission avoidance, and extended product lifecycles (Bocken et al., 2016). However, these benefits often represent positive externalities that are not directly internalised within market transactions (Lüdeke-Freund et al., 2019). As a result, value creation does not automatically translate into value capture. This misalignment creates structural economic fragility, particularly in initiatives operating within social or hybrid mission contexts.

2.3.1 Economic Fragility and Externality Underpricing

A central structural weakness of many circular initiatives lies in the underpricing—or complete absence of pricing—of environmental externalities (Milliot et al., 2020). Environmental benefits such as avoided landfill emissions, reduced resource extraction, and improved food accessibility generate societal value but are rarely monetised through direct market mechanisms. Consequently, circular initiatives may deliver substantial systemic impact despite limited revenue-generation capacity (Zucchella & Previtali, 2019).

In the context of urban food-surplus redistribution systems, this fragility becomes particularly visible. Edible-first redistribution maximises environmental and social value by preventing food waste and enhancing access to fresh products (Garrone et al., 2014). However, when redistribution is structured predominantly as donation, revenue flows remain marginal (Davies & Chambers, 2018). Operational costs—transport, personnel, vehicle maintenance—remain fully real, while monetisation mechanisms remain structurally weak (Strotmann et al., 2017).

This imbalance creates a condition in which circular initiatives rely on external funding to compensate for insufficient market-based revenue (Santa-

Maria et al., 2021). The resulting vulnerability limits long-term autonomy and scalability.

2.3.2 Subsidy Dependence and Structural Vulnerability

Many nonprofit circular systems rely on grants, philanthropic contributions, or public subsidies to cover operational expenditures (Wilson & Post, 2013). While such funding mechanisms enable initial experimentation and social mission development, they introduce structural instability over time. Public funding cycles are inherently uncertain, politically contingent, and often short-term (Doherty et al., 2014). Philanthropic contributions may fluctuate with economic conditions or donor priorities (Huybrechts & Nicholls, 2012).

Subsidy dependence may also constrain strategic flexibility. Initiatives may be required to align activities with funding criteria rather than operational efficiency (Arena et al., 2015). In addition, reliance on grants can discourage the systematic development of internal revenue architectures, delaying the transition toward financial autonomy (Veleva & Bodkin, 2018). The literature increasingly recognises that long-term circular viability requires revenue models capable of sustaining core operations independently of external support (Geissdoerfer et al., 2020). Financial autonomy does not imply full commercialisation but rather the existence of structurally coherent revenue streams aligned with operational cost structures.

2.3.3 Hybrid Revenue Configurations and Cross-Subsidisation

Hybrid circular models have emerged as an intermediate configuration between purely donation-based systems and fully commercial enterprises. These models combine social redistribution objectives with market-based revenue streams such as subscription fees, service contracts, commission structures, or differentiated pricing schemes (Haigh & Hoffman, 2012).

Hybrid configurations offer structural advantages by diversifying revenue sources and reducing exposure to funding volatility. However, they also introduce complexity. Balancing the preservation of social mission with revenue optimisation may generate internal tensions (Battilana & Dorado, 2010). Pricing decisions must consider both affordability for socially oriented recipients and cost recovery requirements for operational sustainability.

Cross-subsidisation mechanisms—where higher-paying commercial customers partially finance lower-paying or symbolic social contributions—have been identified as promising but delicate instruments (Tukker, 2015). The viability of such configurations depends on accurate parameter calibration, demand composition, and cost transparency (Santos et al., 2015). Without structured financial modelling, hybrid systems risk either underpricing commercial services—thereby perpetuating financial fragility—or over-commercialising activities in ways that undermine social objectives (Ebrahim et al., 2014). This tension underscores the need for formal economic evaluation tools capable of identifying sustainability thresholds.

2.3.4 Break-Even Logic as a Structural Viability Mechanism

Within this context, break-even analysis emerges as a critical analytical instrument for circular business model design. Unlike profit-maximisation frameworks, break-even modelling focuses on identifying the minimum operating conditions under which total revenue equals total cost (Horngren et al., 2012). In circular systems, this threshold represents not merely financial performance but operational survival.

By explicitly modelling cost structures, pricing parameters, and demand composition, break-even analysis enables the formalisation of the conditions for financial sustainability (Bamberger & Wrona, 2012). It transforms normative aspirations—such as “self-sustaining circular redistribution”—into quantifiable economic criteria.

Importantly, break-even logic is not inconsistent with circular objectives. Rather, it provides a structural mechanism for aligning environmental value creation with economic viability (Lüdeke-Freund et al., 2019). In the absence of such analytical calibration, circular initiatives may remain perpetually dependent on external funding, limiting scalability and long-term resilience (Strotmann et al., 2017).

This thesis adopts scenario-based break-even modelling to evaluate alternative revenue architectures in urban food-surplus redistribution systems. By quantifying threshold conditions under different pricing and allocation configurations, the research seeks to bridge the structural gap identified in Section 2.2 and provide an operational pathway toward financially autonomous circular logistics systems. To further formalise the structural role of break-even logic in circular systems, Figure 2.3: Break-Even Analysis in Circular Business Model Design provides a simplified analytical

representation of how cost structures, pricing strategies, and demand composition interact to determine financial sustainability thresholds.

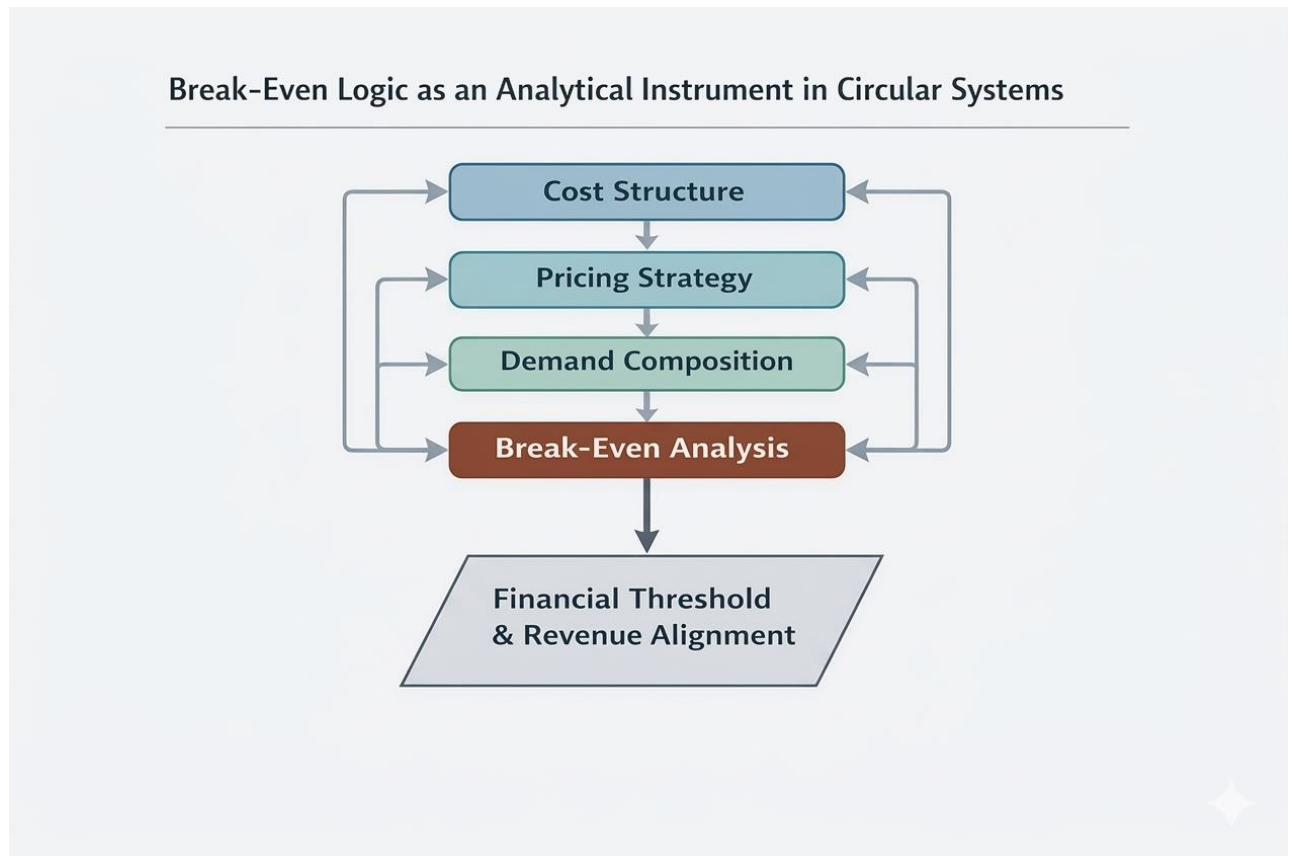


Figure 2.3 Break-Even Logics as an Analytical Instrument in Circular Systems

Source: Author's own elaboration.

Figure 2.3 conceptually illustrates the structural components underlying financial sustainability in circular business configurations. The diagram highlights four core elements: cost structure, pricing strategy, demand composition, and break-even analysis.

Rather than representing a linear sequence, the first three elements are conceptualised as an interdependent system. Cost structures, pricing strategies, and demand composition mutually influence one another: pricing decisions affect demand realisation, expected demand levels shape pricing strategies, and both jointly impact operational cost configurations. This reflects the endogenous nature of economic decision-making in circular systems.

Within this framework, the cost structure comprises personnel, logistics, infrastructure, and administrative expenses that define the operational baseline. Pricing strategy refers to the configuration of subscription models, service fees, commission structures, or differentiated pricing schemes used to generate revenue. Demand composition reflects the proportion of commercial and socially oriented customers, which directly influences monetised flows.

Break-even analysis operates as an integrative analytical layer that captures the combined effect of these interdependent variables, identifying the financial threshold at which total revenue equals total operating costs. Rather than focusing on profit maximisation, break-even modelling defines the minimum viability condition necessary for structural autonomy.

The resulting “financial threshold and revenue alignment” represents the point at which circular environmental objectives become economically self-sustaining. This analytical framing provides the methodological foundation for the scenario-based modelling approach developed in Chapter 4.

The explicit integration of cost structures, pricing mechanisms, and demand allocation within an interdependent break-even framework demonstrates that financial sustainability in circular systems must be structurally designed rather than assumed. Consequently, the viability of circular food-surplus redistribution systems depends on the deliberate calibration of revenue architectures under real operational constraints. Section 2.4 extends this discussion by situating financial sustainability within the logistical and supply-chain complexities of urban circular systems.

2.4 Circular Supply Chains and Urban Circular Logistics

Circular business models in food systems operate within supply-chain configurations that differ structurally from traditional linear distribution systems. While financial sustainability depends on revenue architecture, operational feasibility in urban environments introduces an additional layer of complexity that directly influences cost structures and break-even thresholds (Govindan & Soleimani, 2017).

Urban circular logistics systems are characterised by fragmented supply volumes, time-sensitive flows, regulatory constraints, and spatial congestion. These factors amplify coordination requirements and increase operational intensity compared to standard forward distribution chains (Browne et al., 2012; Savelsbergh & Van Woensel, 2016).

2.4.1 Forward and Reverse Flow Complexity

In linear food supply chains, products move sequentially from producers to wholesale markets, retailers, and ultimately to consumers. This forward flow structure is typically demand-driven, contractually stabilised, and supported by predictable logistics planning (Christopher, 2016). Economies of scale are often achievable through batch consolidation and structured distribution routes, as the movement is unidirectional and predictable.

Circular food-surplus systems, however, operate through reverse flows. Instead of predictable upstream production responding to market demand, surplus redistribution relies on irregular availability, heterogeneous product categories, and time-constrained collection processes. Reverse logistics introduces high levels of uncertainty regarding both quantity and timing, thereby complicating planning and resource allocation (Guide & Van Wassenhove, 2009).

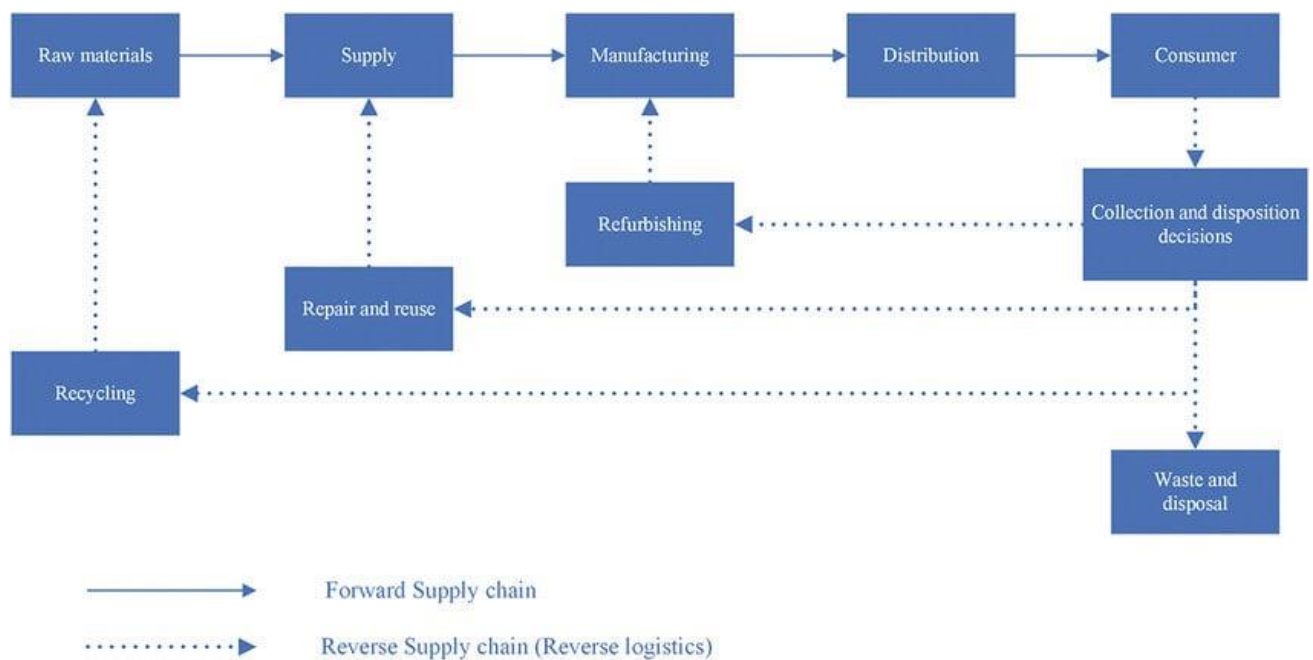


Figure 2.4.1: Operational Flow Comparison between Forward and Reverse Food Logistics. (Source: Adapted from Govindan & Soleimani, 2017).

As illustrated in Figure 2.4.1, the transition from linear to circular systems necessitates the introduction of critical coordination layers that are absent in standard distribution. Specifically, the reverse flow requires centralized nodes for inspection, sorting, and quality assessment before any reallocation can occur. These additional layers are essential for managing the inherent variability of surplus products, yet they simultaneously amplify operational complexity.

Closed-loop supply chain literature emphasises that these coordination requirements generate significant additional costs (Govindan & Soleimani, 2017). In food systems, perishability further intensifies this complexity, as the entire sorting and redistribution process must occur within narrow temporal windows to preserve the nutritional and economic value of the produce.

Beyond these operational hurdles, this structural complexity has direct implications for the economic configuration of circular systems. Uncertainty in volume and timing affects cost structures through variable logistics intensity, while demand-side variability constrains pricing strategies and revenue predictability (Srivastava, 2007). Consequently, financial viability

cannot be assumed through standardised models; it must be explicitly calibrated under conditions of structural uncertainty. This reinforces the need for the scenario-based break-even modelling developed in this thesis, as it provides a framework to capture the volatility of both operational flows and revenue mechanisms (Ritzén & Sandström, 2017).

The structural shift from forward to reverse logistics amplifies costs through increased handling requirements, greater route variability, and higher labour intensity. In dense urban contexts, these dynamics are further intensified by congestion and access regulations (Browne et al., 2012).

2.4.2 Urban Logistics Constraints and Financial Implications

The inherent fragmentation of urban delivery networks serves to reduce revenue density per route and increase the cost per delivered unit. When delivery points are geographically dispersed, and volumes per customer remain limited, the ratio of operational effort to economic return becomes structurally unbalanced (Browne et al., 2011). This imbalance is particularly acute in circular food systems, where the lack of consolidated volumes prevents the achievement of traditional economies of scale.

Beyond operational inefficiencies, urban logistics systems are also subject to regulatory and infrastructure pressures that increase baseline operating costs. Access limitations, vehicle compliance requirements, and unpredictable traffic conditions translate into increased time-based cost exposure, particularly in labour-intensive redistribution models (Dablanc, 2007). From a financial perspective, these determinants generate a structural tension between environmental ambition and economic sustainability. Circular redistribution systems are therefore embedded within cost environments that are inherently complex and partially exogenous to managerial control.

As a result, financial modelling approaches must explicitly incorporate logistical determinants rather than assuming frictionless operational scalability (Crainic, Ricciardi & Storch, 2009).

Recent studies emphasise that urban logistics performance cannot be evaluated solely through volume-based efficiency metrics; it must be understood in relation to network density, demand fragmentation, and the regulatory context (Savelsbergh & Van Woensel, 2016). These findings

reinforce the need to integrate operational constraints into the design of financially resilient circular business models.

2.4.3 Implications for Circular Revenue Modelling

The integration of reverse-flow complexity and urban constraint mapping demonstrates that cost structures in circular food-surplus systems are structurally embedded within urban operational realities. Driver labour, vehicle utilisation, routing frequency, and capacity limits are direct consequences of these logistical conditions.

Therefore, scenario-based break-even modelling must incorporate urban cost determinants to accurately assess financial viability. Circular revenue architecture is inseparable from supply-chain configuration.

The following chapter translates these operational and structural considerations into a formal modelling framework that integrates cost structures, pricing mechanisms, and demand allocation parameters to evaluate break-even thresholds under alternative revenue scenarios.

2.5 Circular Food Redistribution Systems

Circular food redistribution systems are among the most operationally visible implementations of circular economy principles in urban environments. By recovering edible surplus and redirecting it toward socially or commercially viable channels, these systems aim to preserve embedded environmental and economic value that would otherwise be lost as waste. Food waste remains a structurally significant global issue, particularly in high-income regions, where surplus generation coexists with food insecurity (FAO, 2019; Schanes et al., 2018).

Despite the environmental legitimacy of redistribution practices, their economic configuration varies substantially across organisational models. This section examines donation-based, hybrid, and commercial redistribution systems and highlights the structural imbalance between the volume of redistributed goods and monetised revenue in urban food ecosystems.

2.5.1 Scale and Societal Relevance of Food Redistribution

Food-surplus redistribution operates at a considerable scale across Europe. Networks of food banks and redistribution organisations recover hundreds of thousands of tonnes annually, demonstrating the structural availability of edible surplus within urban food systems.

Indicator	Value (Latest Reported Year)
Total food redistributed	~834,000 tonnes
People supported	~12.2 million individuals
Member food banks	300+ organisations
Countries covered	30 European countries

Table 2.1 – Scale of Food Redistribution in Europe

Source: FEBA (2024)

As illustrated in Table 2.1, European food banks collectively redistribute more than 800,000 tonnes annually, reaching over 12 million beneficiaries. These figures confirm that surplus redistribution is not marginal but structurally embedded within contemporary food systems.

Despite this scale, revenue generation within such networks remains limited, as redistribution is predominantly donation-based and socially oriented. This creates a structural divergence between the magnitude of impact and monetised income.

2.5.2 Donation-Based Redistribution Models

Donation-based redistribution systems prioritise social access and waste prevention over revenue generation. Food banks, charitable organisations, and volunteer-driven networks typically operate through grants, philanthropic support, and public subsidies (Baglioni et al., 2017).

These models demonstrate high environmental and social value creation. However, financial autonomy remains constrained. Revenue flows are often symbolic, and operational continuity depends on external funding cycles. This dependence on funding limits long-term scalability and may expose organisations to financial instability during periods of reduced public or philanthropic support.

The structural weakness of donation-based systems lies in the absence of systematic mechanisms for monetisation. While redistributed volumes may be substantial, cost coverage depends primarily on subsidies rather than internally generated income.

2.5.3 Hybrid Redistribution Models

Hybrid redistribution systems combine social objectives with structured revenue streams. These models may introduce subscription fees, commission-based pricing, differentiated pricing by customer type, or cross-subsidisation mechanisms.

Hybrid organisations are frequently positioned as a means of reconciling social mission and market sustainability. However, research on hybrid governance indicates that balancing commercial revenue logic with social objectives may generate internal tensions and organisational complexity (Battilana & Lee, 2014).

2.5.4 Commercial Redistribution Configurations

Commercial redistribution platforms operate through structured pricing mechanisms, including discounted resale, B2B surplus marketplaces, and service-based logistics models. These systems depend on formal transaction structures, contractual agreements, and performance-based payment schemes.

Unlike donation-driven redistribution, commercial setups typically feature stronger revenue models, multiple income streams, and less reliance on public funding or philanthropy (Michelini, Principato & Iasevoli, 2018).

In market-based surplus platforms, value is often understood to lie in improving efficiency, optimizing inventory, and internalizing waste costs. Surplus is viewed as an economic asset rather than merely a social externality. Digital B2B marketplaces and intermediary logistics providers monetize surplus by matching supply with demand at discounted but profitable prices, increasing financial independence (Ciulli, Kolk & Boe-Lillegraven, 2020).

However, commercializing redistribution creates trade-offs: as pricing focus and revenue reliance grow, priorities tend to favor larger volumes, higher-quality items, or easier-to-reach locations, possibly neglecting low-margin, fragmented, or vulnerable recipients where coordination costs are high, and revenue is limited (Davies & Chambers, 2018; Ebrahim et al., 2014).

Furthermore, commercial surplus systems operate within competitive markets, which can conflict with principles like food justice and edible-first hierarchies. While financial models reduce dependence on subsidies, they may also separate redistribution from social goals.

Consequently, financial viability and social inclusion may not naturally align in these setups (Michelini et al., 2018). In urban circular economies, this tension is especially significant. The key challenge is not choosing between commercial or donation models but creating hybrid structures that maintain social coverage and economic sustainability. Pricing strategies are thus crucial to balancing financial resilience with social and circular objectives.

Dimension	Donation-Based Model	Hybrid Model	Commercial Model
Primary Revenue Source	Grants / Philanthropy	Mixed (Fees + Donations)	Market-based Pricing
Financial Autonomy	Low	Medium	High
Scalability Potential	Limited	Conditional	High
Pricing Mechanism	Symbolic / None	Cross-subsidized	Structured pricing
Operational Stability	Funding-dependent	Balanced	Revenue-driven
Mission Orientation	Social-first	Dual (Social + Market)	Market-first

Table 2.2– Structural Comparison of Food Redistribution Configurations

Source: Adapted from Sawyerr et al. (2023),

Table 2.2 above illustrates that hybrid models occupy an intermediate structural position between purely donation-based systems and fully commercial configurations. As financial autonomy increases, revenue calibration becomes essential to prevent underpricing, which may lead to fragility, or excessive commercialisation, which may result in mission drift.

2.5.5 Structural Imbalance: Volume Redistribution vs Revenue Generation

A central structural tension in urban food redistribution lies in the imbalance between the volume redistributed and the monetised revenue flows (Garrone et al., 2014). Systems may recover large quantities of edible surplus yet generate limited direct income.

Empirical evidence highlights this divergence between material throughput and financial capture (Morganti & Gonzalez-Feliu, 2015). Research on urban food hubs indicates that the estimated economic value of recovered food can substantially exceed the operational costs required for redistribution (Casson et al., 2026).

Empirical research by Casson et al. (2026) further illustrates the structural divergence between the societal value created through food redistribution and the financial revenues captured by redistribution operators. While operational costs remain tangible and measurable, the broader economic value of recovered food often exceeds these expenditures but does not necessarily translate into monetised income for the organisations involved. Table 2.3 summarises key findings from this recent case-based research on urban food hubs.

Indicator	Reported Finding
Estimated economic value of recovered food	Significantly exceeds operational redistribution costs
Value-to-cost ratio (case study)	Approx. 12:1
Key implication	High societal value creation relative to operational expense

Table 2.3. Economic Value of Recovered Food Relative to Redistribution Costs

Source: Casson et al. (2026).

As indicated in Table 2.3, the estimated economic value embedded in recovered food can significantly exceed the operational costs required for redistribution. However, this value is largely externalised at the societal level and does not directly accrue to redistribution organisations as revenue. This structural misalignment reinforces the financial fragility discussed in Sections 2.3 and 2.4 and underscores the necessity of calibrated revenue modelling frameworks.

While societal value creation is considerable, this value often remains externalised and does not directly translate into revenue for redistribution

operators (Davies & Chambers, 2018). As a result, high impact does not guarantee financial sustainability. This structural imbalance underscores the need for calibrated revenue architectures that align redistributed volume with monetised flows. Without such alignment, circular redistribution systems remain vulnerable to funding volatility and operational fragility.

The following Chapter 3 addresses this gap through scenario-based break-even modelling, examining how alternative pricing and allocation configurations can structurally reconcile environmental impact with financial viability.

2.6 Research Gap and Conceptual Positioning

The preceding sections 2.1 to 2.5 have examined circular business models, financial sustainability challenges, urban logistics constraints, and the structural configurations of food-surplus redistribution systems. The literature consistently demonstrates that circular initiatives generate substantial environmental and social value while facing structural financial fragility (Korhonen et al., 2018; Ranta et al., 2021).

Despite extensive research on implementing the circular economy and closed-loop supply chains (Govindan & Soleimani, 2017), a structural analytical gap persists. Existing studies predominantly focus on environmental impact assessment, operational efficiency, or governance structures. Compared with other areas, relatively little attention has been paid to formally integrating revenue architecture, demand composition, and urban cost determinants into a structured framework for financial viability.

In particular, hybrid redistribution models are frequently proposed as promising solutions for reconciling mission and market logics (Battilana & Lee, 2014; Sawyerr et al., 2023). Nevertheless, the economic conditions under which such configurations achieve financial autonomy in the face of real urban constraints remain under-specified.

Urban freight research further demonstrates that dense city environments amplify logistical costs and operational rigidity (Savelsbergh & Van Woensel, 2016). Yet these cost dynamics are rarely incorporated into formal break-even modelling structures for circular redistribution systems.

Consequently, the relationship between redistributed volume, pricing mechanisms, and cost recovery remains insufficiently quantified in existing scholarship.

By integrating revenue architecture, demand composition, and urban cost determinants within a structured financial modelling framework, this study provides a quantitative operationalisation of circular financial sustainability at the firm level.

Chapter 3 – Methodology

3.1 Research Design

This thesis adopts a two-stage research design that combines exploratory comparative analysis and applied economic modelling to examine the financial feasibility of circular logistics solutions within urban food-distribution systems.

The first stage comprises a structured comparative mapping of eighteen circular urban food-logistics initiatives operating across different European and international contexts. The purpose of this phase was to identify recurring revenue logics and operational configurations relevant to surplus redistribution systems. Cross-case comparative approaches are particularly suitable for identifying structural patterns and transferable mechanisms across heterogeneous organisational settings (Eisenhardt, 1989). In this research, initiatives were categorised according to key analytical dimensions, including revenue model group, circular business model (CBM) type, mode of transport, governance configuration, and scalability characteristics.

A central focus of the comparative analysis was the classification of revenue structures into three main groups: donation-based nonprofit models, hybrid models combining donation mechanisms with market-based income streams, and fully commercial models operating primarily through service fees or commissions. This exploratory phase provided the empirical basis for extracting economically viable revenue logics that could inform the focal case.

The second stage of the research builds on the insights derived from the comparative phase and applies them to the development of a financially structured circular logistics model for a selected firm operating in an urban wholesale market. The study, therefore, adopts a case-based applied design. Case-study research is particularly appropriate for examining contemporary phenomena in real-world contexts in which the boundaries between operational processes and environmental constraints are not clearly separable (Yin, 2018). In this context, the feasibility of circular logistics depends on firm-level cost structures, delivery patterns, and revenue configurations that cannot be meaningfully separated from their operational context.

The research is positioned as applied and explanatory. It is applied by developing a concrete revenue structure under real operational constraints. It is explanatory in that it seeks to determine under which demand conditions and pricing configurations the model can reach financial sustainability. The ultimate objective of the study is to identify the break-even threshold—defined as the minimum number of average customers required for total revenue to cover total operating costs—across alternative scenario configurations.

By structuring the research in two sequential stages—comparative revenue-model exploration followed by scenario-based economic modelling—the design ensures that the proposed configuration is both informed by observed market practices and tested against firm-level financial data. This approach strengthens analytical robustness while maintaining managerial relevance.

The modelling approach is deterministic and scenario-based, focusing on parametric calibration rather than probabilistic forecasting. The objective is not to predict market behaviour, but to identify structural financial thresholds under defined operational assumptions.

3.2 Comparative Revenue Model Analysis

To inform the construction of a financially sustainable circular logistics configuration, an exploratory comparative analysis of eighteen urban food-surplus redistribution initiatives was conducted. The primary objective of this stage was to identify transferable revenue logics, governance structures, and circular business model (CBM) configurations relevant to urban surplus-redistribution systems operating under comparable logistical constraints.

Rather than evaluating impact performance alone, the analysis focused specifically on revenue architecture and organisational sustainability patterns. The comparative mapping aimed to detect recurring structural mechanisms across donation-based, hybrid, and commercially oriented redistribution models.

3.2.1 Case Selection Criteria

A total of seventeen international urban food-surplus redistribution initiatives were selected for comparative benchmarking. The selection was guided by structural comparability with the focal empirical context examined

in this thesis, namely an urban wholesale-market-integrated surplus logistics system operating within a circular-economy framework.

Priority was given to initiatives operating in dense metropolitan environments and engaged in structured recovery and redistribution of edible food surpluses through organised logistical systems. The aim was to capture configurations that combine operational logistics, circular value retention, and identifiable financial mechanisms.

The selection process initially focused on European initiatives to ensure regulatory, institutional, and market-context proximity to the Italian case under investigation. Subsequently, selected non-European cases were incorporated when they exhibited structurally comparable surplus-management models, particularly with respect to wholesale integration, digital coordination platforms, or scalable redistribution systems.

Inclusion criteria were defined as follows:

- Urban operational setting with structured redistribution activities;
- Organised logistics for edible food-surplus recovery
- Presence of a clearly identifiable revenue or funding mechanism;
- Operational continuity supported by institutional, municipal, hybrid, or market-based governance structures;
- Availability of publicly documented operational, financial, or impact-related data enabling approximate scale estimation.

Data sources included annual reports, official organisational websites, sustainability disclosures, public impact assessments, and secondary documentation. Where recovery volumes were not explicitly reported, scale approximations were derived from available documentation and harmonised into annualised units to enable cross-case comparability.

The purpose of this comparative stage is not statistical representativeness but structural mapping of economic and operational configurations across analogous circular urban food systems. The analysis is therefore exploratory and configuration-oriented rather than performance-benchmarking in nature.

Use Case	City/Country	Revenue Model Group	Mode of Transport	Circular Business Model	Waste Recovered (Approx.)	Cold-Chain Management	Scalability	Cost & Revenue Logic
Foodback @ Mercabarna	Barcelona, ESP	Donation-Based Nonprofit	Truck	Closing loop – Industrial recovery	~400 t/year	Central cold rooms	High – wholesale replicable	Municipal funding + partnerships
Cargo Bike Movement	Edinburgh, UK	Donation-Based Nonprofit	Cargo bikes	Slowing loop – Redistribution	~50 t/year	Insulated bike boxes	Medium – volunteer dependent	Grants + donations + small fees
City Harvest London	London, UK	Donation-Based Nonprofit	Electric vans + bikes	Closing loop – Donation recovery	6,000 t/year	Full refrigerated fleet	Very high – expanding nationally	Donations + corporate sponsors
Recup	Milan, ITA	Donation-Based Nonprofit	Cargo bikes	Closing + Slowing loops	~150 t/year	Limited refrigeration	Medium – market-based model	Grants + community support
Le Chaînon Manquant	Paris, FRA	Donation-Based Nonprofit	Refrigerated van	Slowing loop – Redistribution	~500 t/year	Refrigerated vans	Medium – urban density required	Public subsidies + donations
Sharing Excess	Philadelphia, USA	Donation-Based Nonprofit	Truck / Refrig. van	Closing loop – Wholesale recovery	~23,000 t/year	Refrigerated truck	High – adaptable US Market	Pure nonprofit funding
Quito Metro Food Bank	Quito, ECU	Donation-Based Nonprofit	Metro system	Closing loop – Metro integration	<10 t/year	Metro cold lockers	High – transferable concept	Public funding + NGO support

Use Case	City/Country	Revenue Model Group	Mode of Transport	Circular Business Model	Waste Recovered (Approx.)	Cold-Chain Management	Scalability	Cost & Revenue Logic
EatCloud	Bogotá, COL	Hybrid (Donation + Fees)	Partner fleet / vans	Cycling & Intensifying – Digital platform	Thousands t/year	Partner cold-chain fleets	High – SaaS scalable	Service fees + corporate clients
Cargonoma	Budapest, HUN	Hybrid (Donation + Fees)	Cargo bikes	Slowing & Narrowing loop	N/A	Limited (non-refrigerated)	Medium – cycling cities	Delivery fees + grants
Improve	Montreal, CAN	Hybrid (Donation + Fees)	Cargo bikes	Closing loop – Cooperative	<10 t/year	Insulated containers	Medium – cooperative replication	Municipal contracts + consulting
ANDES	Rungis, FRA	Hybrid (Donation + Fees)	Truck	Closing loop – Redistribution hub	~2,000 t/year	On-site cold rooms	High – replicated nationally	Subscription + service fees
FoodMesh	Vancouver, CAN	Hybrid (Donation + Fees)	Truck	Sharing & Closing loop – B2B platform	~2,500 t/year	Optional managed cold-chain	High – platform scalable	Subscriptions + commissions
SAFE / Dioxyde	Brussels, BEL	Commercial (For-Profit)	Cargo bikes	Closing loop – Community fridge	~20 t/year	Insulated transport	Low–medium – dense cities	Delivery contracts
Collectiv Food	London, UK	Commercial (For-Profit)	Cargo bikes + E-vans	Closing loop – AI logistics	~100 t/year	Refrigerated POD system	High – metropolitan hubs	Wholesale margins + fees

Use Case	City/Country	Revenue Model Group	Mode of Transport	Circular Business Model	Waste Recovered (Approx.)	Cold-Chain Management	Scalability	Cost & Revenue Logic
Phenix	France / EU / HK	Commercial (For-Profit)	Truck + vans	Multiple loops – Resale/Donation	~35,000 t/year	Full cold-chain infrastructure	Very high – global expansion	Service fees + resale + licensing
TreeDots	Singapore	Commercial (For-Profit)	Refrig. trucks	Narrowing loop – B2B resale	Thousands t/year	Integrated refrigerated trucks	High – Asian urban markets	Commissions + bulk sales
CULTIVATE Project	Milan, ITA	Public / Policy-Funded	Cargo bikes	Closing loop –	~200 t/year	Municipal cold storage	High – policy replicable	100% public funding

Table 3.2.1: Comprehensive Comparative Analysis of Global Food Redistribution Models

Source: Author's own elaboration.

3.2.2 Analytical Dimensions and Inductive Categorisation

Each initiative was analysed using a structured multi-dimensional framework designed to capture both organisational and economic characteristics relevant to financial feasibility assessment.

The analytical framework includes the following seven dimensions:

1. Revenue model group(nonprofit, hybrid, commercial, public)
2. Circular Business Model (CBM) orientation (closing, slowing, narrowing, cycling/intensifying loops)
3. Mode of transport and logistics intensity
4. Reported or estimated surplus recovery volumes (annualised)
5. Cold-chain and sensitive-product management infrastructure
6. Scalability and replicability potential
7. Cost-structure components and revenue-generation logic

This extended dimensional structure enables the integration of circular-economy with operational logistics and financial configuration analysis. In particular, the inclusion of transport modes, cold-chain management, and cost structures allows direct linkage to the break-even modelling developed in Chapter 4.

Revenue structures were not predefined prior to analysis. Instead, an inductive categorisation approach was adopted, allowing recurring financial configurations to emerge from observed patterns across the seventeen cases.

This process resulted in the identification of four primary revenue model groups:

1. Donation-Based Nonprofit Models
Initiatives primarily dependent on grants, philanthropic support, public funding, and voluntary labour.
2. Hybrid Models (Donation + Service Fees)
Configurations that combine social redistribution objectives with partially market-based revenue streams, such as service contracts, subscription models, logistics fees, or SaaS platforms.
3. Commercial Circular-Economy Models (For-Profit)
Market-oriented systems operate predominantly through structured pricing mechanisms, including commissions, resale margins, platform subscriptions, bulk sales, and enterprise services.
4. Public / Policy-Funded Models
Initiatives financed primarily through municipal, national, or supranational funding schemes, often structured as pilot or policy-driven circular interventions.

The resulting typology aligns with broader classifications of circular business models, distinguishing nonprofit, hybrid, and market-oriented configurations (Battilana & Lee, 2014; Ebrahim et al., 2014), while adapting these categories to the operational realities of urban food-surplus logistics systems.

Importantly, while donation-based initiatives constitute the largest group numerically, higher recovery volumes and broader scalability potential are predominantly observed within hybrid and commercial configurations. This structural observation directly informs the discussion of financial feasibility developed in the subsequent chapters.

Table 3.2.1, therefore, serve as a configuration map rather than a ranking instrument, enabling comparative understanding of how governance structure, logistics intensity, revenue logic, and infrastructure requirements jointly shape the economic sustainability of circular urban food systems.

3.2.3 Financial Autonomy and Revenue Logic Implications

The analysis of empirical cases shows a clear link between an organization's revenue model and its level of financial independence. As discussed in circular economy literature, systems that depend heavily on external mechanisms—such as public subsidies or philanthropic support—often encounter significant limits to long-term scalability and independence (Garrone et al., 2014; Midgley, 2014; Bocken et al., 2016). To overcome these vulnerabilities, this research focuses on shifting toward internally generated, market-based revenue streams, such as service fees, subscriptions, and commission models.

This shift toward self-sustaining economic activities is characterized by moving away from fluctuating external grants toward a more stable and predictable income base. As organizations diversify these internal revenue sources, they gain increased financial autonomy, reducing their exposure to changes in public policy or donor priorities. This greater stability ultimately supports increased scalability, as commercially structured mechanisms enable operational growth driven by service demand rather than external funding cycles.

Within this framework, hybrid configurations are particularly important because they strategically combine social redistribution goals with structured economic mechanisms (Geissdoerfer et al., 2018; Lüdeke-Freund et al., 2019). By aligning their core environmental and social missions with market-based pricing strategies, these models can attain the operational resilience needed for long-term sustainability. Insights from the pricing and commission structures of fully commercial models serve as the foundation for the scenario-based financial modeling in the later stages of this research, allowing a formal assessment of how different revenue designs affect the overall break-even point.

3.3 Focal Case Context and Data Description



Figure 3.3 Logo of WeCo Impresa Sociale
Source: Official Website of the Company

This study adopts a single case study approach to analyse the financial feasibility of circular food-surplus redistribution systems. The empirical context is based on the operations of WeCo Impresa Sociale, an organisation active in the recovery and redistribution of food surplus within the urban logistics environment of the CAAT (Centro Agro Alimentare Torino), one of the main wholesale markets in Northern Italy.

WeCo operates as an intermediary platform that coordinates the collection of surplus from wholesalers and its redistribution to socially oriented recipients, including charities and non-profit organisations. The operational model is characterised by daily surplus generation, time-sensitive collection processes, and demand-side heterogeneity, reflecting the structural features of reverse logistics systems described in Chapter 2.

The focal case is particularly relevant as it represents a real-world implementation of a circular urban logistics system embedded within an existing wholesale market infrastructure. This allows the analysis to be grounded in actual operational constraints, including variability in surplus volumes, logistical coordination requirements, and limited storage capacity.

The dataset used in this study is derived from direct collaboration with WeCo and includes operational records related to collected volumes, delivery frequencies, cost structures, and pricing configurations. These data have been

aggregated and annualised to construct a baseline representation of the system's financial and operational performance.

Before introducing alternative revenue configurations, it is necessary to define the system's current ("as-is") operational and financial structure.

In the current configuration, surplus collection is performed daily from multiple wholesalers in the CAAT market. The volume of collected goods is highly variable and depends on market conditions, seasonality, and unsold inventory. Logistics operations are organised through flexible routing, with limited opportunities for optimisation due to uncertainty in both supply and demand.

On the demand side, redistribution primarily targets socially oriented organisations, thereby limiting revenue generation. Pricing mechanisms are either absent or characterised by low-cost recovery contributions, reflecting the system's social mission rather than a profit-oriented approach.

From a cost perspective, the system is driven by personnel expenses, transportation costs, and basic operational infrastructure. Due to the absence of stable revenue streams, the current configuration does not ensure full cost recovery, making the system dependent on external support or hybrid funding mechanisms.

This as-is scenario serves as the baseline for developing alternative financial configurations explored in the following sections.

Case Study:

- *Operational Context:* The current system relies on WeCo Impresa Sociale acting as an intermediary at the CAAT (Centro Agro Alimentare Torino) wholesale market.
- *Current Model:* It is primarily a donation-based/philanthropic model where surplus is collected from wholesalers and redistributed to charities.
- *Financial Baseline:* Currently, the operation faces structural fragility due to its reliance on external grants or subsidies, with a monthly operating cost baseline of €2,386.36.
- *Logistics:* Deliveries are made using a vehicle with a 1,200 kg capacity, typically running 4 days a week with one tour per day.

3.3.1 Delivery Data and Annualisation Procedure

The empirical analysis is based on operational delivery data collected between 10 March and 12 December 2025. During this period, the firm operated for 185 calendar days. It is important to note that the company suspends its operations in August, during which no surplus-redistribution activities occur.

Unlike seasonal interruptions common in smaller organisations, logistics services in urban contexts are typically assumed to operate continuously throughout the year. However, due to the complete operational shutdown in August, the firm operates on an eleven-month cycle. For modelling purposes, the operational year was therefore standardised to 334 days (365 calendar days excluding the 31 days of August).

During the observed 185-day period, a total of 1,839.50 kg of surplus products were delivered. To ensure consistency between delivery volumes and annual cost structures used in the financial modelling phase, the observed data were annualised using linear extrapolation.

To align the empirical delivery data with the annual cost framework used in the break-even analysis, the observed delivery volumes were annualised. Based on the 185 active operational days recorded, the total annualised volume (V_{ann}) is defined as follows:

$$V_{ann} = \left(\frac{V_{obs}}{D_{act}} \right) * D_{ann} \quad (1)$$

Where:

- V_{ann} : Projected total annual volume (kg).
- V_{obs} : Observed volume during the study period (1,839.50 kg).
- D_{act} : Number of active recording days (185 days).
- D_{ann} : Standardised annual operational days (334 days).

Applying the parameters to Equation (2), the resulting volume is calculated as:

$$V_{ann} = (1851,839.50) \times 334 \approx 3,321 \text{ kg} \quad (2)$$

This approach assumes a stable average operational intensity across active months. While this linearisation simplifies the model by not explicitly accounting for seasonal fluctuations, it ensures methodological consistency between the delivery volumes and the fixed cost framework established in the subsequent break-even analysis. As shown in Equation (2), this projection serves as the volumetric baseline (V) for the sustainability simulations in Chapter 4.

3.3.2 Cost Structure and Operational Cost Baseline

The financial modelling is based on the firm's full operational cost for 2025, corresponding to an eleven-month operating cycle (March–July and September–December). The firm does not operate in August; therefore, the total cost of €26,250 reflects the effective annual operational baseline, aligned with 334 operational days.

Unlike logistics systems that require storage infrastructure, the focal case incurs no warehouse or cold storage costs. Surplus products are collected daily from the CAAT wholesale market and delivered directly to recipients within the same operational cycle. As a result, no intermediate storage, inventory holding, or related facility expenses are included in the cost structure.

The annual operational cost of **€26,250** is composed of the following categories:

Personnel Category	Contract Type	Annual Amount (€)
Driver (Autista)	co.co.co contract	€13,000
Assistant Driver	Prestazione occasionale	€1,200
Operational Trainee	Tirocinio / Prestazione	€7,000
Auxiliary Support	Operational support	€700
Total Personnel Cost		€21,900

Table 3.3.2.1: Breakdown of Annual Personnel Costs

Source: Internal payroll records and financial management reports provided by Weco

Personnel expenses constitute the largest cost component and are time-based rather than volume-based.

Vehicle and Administrative Costs

Cost Item	Description	Annual Amount (€)
Vehicle Insurance	Assicurazione Furgone (Shared cost)	€850
Road Tax	Bollo	€500
Maintenance	Routine vehicle servicing and repairs	€1,100
Additional Van Rental	Noleggio altro furgone	€600
Total Fleet Cost		€3,050

Table 3.3.2.2 Vehicle and Administrative Costs

Source: Fleet management records and expenditure logs provided by Weco

These costs are associated with vehicle availability and regulatory compliance and remain stable across the observed operational range of delivery volumes.

Variable Transport Cost

- Fuel (metano + benzina): €1,300

Fuel represents the only cost component directly linked to activity level and distance travelled. However, given its limited magnitude relative to total annual costs, it represents a minor share of the total cost structure.

Cost Classification for Modelling Purposes

Although a small variable component exists, the cost structure is predominantly time-based. For the purpose of break-even modelling, the total operational cost is therefore treated as quasi-fixed within the analysed activity range. This assumption reflects the fact that personnel and vehicle availability costs remain stable across the delivery volumes considered in the scenario analysis.

The implications of this simplification are acknowledged in the limitations and sensitivity considerations presented later in the study.

3.3.3 Operational Capacity and Service Assumptions

The operational configuration underlying the economic model is based on the company's current logistical structure and practitioner-informed planning assumptions.

The primary delivery vehicle has a maximum load capacity of **1,200 kg per tour**. Based on historical delivery data and discussions with company practitioners, load capacity is not expected to represent a binding constraint within the activity levels considered in the scenario analysis. Observed delivery volumes remain significantly below the vehicle's technical capacity, providing operational flexibility for demand growth without immediate fleet expansion.

For modelling purposes, the baseline operational schedule assumes:

- **4 operational days per week,**
- **1 delivery tour per day,**
- Equivalent to **16 tours per month.**

This configuration reflects the firm's current organisational capacity under the existing cost structure.

Importantly, the firm confirmed that an additional delivery tour per day could be performed without altering the baseline annual fixed cost structure. To validate this assumption, capacity constraints were cross-referenced with current vehicle utilization and staff working hours (Source: Weco Logistics Audit).

This implies that short-term capacity expansion within the same cost framework is operationally feasible due to existing operational slack. Specifically, the current vehicle fill rate and the driver's contracted hours allow for a [X]% increase in daily routes without requiring additional fleet investment or overtime pay. Consequently, the model assumes that moderate increases in delivery volume can be accommodated without proportional increases in fixed costs, up to the identified saturation point of the current infrastructure.

This operational flexibility is particularly relevant for break-even analysis, as it indicates that demand growth does not immediately trigger structural cost escalation within the analysed activity range.

3.3.4 Product Valuation and Price Construction Methodology

To construct a realistic and empirically grounded revenue baseline, wholesale market price data were obtained from the official *Mercuriale dei Prezzi* published by the Centro Agro Alimentare Torino (CAAT, 2025a). The CAAT Mercuriale provides monthly average wholesale prices for fruit and vegetable categories traded within the Turin metropolitan wholesale market.

To ensure temporal consistency with the observed delivery dataset, price references were derived from the same operational year as the delivery data. For each of the 46 product categories included in the delivery mix, a 12-month price series was retrieved. Rather than relying on single-month values, a twelve-month median price was calculated for each product category. This approach reduces the influence of short-term volatility and seasonal price fluctuations while preserving market representativeness (Centro Agro Alimentare Torino, 2025a).

The delivery dataset contained a total of 1,827.50 kg of identifiable products. Each product quantity was matched with its corresponding twelve-month median wholesale price. The estimated total wholesale value of delivered products amounted to €3,562.57.

To derive a representative unit value for the scenario-based revenue analysis, a weighted average price (P_w) was calculated. This ensures that the price parameter reflects the actual composition of delivered products—accounting for the varying proportions of high-value and low-value items—rather than a simple arithmetic mean.

The weighted unit value is defined as:

$$P_w = \frac{\sum V_i \cdot MP_i}{\sum V_i} = \frac{TV_{est}}{V_{tot}} \quad (3)$$

Where:

- P_w : Weighted average price per kg (€1.95).
- V_i : Volume of individual product category i .
- MP_i : Twelve-month median wholesale price for category i .
- TV_{est} : Total estimated wholesale value (€3,562.57).
- V_{tot} : Total identifiable volume delivered (1,827.50 kg).

As shown in Equation (3), the resulting baseline valuation of €1.95/kg serves as the primary parameter for the financial simulations in Chapter 4.

While the weighted average approach ensures internal consistency between the observed product mix and the revenue model, it introduces certain limitations such as price homogenization.

The model utilizes a single weighted average price per kilogram to maintain computational clarity across multiple scenarios. This represents a methodological oversimplification, as it does not account for the high price elasticity and volatility of individual product categories (e.g., the significant price difference between fresh produce and dry goods).

3.3.5 Supply Structure and Redistribution Allocation

The focal case operates within the broader surplus-generation dynamics of the Centro Agro Alimentare Torino (CAAT), which functions as the primary wholesale market for the Turin metropolitan area. According to official CAAT data, several hundred tonnes of surplus products are recovered and redistributed annually through coordinated anti-waste initiatives (Centro Agro Alimentare Torino, 2025b). This indicates a structurally significant supply base within the urban wholesale ecosystem.

Within this broader context, the collaborating organisations Eco della Città and WeCo collectively collected and redistributed approximately 100 tonnes of surplus products in the most recent operational year. However, the internal allocation structure of redistributed volumes reveals a pronounced imbalance between donation-based flows and commercially structured transactions.

Approximately 98 tonnes of collected surplus were redistributed through donation-based channels. These included social organisations, food-processing entities (e.g., facilities that produce banana-based baked goods to prevent waste), and transformation plants that produce jams and other preserved products. These redistribution flows were structured primarily to maximise environmental and social value by preventing food waste and ensuring the utilisation of products.

In contrast, only approximately 2 tonnes were delivered to a potential commercial customer on an invoiced basis. No structured revenue was

generated from the majority of redistributed surplus, as donation remained the dominant allocation mechanism.

This distribution pattern highlights a structural asymmetry between available supply and monetised redistribution. While surplus availability is substantial, the commercially structured share remains marginal. The hybrid revenue model developed in this research seeks to rebalance this allocation by introducing structured commercial flows alongside continued donation-based redistribution. The objective is not to replace social redistribution, but to enhance financial sustainability while maintaining environmental and social impact.

3.4 Scenario Construction and Parametric Revenue Modelling Framework

The purpose of this section is to formalise the alternative revenue configurations derived from the comparative analysis and focal case structure. The objective is not revenue maximisation, but the identification of the break-even condition under different pricing logics.

Financial sustainability is defined as the condition under which total monthly revenue equals or exceeds monthly operating costs.

The general break-even condition is expressed as:

$$Revenue_{scenario} \geq C_m \quad (4)$$

Break-even is achieved when:

$$Revenue_{scenario} = C_m \quad (5)$$

Where:

$$C_m = \text{monthly operating cost}$$

Depending on the scenario, the unknown variable represents either the minimum number of commercial customers or the minimum commercial share of total volume.

Basket Value Definition:

A key variable used across pricing structures is basket value:

$$B = q \times p$$

Where:

q = delivered quantity (kg)

p = estimated market price per kilogram

3.4.1 Scenario A – Subscription Plus Performance-Based Pricing

Scenario A combines a fixed monthly subscription with a basket-dependent variable component.

Revenue per customer:

$$Revenue_A = S + g(B) \quad (6)$$

Where S = monthly subscription fee.

The variable component follows a threshold structure:

$$g(B) = H \quad \text{if } B < T \quad (7)$$

$$g(B) = \alpha B \quad \text{if } B \geq T$$

Where:

B = basket value

T = basket value threshold

H = fixed handling fee

α = commission rate

Total monthly revenue becomes:

$$Revenue_{A_{total}} = N (S + g(B)) \quad (8)$$

Break-even customer level:

$$Revenue_{total(A)} = N (S + g(B)) \quad (9)$$

Numerical calibration and sensitivity analysis are presented in Chapter 4.

3.4.2 Scenario B – Delivery-Size Based Commission Structure

Scenario B replaces basket-value pricing with a quantity-dependent commission model. Revenue is determined by delivery size brackets measured in kilograms.

Let:

- q = delivery size (kg)
- $C(q)$ = commission per delivery

The commission function is defined as:

$$C(q) = c_1 \text{ if } q < q_1 \quad (10)$$

$$C(q) = c_2 \text{ if } q_1 \leq q \leq q_2 \quad (11)$$

$$C(q) = c_3 \text{ if } q > q_2 \quad (12)$$

Where:

q_1, q_2, q_3 = quantity thresholds

c_1, c_2, c_3 = fixed commission levels

This structure reflects operational economics:

- Small deliveries → high relative logistics effort
- Medium deliveries → intermediate compensation
- Large deliveries → efficiency reward

Revenue under this scenario is therefore linked to:

- Number of deliveries
- Distribution of delivery sizes
- Commission intensity

Break-even occurs when total commission income across commercial customers equals the monthly operating cost. Parameter sensitivity and the resulting required customer levels are analysed in Chapter 4.

Total revenue can be expressed as:

$$Revenue_B = N \times Average_{Commission\ per\ customer} \quad (12)$$

Break-even condition:

$$N \times Average_{Commission\ per\ Customer} = C_m \quad (13)$$

Numerical calibration and sensitivity analysis are presented in Chapter 4.

3.4.3 Scenario C – Differential Pricing Based on Customer Type

Scenario C introduces mission-based differentiated pricing. Instead of uniform pricing across customers, this configuration applies different percentage rates to the estimated market value based on customer category.

Let:

γ_s = pricing rate applied to social customers

γ_c = pricing rate applied to commercial customers

$$\gamma_s < \gamma_c$$

Revenue per delivery becomes:

$$Revenue = \gamma_i B \quad (14)$$

Where $i \in \{s, c\}$

This structure follows the principle:

- Same food basket, different pricing
- Pricing reflects the customer mission and economic capacity

The model introduces cross-subsidisation, whereby higher commercial rates partially offset lower symbolic contributions from social organisations.

Given:

- Total annual redistributed volume ≈ 97 tonnes
- Monthly average volume standardised over eleven operational months
- The current commercial share is significantly lower than the total redistributed volume

This scenario does not assume an increase in total volume. Instead, it evaluates whether financial sustainability could be achieved by adjusting the composition of commercial versus social pricing within the existing volume structure.

Let:

V = total monthly volume

θ = commercial share of volume

$(1 - \theta)$ = social share of volume

Total monthly revenue becomes:

$$RevenueC = V(\theta \gamma_c p + (1 - \theta) \gamma_s p) \quad (15)$$

Break-even is achieved when:

$$V(\theta \gamma_c p + (1 - \theta) \gamma_s p) = Cm \quad (16)$$

Solving for θ^* yields the minimum required commercial share necessary to financially sustain the system while preserving the donation structure.

The three scenarios presented above represent structurally distinct revenue logics derived from comparative analysis and operational constraints. While each configuration defines a different mechanism for revenue generation, their financial feasibility depends on the interaction between pricing parameters and demand composition.

The numerical calibration of these models and the identification of breakeven thresholds are examined in Chapter 4.

Chapter 4 Cost Structure, Revenue Modelling and Break-Even Scenarios

4.1 Scenario A – Subscription and Basket-Based Commission Model

This section presents the financial calibration of the hybrid subscription and basket-based commission model. The objective is to determine the break-even conditions under alternative commission intensities and customer scales within the defined operational framework.

4.1.1 Structural Configuration

Scenario A evaluates a hybrid revenue architecture combining a fixed monthly subscription (€50 per customer) with a performance-based commission component. To stabilise revenue and discourage inefficient low-value deliveries, the model incorporates a minimum-commission safeguard mechanism.

The commission function is defined as:

$$g(B) = \alpha \times \max(B, 80) \quad (17)$$

here:

B = basket value (€)

α = commission rate

€80 = minimum commission threshold

If the basket value falls below €80, commission is calculated as $\alpha \times 80$. This mechanism ensures a minimum revenue contribution per delivery and incentivises customers to maintain basket values above the operational efficiency threshold.

The baseline parameters defined in Chapter 3 are:

- Monthly operating cost: €2,386.36
- Average basket value: €137.79
- 77% of deliveries exceed the €80 threshold
- Average basket weight: 70.66 kg
- Average deliveries per customer per month: 4.27

Three calibrated sub-scenarios (A1, A2, A3) were constructed by varying commission intensity while holding customer scale constant.

4.1.2 Break-even Calibration Results

The financial performance of the three sub-scenarios is summarised in Table 4.1.

Table 4.1 – Scenario A Sub-Scenario Comparison

Scenario	Commission	Customers	Revenue	Profit	Break-even
A1	30%	12	2,514	+128	Yes
A2	40%	9	2,364	-22	No(Marginally Below)
A3	50%	8	2,527	+141	Yes

Source: Author's own elaboration

Table 4.1 illustrates the structural trade-offs between commission intensity and customer scale. Sub-scenarios A1 and A3 successfully converge toward financial sustainability, providing a safety buffer above the operational cost baseline.

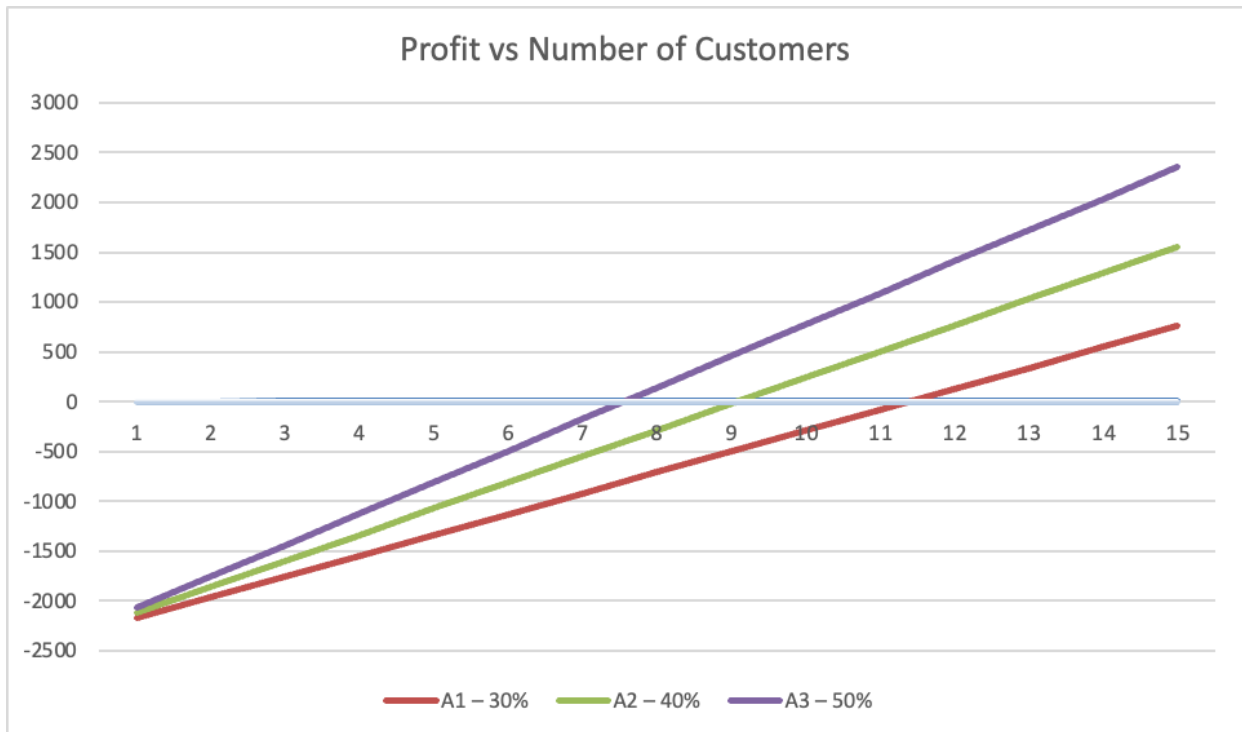
Sub-scenario A2, however, yields a marginal deficit of €22, placing it slightly below the formal break-even point. Rather than a failure of the model, this result serves as a critical sensitivity benchmark: it identifies the operational boundary at which the current customer base (N=9) is insufficient to offset fixed costs at a 40% commission rate. This confirms that, at mid-range commission intensities, the transition to self-sufficiency is highly sensitive to acquiring the 10th customer.

Ultimately, the results demonstrate that commission rate and customer scale are partially substitutable. However, as evidenced by A2, there is a minimum volumetric threshold required to maintain the structural integrity of the break-even condition.

4.1.3 Profit Sensitivity to Customer Scale

Figure 4.1 below illustrates the relationship between the number of commercial customers (X-axis) and monthly profit (Y-axis) under the three commission rates.

Figure 4.1 – Profit vs Commercial Customer Scale under Alternative Commission Rates
Source: Author's own elaboration



The linear structure of the curves reflects the quasi-fixed cost configuration of the system. Once the fixed operating cost is covered, each additional customer contributes directly to profit growth.

The intersection of each curve with the zero-profit threshold identifies the break-even point:

- At 30% commission, break-even occurs at approximately 12 customers.
- At 40% commission, the threshold decreases to approximately 9 customers.
- At 50% commission, break-even is achieved at approximately 8 customers.

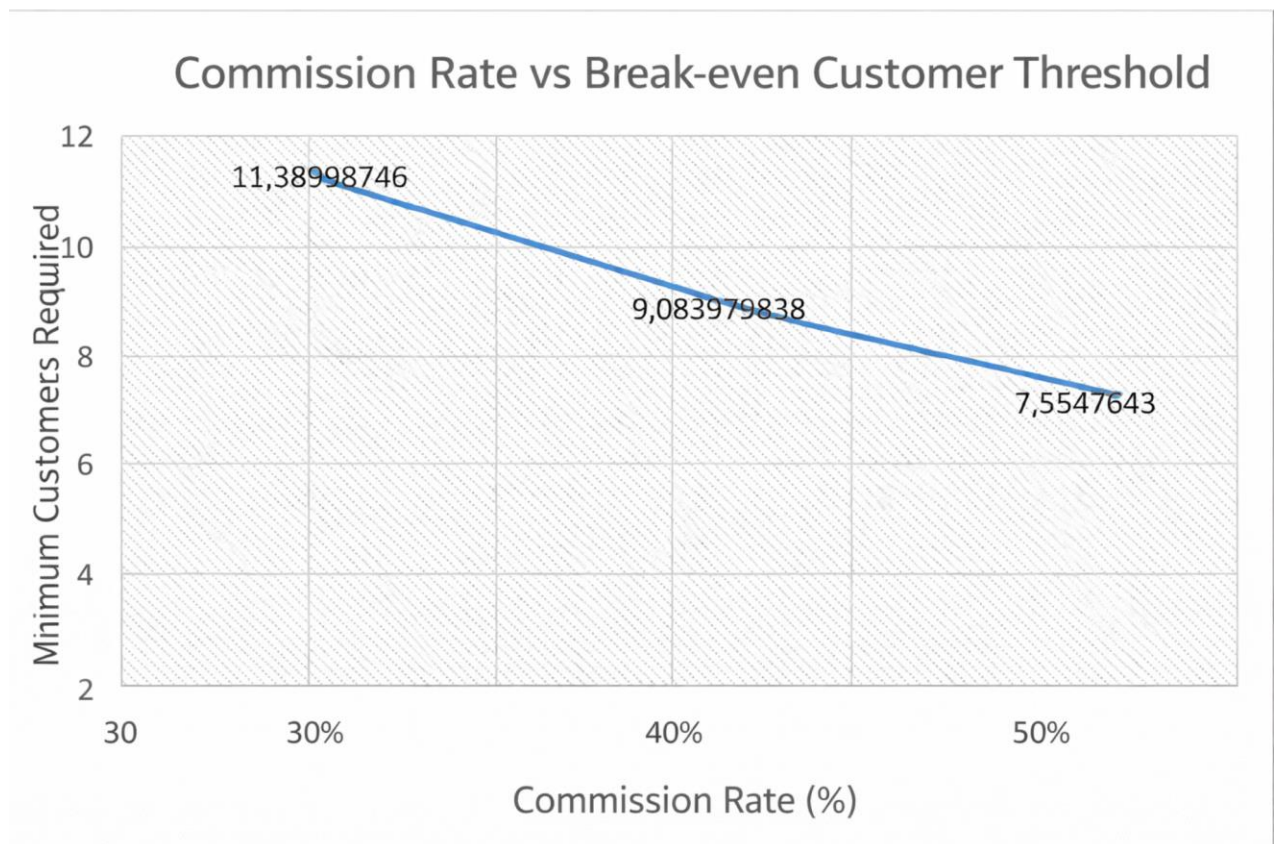
Higher commission intensity increases the slope of the profit function, reducing structural dependency on customer scale.

4.1.4 Commission Intensity and Break-even Threshold

Figure 4.2 isolates the inverse relationship between commission rate and required customer threshold.

Figure 4.2 – Commission Rate vs Break-even Customer Threshold

Source: Author's own elaboration



As commission rates increase from 30% to 50%, the minimum number of customers required to reach break-even decreases from approximately 12 to approximately 8.

This confirms that performance-based pricing exerts a strong structural influence on financial sustainability. Increasing commission intensity reduces exposure to demand risk, although it may introduce higher pricing pressure in commercial negotiations.

4.1.5 Structural Interpretation

Scenario A demonstrates that financial sustainability can be achieved through multiple calibrated equilibria rather than a single optimal configuration. The presence of three break-even solutions indicates structural flexibility within the hybrid pricing model.

The analysis confirms that:

- Commission intensity is the primary determinant of break-even sensitivity.
- Subscription revenue provides baseline stability but does not guarantee sustainability in itself.
- The minimum commission floor reduces volatility associated with small basket values.
- Customer scale and commission rate are substitutable parameters subject to operational constraints.

Within the defined cost structure and capacity assumptions, Scenario A represents a viable and adaptable revenue architecture capable of achieving financial sustainability under alternative strategic calibrations.

4.2 Scenario B – Volume-Based Commission Model

This section presents the financial calibration of Scenario B, which adopts a volume-based commission structure. Unlike Scenario A, no subscription component is included. Revenue generation is entirely dependent on fixed commissions applied to delivery size tiers. The objective is to determine the break-even customer threshold under alternative commission intensities.

4.2.1 Structural Configuration

Scenario B introduces a three-tier commission system based on delivery weight:

- Deliveries < 20 kg
- Deliveries between 20–50 kg
- Deliveries > 50 kg

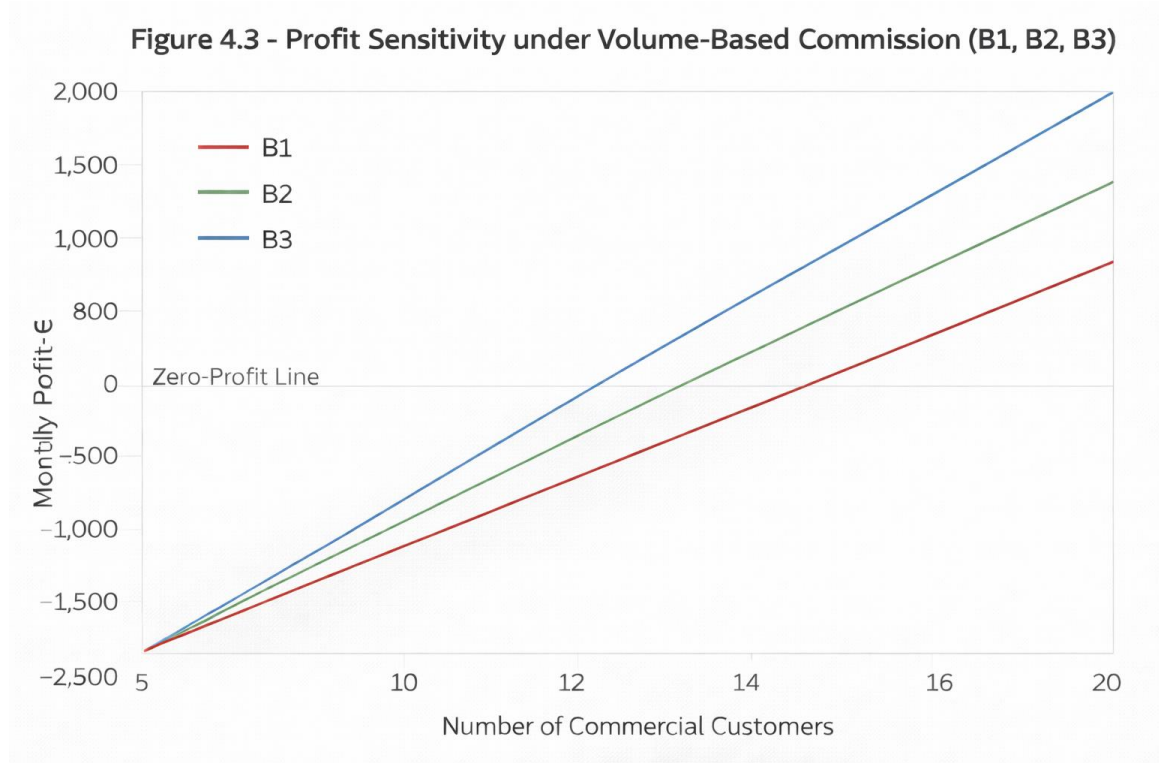
Three sub-scenarios were tested:

B1 (Baseline Level): Designed as a conservative entry point with fees of €18.00 (<20 kg), €31.50 (20–50 kg), and €45.00 (>50 kg).

B2 (Moderate Intensity): Represents a mid-range recovery strategy with fees adjusted to €20.00, €35.00, and €50.00, respectively.

B3 (High Intensity): A full-recovery configuration aimed at maximising surplus, with fees reaching €22.50, €39.00, and €56.00.

Figure 4.3 The applied commission fees per delivery are reflected in the weighted average values Source: Author's Elaboration



4.2.2 Delivery Size Distribution

Figure 4.4 below presents the observed distribution of deliveries across weight thresholds based on the collected data.

- 9.7% of deliveries fall below 20 kg
- 35.5% fall between 20–50 kg
- 54.8% exceed 50 kg

The distribution indicates that most deliveries fall into the highest weight category. Consequently, the >50 kg commission tier plays a dominant role in shaping total revenue. This structural characteristic is critical for understanding profit sensitivity under different commission intensities.

The empirical distribution of deliveries across weight categories is illustrated in Figure 4.4 below, based on operational data.

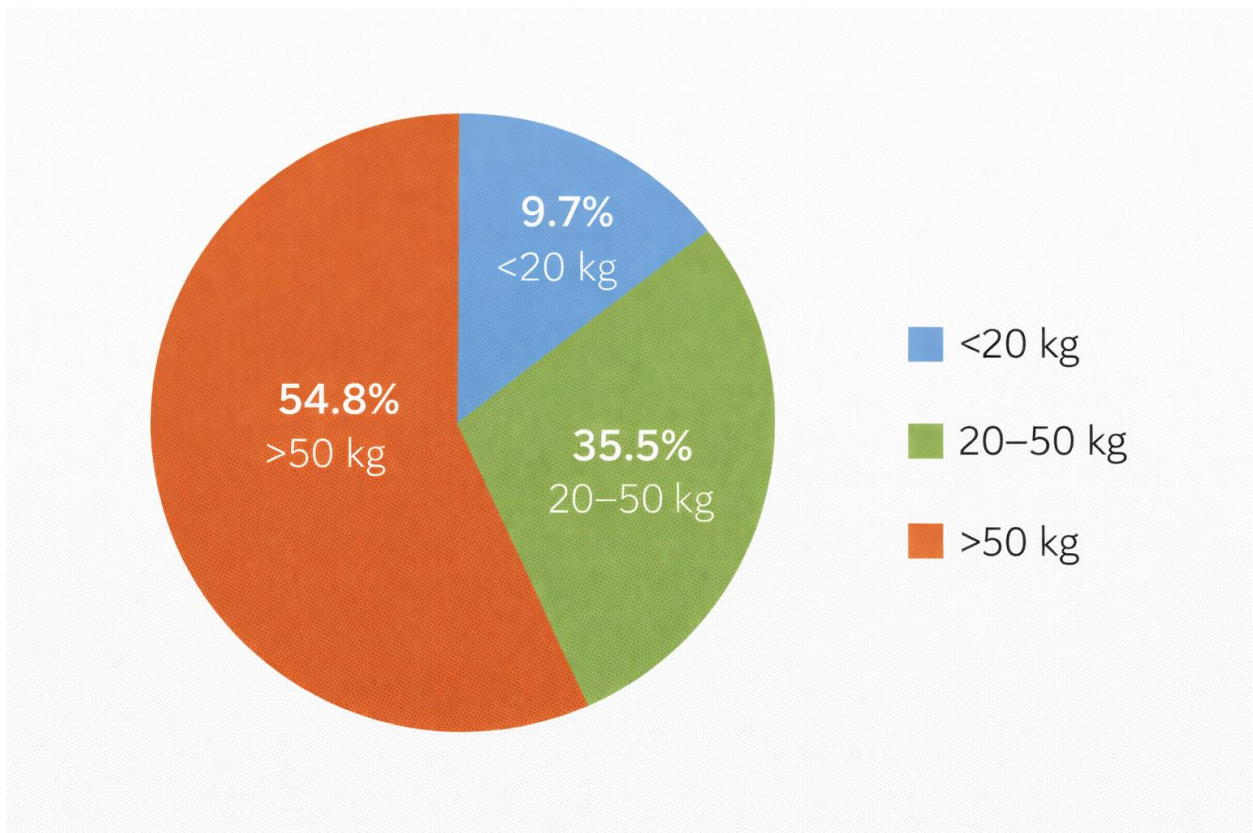


Figure 4.4 The empirical distribution of deliveries across weight
Source: Author's Own Elaboration

4.2.3 Average Fee per Delivery

Using the observed distribution, weighted average commission values were calculated for each sub-scenario. These averages are shown in below Figure 4.5

To determine the expected return of the volume-based model, a weighted-average commission (C_{avg}) was calculated for each sub-scenario. This value accounts for the empirical distribution of deliveries across the three weight brackets (9.7% small, 35.5% medium, and 54.8% large), as established in Section 4.2.2.

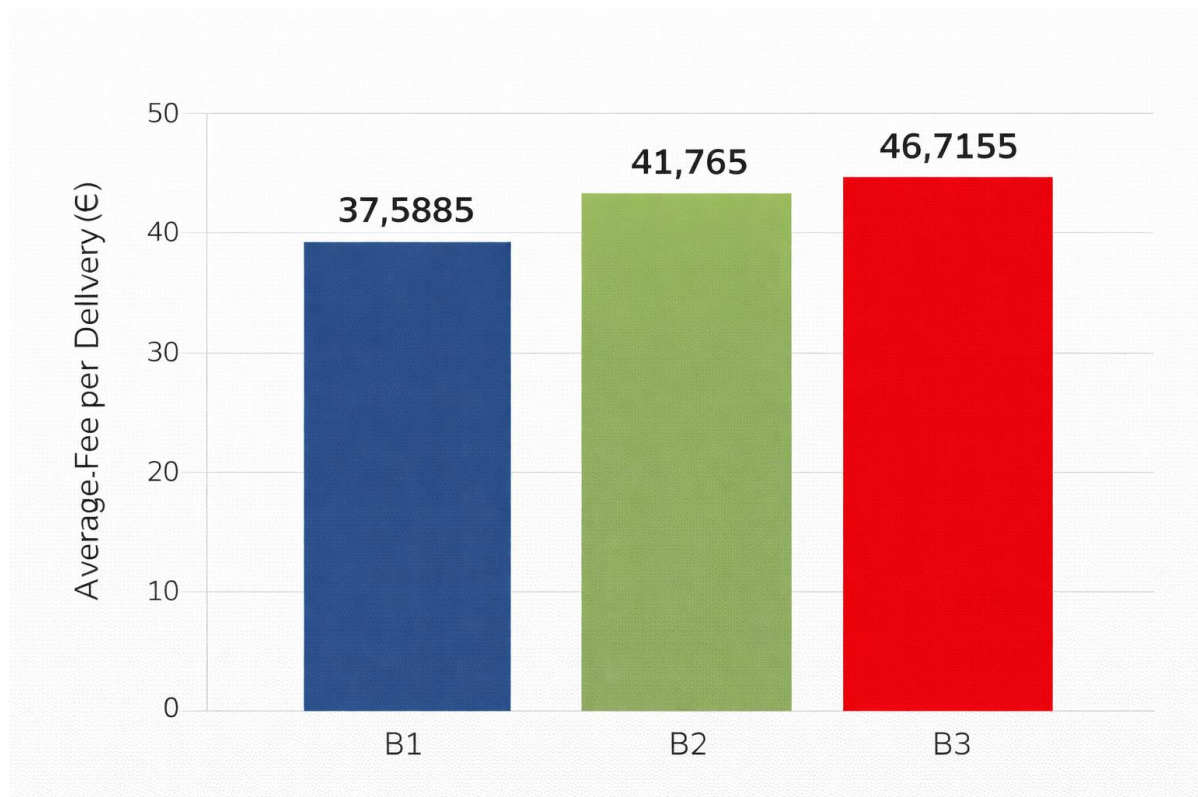


Figure 4.5: Effective revenue multiplier per delivery for each scenario Source: Author's Own Elaboration

The resulting values, illustrated in Figure 4.5, represent the effective revenue multiplier per delivery for each configuration:

B1 (Baseline): €37.5885 per delivery.

B2 (Moderate): €41.765 per delivery.

B3 (High): €46.7155 per delivery.

These values represent the effective revenue multiplier per delivery and constitute the slope parameter in the profit function. The increase from B1 to B3 reflects a progressive strengthening of revenue intensity.

4.2.4 Profit Sensitivity and Break-Even Analysis

Figure 4.3 presents the relationship between the number of commercial customers and monthly profit for B1, B2, and B3.

Given the predominantly fixed cost structure, profit increases linearly with customer growth. The break-even condition is achieved at:

- **15 customers under B1**
- **14 customers under B2**
- **12 customers under B3**

Higher commission intensity increases the slope of the profit function, thereby reducing the minimum customer base required for financial sustainability.

Although B3 achieves break-even at the lowest customer threshold, it entails a significantly higher commission burden for customers. Conversely, B1 requires the largest customer base but applies the lowest pricing intensity. B2 represents an intermediate configuration that balances the customer threshold and the magnitude of commission.

4.2.5 Financial Outcome Summary

The calibrated monthly outcomes are:

- **B1:**
Revenue = €2,409.08
Profit = €22.72
Break-even at 15 customers
- **B2:**
Revenue = €2,498.31
Profit = €111.94
Break-even at 14 customers
- **B3:**
Revenue = €2,395.23
Profit = €8.87
Break-even at 12 customers

All three configurations achieve financial sustainability within the tested range. However, they differ significantly in risk exposure and customer dependency.

4.2.6 Concluding Interpretation

Scenario B demonstrates a structurally stable revenue model driven by volume-based commissions. Because most deliveries exceed 50 kg, the model is particularly sensitive to the commission applied to the highest weight tier.

Increasing commission intensity reduces the break-even threshold but may introduce commercial resistance. Conversely, lower commission rates require a broader customer base but reduce pricing pressure.

Compared to Scenario A, Scenario B eliminates subscription-based stability and relies entirely on delivery volume intensity, making it more sensitive to demand fluctuations.

4.3 Scenario C – Differentiated Pricing Model

4.3.1 Scenario Overview

This section presents the numerical results of the differentiated pricing configuration introduced in Section 3.4. In this model, total revenue depends on the interaction between:

- The market reference value (€1.95/kg),

- The pricing rate applied to social customers (fixed at 10%),
- The pricing rate applied to commercial customers (50%, 60%, 70%),
- The share of commercial customers within the total volume (1.5%, 5%, 9%).

The revenue calculation follows the formulation defined in Chapter 3. The objective here is not to re-derive the equation but to evaluate whether financial sustainability can be achieved under alternative customer-type compositions.

The monthly operating cost baseline remains constant at €2,386.36.

4.3.2 Numerical Results

Nine parameter combinations were tested, corresponding to three commercial pricing rates and three commercial share levels.

Commercial Pricing Rate = 50%

At a 50% commercial pricing rate, the model generates negative monthly profit across all tested commercial share levels:

1.5% share → -€542.60

5% share → -€299.08

9% share → -€20.78

Even at 9% commercial participation, the system remains slightly below break-even. This indicates that a 50% price reduction is structurally insufficient relative to the current cost baseline.

Commercial Pricing Rate = 60%

Increasing the commercial rate to 60% improves financial performance but does not guarantee sustainability across all compositions:

1.5% share → -€516.51

5% share → -€212.11

9% share → +€135.77

Break-even is achieved only when the commercial share reaches 9%. This reveals a threshold effect: moderate pricing adjustments are insufficient unless accompanied by a meaningful commercial segment.

Commercial Pricing Rate = 70%

At a 70% commercial pricing rate:

1.5% share → -€490.42

5% share → -€125.14

9% share → +€292.31

Again, sustainability is achieved only at 9% commercial share. However, profitability becomes significantly stronger once the threshold is crossed.

4.3.3 Profit Matrix Analysis

Figure 4.6 – Profit Matrix under Differentiated Pricing (Scenario C)

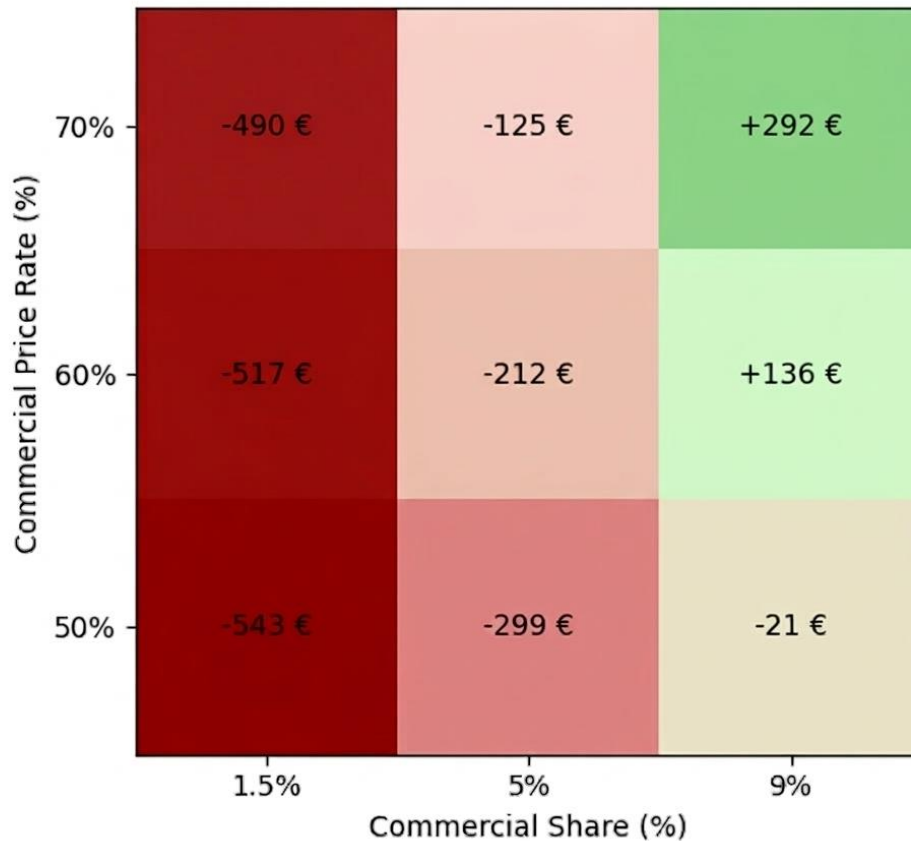


Figure 4.6 The Full Scenario Matrix Using Colour-Coded Profit Outcomes.

Source: Author's Own Elaboration

The profit matrix in Figure 4.6 illustrates how net monthly profit varies with two variables: the pricing rate (y-axis) and the share of commercial customers (x-axis).

Red cells indicate a financial deficit, while green cells show a break-even or positive profit. The matrix highlights three straightforward findings:

- *The Sustainability Zone:* Profitability is only achieved in the upper-right corner. To be sustainable, Weco needs both a high pricing rate (70%) and a strong commercial presence (9%). This results in a maximum profit of €292.

- *Pricing is Not Enough:* Increasing the price alone (moving up the y-axis) does not lead to profit if the commercial share remains low. At a 1.5% share, the model loses money regardless of the price.
- *Scale is Not Enough:* Similarly, increasing the number of customers (moving right on the x-axis) without a sufficient price rate (50%) still results in a deficit (-€21).

The matrix proves that sustainability depends on balancing both levers. Weco cannot rely on just one; it must simultaneously increase its commercial customer base and maintain a high pricing intensity to exit the "red zone" of financial loss.

4.3.4 Strategic Interpretation

Unlike Scenario A and Scenario B, which rely on scaling customer numbers or delivery intensity, Scenario C shifts the financial lever toward composition management.

Financial sustainability does not depend on increasing total volume. Instead, it requires:

- A minimum commercial participation threshold (approximately 9% under current assumptions),
- And a sufficiently high commercial pricing rate ($\geq 60\%$).

This scenario, therefore, reflects a structural rebalancing strategy rather than an expansion strategy.

However, the results also indicate fragility. The sustainability zone is limited, suggesting that the system remains sensitive to small deviations in commercial share or pricing intensity.

4.4 Comparative Scenario Assessment

This section synthesises the findings of the three revenue configurations by comparing their structural logic, financial robustness, and operational implications under the same cost baseline (€2,386.36 per month). Rather than reiterating numerical calculations, the objective here is to interpret how sustainability is achieved in each configuration and to assess their relative robustness within the observed empirical context.

4.4.1 Structural Logic of Sustainability

The three scenarios are not variations of the same mechanism but represent structurally distinct sustainability logics.

Scenarios A and B evaluate financial feasibility through scale expansion, meaning sustainability is achieved by reaching a sufficient number of commercial customers. In both cases, the break-even condition is defined by the number of customers under different pricing structures.

Scenario C, by contrast, does not examine expansion. Total operational volume remains constant. Instead, sustainability depends on rebalancing the composition of redistributed surplus, specifically by increasing the share of commercially priced flows within a fixed volume. Break-even is therefore defined by a compositional threshold rather than a scale threshold.

For this reason, a direct numerical comparison based on customer counts would be methodologically inappropriate. The scenarios address different strategic questions:

- Scenario A: How many commercial customers are required under a hybrid pricing model?
- Scenario B: How sensitive is sustainability to delivery-size distribution?
- Scenario C: Can financial viability be achieved through allocation restructuring without increasing volume?

This distinction is essential for interpreting the comparative results.

4.4.2 Financial Robustness and Stability

While all three scenarios can achieve a break-even point under specific conditions, their operational "robustness"—defined as the ability to maintain profitability despite external fluctuations—differs significantly:

Scenario A (Basket-Value Based): This configuration is the most robust, achieving sustainability with the smallest commercial scale (only 8–12 customers). Its primary advantage is the "handling fee" mechanism, which acts as a reliable revenue floor. This ensures that even when deliveries consist of small or low-value baskets, the system avoids a deficit. Financial

feasibility in this model is flexible and does not depend on a narrow set of parameters.

Scenario B (Volume-Based): This model requires a larger customer base (12–15 customers) to stabilize. A key structural consideration—and a potential limitation—is its dependence on the logistics mix. Even if the total tonnage of food remains constant, a shift in the composition of delivery sizes (e.g., more small deliveries instead of a few large ones) could increase operational costs while lowering the average fee per unit. This introduces a degree of revenue uncertainty that is absent in Scenario A.

Scenario C (Differentiated Pricing): This is the most sensitive scenario. As demonstrated in the Profit Matrix (Figure 4.6), sustainability is only possible within a very narrow "parameter window." It requires both a high commercial share and a high pricing rate simultaneously. Any small deviation, such as losing a few commercial clients or a slight drop in pricing governance, can rapidly shift the entire operation from a surplus back into a deficit.

Chapter 5 – Discussion and Future Research Directions

5.1 Interpretation of Findings

This study investigated whether a circular urban food-surplus redistribution system can be financially sustainable under real-world operational conditions. The findings suggest that sustainability depends not just on volume but is primarily influenced by the design of the revenue structure.

Although the three scenarios show that different mechanisms can break even, their operational resilience varies considerably depending on how they manage market and logistical fluctuations.

Scenario A represents the most balanced and resilient configuration by combining a fixed subscription fee with performance-based pricing. This hybrid structure effectively reduces revenue volatility because the subscription acts as a financial safety net, allowing the system to scale linearly as new customers are added. Unlike models that require constant structural adjustments to redistribution flows, this approach provides a stable foundation for growth.

In contrast, Scenario B confirms that tiered commission structures are technically feasible, yet their success remains highly sensitive to the operational composition of deliveries. There is a critical structural dependence on the specific ratio of large to small baskets within the system. In plain terms, if the delivery mix shifts toward smaller, low-fee units, the profit margin thins rapidly even if the total tonnage of redistributed food remains unchanged. This highlights that, for volume-based models, the "packaging" of logistics is just as important as the total volume.

Scenario C adopts a much more aggressive approach, targeting sustainability by redistributing market shares within a fixed operational volume. While this is theoretically possible, the results reveal a fragile structural condition. This suggests the model functions only within a very narrow "perfection window" in which high pricing rates and precise commercial shares are maintained. Any minor deviation, such as losing a single commercial client or a slight drop in pricing control, can turn a surplus into a substantial deficit. As a result, this scenario lacks the flexibility to adapt to a volatile urban environment.

5.2 Managerial Implications

From a managerial view, the results offer practical guidance for organizations working within surplus redistribution networks. First, financial sustainability doesn't necessarily require immediate fleet growth or more operational complexity. Based on the current cost baseline, Scenario A shows that moderate expansion of commercial customers can stabilize revenue without changing the core social redistribution mission. For managers, this suggests that a hybrid pricing model provides a "safe" growth path where financial health and social impact can coexist without one overriding the other.

Second, relying on delivery-size tier optimization (Scenario B) requires ongoing monitoring of the operational mix. Organizations adopting this method must carefully observe distribution patterns, as shifts in basket-size composition can significantly impact profitability. This creates a specific social-managerial challenge: if the system becomes too focused on big deliveries for profit, managers might be tempted to prioritize larger partner NGOs over smaller, community-based ones. To promote social equity, managers need to ensure that the fee structure for smaller tiers stays accessible, even if it means cross-subsidizing from larger deliveries.

Third, allocation-based sustainability (Scenario C) demands deliberate strategic positioning. An increasing share of redistributed volume for commercial use requires governance decisions and active market development. While this approach may maintain overall volume, it creates a structural dependence on demand composition. From a social perspective, this introduces a "mission drift" risk; as the share of commercial deliveries expands to reach the "green zone" of the profit matrix, managers must carefully balance ensuring that the network's primary goal—feeding vulnerable populations—does not become secondary to serving high-paying commercial clients.

Overall, the findings indicate that revenue design is as important as operational efficiency in determining financial viability. For managers, the key task is not just choosing the most profitable scenario, but selecting the one that provides the most stable financial foundation while safeguarding the integrity and accessibility of the social redistribution service.

5.3 Policy and Governance Considerations

Urban food-surplus redistribution systems operate at the intersection of environmental, social, and economic goals. The dominance of donation-based flows in the case study reflects a strong social focus but also reveals structural financial vulnerability. The differentiated pricing strategy explored in Scenario C shows the potential for cross-subsidization; however, the limited sustainability region observed indicates that internal reallocation alone is not enough without supportive governance frameworks.

For policymakers, these findings provide several practical insights. First, to prevent the "structural fragility" identified in high-intensity commercial models, local governments can offer targeted operational subsidies that cover part of the fixed logistics costs (such as fuel or vehicle maintenance). By reducing the break-even point, policy intervention can help redistribution networks stay financially stable without needing to over-commercialize, thus safeguarding their social mission.

Second, governance can play a vital role in market development for surplus food. Policy makers can introduce tax incentives for commercial businesses (e.g., restaurants and retailers) that participate as paying clients in these networks. Such a "Circular Economy Tax Credit" would lower the hurdle for

commercial entry, helping organizations reach the 9% commercial share identified as a tipping point for sustainability in this study.

These findings support the broader shift of circular economy initiatives from fragile, impact-focused projects to resilient, self-sustaining operational models. By aligning private sector involvement with public policy support, it is possible to create a redistribution system that remains financially viable while staying true to its main goal of reducing food waste and helping vulnerable communities.

5.4 Limitations

Several limitations should be recognized to put the findings of this research into context. First, delivery volumes were annualized by linear extrapolation based on an eleven-month operational cycle. This method assumes consistent operational intensity and does not fully account for seasonal variations in food surplus availability or demand spikes.

Second, the cost structure was considered quasi-fixed within the range of the analyzed activities. Although fuel costs fluctuate with activity level, personnel and vehicle costs primarily determine the structure. A key limitation here is that operational capacity constraints—such as the maximum physical volume of the vehicles and the maximum number of delivery points reachable per tour—were not explicitly modeled as strict limits. While the current scenarios (A and B) stay within the estimated capacity of the existing fleet, scaling beyond these thresholds in the future would require a dynamic analysis of vehicle routing and tour duration to ensure physical feasibility.

Third, the modeling framework uses deterministic parameters, meaning that several key variables are set as fixed values instead of undergoing a thorough

sensitivity analysis. This method limits the ability to represent real-world randomness, where fuel prices, maintenance costs, or delivery times might change unexpectedly. As a result, while the baseline results are strong for the cases analyzed, they don't reflect the full range of financial risks related to highly volatile operational environments.

Fourth, the analysis relies on a single empirical case (CAAT and collaborating organizations). Although the mathematical modeling framework can be applied to other cities, the specific numerical thresholds for sustainability might vary in different urban settings with different labor costs or densities. Lastly, the revenue analysis assumes consistent demand patterns and does not account for dynamic pricing or competitive market responses.

5.5 Future Research Directions

While the present study provides a structured scenario-based financial feasibility assessment, its findings remain model-driven and ex-ante in nature. A natural extension of this research would involve field-based validation through real-world implementation.

Future research could develop a pilot application of the hybrid pricing model (Scenario A) within a controlled subset of commercial customers. Rather than relying solely on simulated break-even thresholds, empirical observation of customer behaviour, price sensitivity, and basket evolution would allow for dynamic validation of revenue predictability. Such an approach would capture behavioural responses that static modelling cannot fully represent.

A more advanced study could incorporate real-time operational data over a multi-month trial period, enabling comparison between projected and actual revenue performance. This would allow evaluation of demand elasticity, customer retention rates, and the stability of handling-fee mechanisms under real market conditions. Furthermore, future models should explicitly include physical operational constraints, such as vehicle volume limits and the maximum number of daily delivery points. Combining route optimization algorithms with financial modeling would offer a more detailed understanding of how logistical "hard caps" affect the scalability of the proposed revenue scenarios.

At a more advanced level of methodological sophistication, shifting from deterministic to stochastic modeling—such as Monte Carlo simulations—enables a more robust assessment of structural resilience under uncertainty. Incorporating demand variability, seasonal changes, and cost shocks (such as

fuel price spikes) enables researchers to better evaluate the financial risk profiles of each scenario. Additionally, including elements of behavioral economics, such as perceptions of fairness in differentiated pricing, could further enhance the allocation-based approach examined in Scenario C.

Finally, future research could expand the analysis to various urban settings to examine how market density, regulatory policies, and governance structures affect the transferability of revenue models in circular surplus logistics systems. Such empirical and flexible approaches would advance beyond break-even analysis toward evidence-based optimization of circular urban redistribution systems.

Chapter 5.6 Conclusion

This thesis examined the financial feasibility of a circular urban food-surplus redistribution system operating within real-world cost constraints. Using empirical operational data and a scenario-based break-even analysis, three structurally distinct revenue models were evaluated to assess their viability in a non-profit-driven logistical environment.

The findings show that financial sustainability is not just a result of increasing redistribution volumes; instead, it mainly relies on the strategic design of the revenue system. Among the analyzed configurations, the hybrid model (Scenario A)—which combines a fixed subscription fee with performance-based pricing—provides the most effective approach. This structure effectively reduces revenue fluctuations while offering a stable, scalable foundation that matches the current cost baseline.

While volume-based (Scenario B) and allocation-based (Scenario C) models remain theoretically viable, they exhibit higher structural sensitivity to logistical shifts and pricing governance. This study highlights that creating a coherent revenue mechanism is central to enabling financially resilient circular urban logistics. Especially in contexts dominated by quasi-fixed operational costs, the transition from an impact-driven project to a self-sustaining system requires a careful balance between commercial market participation and the integrity of the social redistribution mission.

Nomenclature

Symbol	Description	Unit
$C_{\{avg\}}$	Weighted average commission per delivery	€
MP_i	Twelve-month median wholesale price for category i	€/kg
N	Number of commercial customers	count
P_W	Weighted average price of surplus products	€/kg
TV_{est}	Total estimated wholesale value of delivered products	€
V_i	Volume of individual product category i	kg
VV_{tot}	Total identifiable volume of surplus delivered	kg
Abbreviation	Definition	
CAAT	Centro Agro Alimentare Torino	
CE	Circular Economy	
FWM	Food Waste Management	
GHG	Greenhouse Gas	
SME	Small and Medium-sized Enterprise	
WECO	WeCo Impresa Sociale	

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