

MASTERS IN
MANAGEMENT AND INDUSTRIAL STRATEGY

MASTER'S FINAL WORK
DISSERTATION

**FROM ADOPTION TO INTERNALIZATION: A CASE STUDY ON
SMART LOCKERS BY CTT**

ISABEL MARIA REIS CARVALHAL

SEPTEMBER-2025

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ABSTRACT

The growing complexity and pressure in last-mile logistics have pushed traditional postal operators to adopt new delivery solutions. Smart lockers are one of these solutions, emerging as a strategic innovation that addresses operational challenges and offers flexibility and convenience. Internal goals and external pressures often drive the adoption of these innovations, and as these solutions become more critical in operations, organizations are faced with complex decisions on how to implement them in a way that ensures benefits, adaptability and long-term competitiveness.

The case study of CTT is used to understand the adoption and development of the smart locker solution as a response to last-mile challenges. By analyzing the development process, the decision-making dynamics and technical design choices, the study seeks to explain the rationale behind the internalization strategy.

In this research, a qualitative method was adopted to understand subjective experiences, organizational perspectives, and the broader contextual factors. The data was collected using semi-structured interviews complemented with data from internal and online documents.

Findings revealed that the decision to internalize was driven not only by high market costs and lack of flexibility but also by a strategic view of this type of solution. The decision evolved into a broader strategy for retaining control and knowledge over the solution. This development was implemented by combining internal coordination with national specialized partnerships. The solution was designed in a modular system architecture that enables scalability and cost reduction. This study contributes to the literature by demonstrating how infrastructure-oriented solutions can transform from reactive cost-saving initiatives into long-term enablers of organizational differentiation, learning, and autonomy.

Keywords: logistics innovation, make-or-buy, last-mile delivery, smart lockers.

RESUMO

A crescente complexidade e pressão na logística de última milha levaram os operadores postais tradicionais a adotar novas soluções de entrega. Os cacifos inteligentes são uma dessas soluções, surgindo como uma inovação estratégica que aborda os desafios operacionais e oferece flexibilidade e conveniência. Objetivos internos e pressões externas muitas vezes impulsionam a adoção dessas inovações e, à medida que essas soluções se tornam mais críticas nas operações, as organizações deparam-se com decisões complexas sobre como implementá-las de forma a garantir benefícios, adaptabilidade e competitividade a longo prazo.

O estudo de caso dos CTT é utilizado para compreender a adoção e o desenvolvimento da solução dos cacifos inteligentes como resposta aos desafios da última milha. Ao analisar o processo de desenvolvimento, a dinâmica de tomada de decisões e as escolhas de *design* técnico, o estudo procura explicar a lógica por detrás da estratégia de internalização. Nesta investigação, foi adotado um método qualitativo para compreender experiências subjetivas, perspetivas organizacionais e fatores contextuais mais amplos. Os dados foram recolhidos através de entrevistas semiestruturadas, complementadas com dados de documentos internos e online.

Os resultados revelaram que a decisão de internalizar foi motivada não só pelos elevados custos de mercado e pela falta de flexibilidade, mas também por uma visão estratégica deste tipo de solução. A decisão evoluiu para uma estratégia mais ampla de manter o controlo e o conhecimento sobre a solução. Este desenvolvimento foi implementado combinando a coordenação interna com parcerias nacionais especializadas. A solução foi concebida numa arquitetura de sistema modular que permitiu escalabilidade e redução de custos. Este estudo contribui para a literatura ao demonstrar como as soluções orientadas para a infraestrutura podem transformar-se de iniciativas reativas de redução de custos em facilitadores de longo prazo da diferenciação, aprendizagem e autonomia organizacionais.

Palavras-chave: inovação logística, *make-or-buy*, entrega na última milha, cacifos inteligentes.

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1. INTRODUCTION

Innovation in logistics has evolved beyond process optimization to become a more strategic asset in competitive advantage (Grawe, 2009). Particularly, in the last-mile file, new innovative solutions have gained relevance, such as smart locker technology that has proven to be critical, providing convenience, security, and efficiency. The increasing demand for fast, efficient and sustainable delivery solutions has transformed logistics, giving a crucial place to innovation. Smart lockers are emerging as critical technology reducing the gap between customers' expectations and sustainability issues (Schnieder, Hinde, West, 2021).

While the adoption of these solutions, their advantages and prospects have been studied in literature, the strategic decisions behind how these solutions are sourced and developed remain less explored. The literature has explored factors that influence the decision to adopt logistics innovations, such as firm size, R&D intensity, product innovation, international market engagement, and competitive pressure. But the internal process that unfolds once adoption occurs is the main goal for this study. Should companies acquire a ready-to-use solution, or invest in building their own solution?

Strategic sourcing choices involve weighing factors such as long-term control, knowledge retention, flexibility and cost. Firms tend to internalize when transactions involve high uncertainty or asset specificity, to reduce coordination and mitigate dependency (Williamson 1975, 1985). At the same time, when a resource is considered strategically critical, building it internally can provide competitive advantage and long-term positioning (Barney, 1991). Operational inefficiencies, costs, combined with modular design and automation, can also drive firms to internalize development (Nujen, Halse, & Solli-Sæther, 2015).

This study aims to explore and investigate the case of CTT, a postal company and logistic operator that opted for the development of smart lockers internally, also known as Locky. The goal of this research is to explore the motivations behind the internalization of development, as well as the factors that shaped the decision over time. It also aims to understand how logistics solutions contribute to this choice.

Regarding the context, this study was guided by two central research questions:

RQ1: What are the factors that influence the make-or-buy decision in logistics innovation?

RQ2: How did last-mile solutions shape and justify the decision to internalize the development?

To answer this question, a qualitative case study was conducted, combining semi-structured interviews with key decision makers and analysis of internal and online documentation. The theoretical framework blends insights from innovation drivers, make-or-buy decisions frameworks, along with recent research on logistics innovations and Smart lockers infrastructure.

This work is organized into five chapters. Followed by this introduction, a review of the literature was conducted in chapter two. The third one presents the methodological approach used in the research. The fourth chapter contains the analysis of empirical findings and finally, the fifth chapter summarizes the conclusions, highlighting contributions and limitations and directions for future research.

2. LITERATURE REVIEW

2.1 Logistics Innovation and key Drivers

2.1.1 Logistics Innovation

Innovation can be understood as the process of introducing and implementing new ideas that generate economic, social, and environmental value. Innovation has long been recognized as a fundamental driver of economic and operational progress. Schumpeter (1934) introduced the concept of innovation as the creation of new combinations of resources and processes.

More recent studies have described innovation as the result of a process change and novelty (Van der Kooij, 2017). Innovation is a functional change in the system, observed from a specific perspective, with phased character and resulting from intentional human activity. This new approach complements the classic definitions by establishing a more precise distinction between significant change and simple modifications.

According to the Oslo Manual (OECD & Eurostat, 2018, page 20) innovation is “new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)”. Product innovation refers to the introduction of new or significantly improved goods or services on the market. Business process innovation refers to the implementation of new or improved processes in the organization's internal functions.

Flint et al. (2005) build upon this foundational idea by defining logistics innovation as “any logistics-related service from the basic to the complex that is seen as new and helpful to a particular focal audience. This audience can be internal, focusing on operational efficiency, or external, prioritizing customer-centric improvements “. Their research underscores the dynamic nature of logistics innovation, which requires firms to continuously adapt to changing market conditions and technological advancements.

Grawe (2009) further develops this notion, highlighting that logistics innovation extends beyond cost reduction to include value creation and service differentiation. His research

illustrates how companies can leverage logistics innovation to gain a competitive edge by offering superior service quality and optimizing supply chain processes.

Logistics innovation can take multiple forms, including technological, process, and service-related advancements. Technological innovations involve adopting cutting-edge tools like IoT-enabled tracking systems, AI-driven demand forecasting, and blockchain-based supply chain management. Process innovations focus on optimizing internal operations through lean management techniques and automation. Service innovations, on the other hand, aim to improve customer interactions by offering personalized, responsive logistics solutions.

2.1.2 Key drivers for the adoption of Logistics innovation

Logistics innovation is driven by internal and external factors that push companies to adopt new technologies, processes, and models for better supply chain performance. Holl and Mariotti (2022) identify key drivers, including firm size, R&D intensity, product innovation, international market engagement, and competitive pressure. Larger firms, with more resources, tend to innovate more easily, while smaller firms face greater difficulties due to limited resources.

Technological advancements are a fundamental driver of logistics innovation. Lagorio et al. (2022) emphasize the role of Industry 4.0 technologies, such as IoT, big data analytics, blockchain, and cloud computing. These innovations enhance communication, flexibility, and decision-making by providing real-time supply chain visibility. R&D investments also enable firms to respond quickly to market changes and seize new opportunities. The availability of modern technological infrastructure, like automated tracking systems and digital tools, further supports this process (Lagorio et al., 2022).

External influences such as regulatory requirements and customer expectations also drive innovation. Regulations related to emissions and sustainability push companies toward green logistics practices, while increasing customer demands for faster and more flexible deliveries encourage the development of advanced last-mile solutions (Lagorio et al., 2022). Environmental logistics innovation is predominantly driven by customer demand rather than regulatory pressure. Cost reduction and improving performance also act as

motives for the adoption of logistics innovations. Overall, logistics innovations adoptions are strongly connected to internal strategic objectives and the pressures in the dynamic competitive market (Lagorio et al., 2022).

2.1.3 Challenges in the Adoption of Logistics Innovations

Despite these drivers, companies encounter significant challenges when adopting logistics innovations. Resource limitations are one of the primary obstacles, particularly for small and medium-sized enterprises (SMEs). Holl and Mariotti (2022) point out that SMEs often lack the financial resources and skilled workforce necessary to implement new technologies, while larger firms must balance innovative investments with ongoing operational needs.

According to Lagorio et al. (2022), technological integration poses another challenge, because the transition from traditional systems to advanced digital platforms requires aligning new tools with existing infrastructure. Market-related challenges also affect innovative efforts once companies must adapt to fluctuating demand, increase competition, and shifting customer expectations while maintaining operational efficiency.

Finally, navigating through various environmental, safety and trade regulations requires continuous monitoring and adaptation, increasing the overall cost and complexity of innovation.

All these different drivers and challenges in adopting these types of innovations are crucial to understand since they directly influence how an organization is going to adopt a specific type of innovation in logistics. However, understanding why a company innovates and what prevents it from doing so is only a part of the process. Next, it is important to understand how this innovation will be implemented within the organization. This converts into the choice of buying a ready solution or developing in-house. The next chapter is dedicated to exploring how companies decide to buy or to develop internal solutions.

2.2 Make or Buy Decisions

The make-or-buy decision, determinates which activities or components are being sourced internally or externally, has been a subject of academic research since the mid-20th century, but has gained complexity through time. According to literature, the make-or-buy decision is dominated by two theoretical central perspectives: Transaction Cost Economics (TCE) and The Resource-Based View (RBV). This theoretical integration has been essential to understanding complex decisions (Klein & Mazzoni, 2025).

Initially proposed by Coase (1937) and further developed by Williamson (1975, 1985) through TCE. However, recent studies have shown that this logic is no longer sufficient to explain and capture the complexity of contemporary organizations. Make-or-buy decisions have been revealed to be deeply connected to operational and strategic factors, such as the need for flexibility, the degree of trust in suppliers and the ability to respond quickly to market demands (Arora & Kumar, 2022).

The make-or-buy decision was initially studied in economics, and later in operations management and strategic management, where it has become a key source of decision-making. Therefore, the make or buy decision should be made and considered as a strategic decision (Cáñez et al., 2000). Literature argues that TCE remains a useful theoretical tool, but is insufficient to explain the complexity of organizations. RBV offers this complementary perspective, and this integration makes it possible to consider not only transaction costs, but also strategic resources (Klein & Mazzoni, 2025).

TCE argues that markets do not operate without cost. In addition to production costs, transactions entail additional costs related to the search for information, negotiation, formulation of contracts and their monitoring and enforcement. According to Williamson (1985), central determinants of transaction costs are: asset specificity, uncertainty, transaction frequency, opportunism and bounded rationality. Overall, this theory builds on the premise that organizations choose to govern activities internally when the transactional costs are lower than doing it externally.

Asset specification is considered in literature as one of the most important determinants of the decision make-or-buy (Klein & Mazzoni, 2025). Asset specificity refers to the

degree to which a resource or investment is adapted to a particular transaction, making it difficult to reuse in other circumstances without significant loss of value (Gulbrandsen, Sandvik, & Haugland, 2009). There are different types of specificity, such as physical (linked to unique equipment or materials), human (related to specific expertise), and site (dependent on the geographical location of the assets).

On the other hand, RBV offers an internal perspective on sustainable competitive advantage, emphasizing the role of organization resources and capabilities (Barney, 1991). RBV is built around the premise that a company should not outsource an activity that can bring them a competitive advantage. According to Barney (1991), firm resources are all assets, capabilities, organizational processes, firm's attributes, information and knowledge the company controls.

The analysis is based on identifying as a source of sustainable competitive advantage only those resources that are valuable, rare, inimitable and non-substitutable. According to Barney (1991, p. 106) "firm resources can only be a source of competitive advantage when they are valuable", this means that resources that help to respond to external conditions, taking advantage of opportunities or defusing threats in the competitive environment are considered valuable.

A resource is considered rare when it is not widely possessed by current or potential competitors (Barney, 1991, p. 106). Therefore, for a resource to make a real contribution to a company's competitive position, it cannot be widely available on the market. Barney (1991, pp. 107-110) emphasizes that even valuable and rare resources will not generate sustainable advantage if they can be easily imitated. A resource is inimitable when it is difficult (or very expensive) to copy. Finally, Barney (1991, p. 111) states that a resource can only sustain a competitive advantage if there are no strategically equivalent substitutes. Even if a resource is valuable, rare and inimitable, it can be replaced by a different resource that produces the same strategic effect.

Overall, these theories argue that companies internalize activities when transactions costs are high and should internally retain resources that are valuable, rare, difficult to imitate and irreplaceable, as they are sources of sustainable competitive advantage.

As there is no absolute make or buy, literature introduced this critical perspective that comes especially under conditions of uncertainty and technological change (Klein & Mazzoni, 2025). They showed how this definition could be insufficient, because “decisions to outsource production and other functions are different from decisions to outsource technological knowledge” (Brusoni et al., 2001).

What has been seen is that when facing make-or-buy decisions, collaboration becomes a strategic answer in complex environments. In make-or-buy decisions, cooperation with specialized partners can favor access to external capabilities without compromising strategic control. To achieve high performance, many industrial companies keep critical activities under their own governance, even when they use partnerships for operational components. In these hybrid models, the ‘make’ takes place, where execution is shared but control remains centralized (Bustinza, Lafuente, Rabetino, Vaillant, & Vendrell-Herrero, 2019).

Beyond strategic frameworks, literature also highlights that firm’s decision to internalize may also be in response to operational inefficiencies observed in outsourced arrangements (Nujen, Halse & Solli-Sæther .2015). The decision to re-internalize may follow outsourcing failures, such as rigid supplier arrangements, high costs, and the need for faster adaptation to client demands. In this view, the “make” decision may arise not only from core capabilities or strategic technology, but may emerge as a response to economic inefficiency, rigid supplier arrangements, or the need to regain control over key activities. This study also evidences that advances in automation and the use of modular system architectures can enhance the feasibility and efficiency of internalization, reducing reliance on external providers and supporting greater operational agility. Importantly, it also emphasizes that the success of internalization depends significantly on the organization’s ability to reintegrate previously externalized knowledge. (Nujen et al., 2015).

2.3 Smart Lockers as Response to Last-Mile Innovation Strategies

2.3.1 E-commerce Growth and last-mile pressure

Logistics plays a crucial role in trade and commerce, but with the birth of e-commerce, this has drastically increased. Research shows that in e-commerce, the logistics

distribution process is a key factor in ensuring smooth development and it impacts various aspects of the value chain. Recently, terminal distribution has become a focal point and each company is exploring different service modes to address challenges and improve efficiency (Liu, Zhang, & Wang, 2019).

In logistics, two main models of distribution can be distinguished: direct and indirect distribution. Direct distribution involves door-to-door delivery by logistics ensuring goods are brought directly to customers (Yamada et al., 1999). On the other hand, indirect distribution requires customers to pick up their goods from designated pickup points. These models cater to different needs while seeking to optimize logistics.

This segment is widely recognized as one of the most resource-intensive and environmentally impactful stages in the supply chain, with costs associated with last-mile delivery comprising between 13–75% of the total logistics expenditure, depending on variables such as consumer density, delivery time windows, and shipment characteristics (Olsson, Hellström, & Pålsson, 2023).

With the emergence of e-commerce, the retail industry has been shaped, redefining how customers shop and their expectations. This transformation has been accelerated due to the COVID-19 pandemic alongside the increased adoption of mobile technology. In 2020, the United Nations Conference on Trade and Development (UNCTAD) analyzed the growth of the share of global online retail trade which increased from 16% to 19%, indicating an accelerated migration to digital platforms.

Global e-commerce growth is expected to continue, with research indicating sales will reach \$6.09 trillion by 2024, an 8.4% increase from the previous year. Two major powers, the United States and China, together reach \$2.32 trillion in 2023 (Shopify, 2024).

In the Portuguese market, e-commerce is also expanding rapidly, being predicted to reach \$5.88 billion in 2024 and to grow at a compound annual growth rate of 11.16%, reaching \$9.98 billion by 2029. According to Mordor Intelligence (2024), this growth is explained by the process of urbanization and changes in consumer lifestyles.

2.3.2 The Emergence of Smart Lockers in Last-mile Delivery

Smart lockers are an innovative and practical solution to last-mile delivery challenges. These lockers are located in public areas, which include shopping centers or streets allowing customers to choose a convenient location for their pick-up. The smart locker goal is to enable customers to collect their deliveries at any time while facilitating physical distancing measures (Luís, Martins, Caldeira, & Soares, 2022).

The global market for smart lockers has experienced significant growth, driven by the expansion of e-commerce and the increasing demand for contactless delivery solutions. According to a report by MarketsandMarkets (2023), the smart locker market is expected to grow from USD 2.1 billion in 2023 to USD 3.6 billion by 2028. Companies and logistics providers are rapidly adopting these systems to reduce costs, improve efficiency, and enhance customer satisfaction.

Smart lockers offer significant advantages in last-mile delivery logistics, making them a key innovation for improving efficiency, security, and sustainability. One of their main benefits is operational efficiency. By reducing failed deliveries and consolidating multiple orders into a single location, smart lockers streamline logistics operations, optimizing delivery routes and reducing transportation costs (Yuen, Wang, & Wong, 2018).

From a consumer perspective, smart lockers provide flexibility and convenience. They enable 24/7 access to parcels, allowing customers to collect deliveries at their preferred time without needing to be home for a delivery. Additionally, smart lockers offer increased privacy and security, as packages are stored in monitored, access-controlled compartments rather than left unattended at doorsteps (Vakulenko, Hellström, & Hjort, 2018).

By reducing the number of delivery vehicles on the road and minimizing repeated delivery attempts, smart lockers lower carbon emissions and fuel consumption. Research shows that their adoption can significantly reduce urban congestion and the environmental impact of last-mile logistics (Chen, Li, & Tang, 2017). This makes them a practical solution for cities seeking to implement greener logistics systems.

Researchers observed that, in Poland, the use of smart lockers for deliveries could reduce carbon emissions to only 5% of those generated by traditional door-to-door delivery (Schnieder, Hinde, West, 2021). According to the Green Last Mile Europe 2022, a single locker can reduce up to 13,845 kg of CO₂ emissions annually, positioning them as a highly sustainable alternative.

2.3.4 Future Prospects of Smart Lockers

The academic study of smart lockers has taken multiple approaches, focusing on optimization, route planning, customer acceptance, and environmental impact (Dissauer, Einspieler, Krauser, Schartner, & Woschank, 2024). Several studies have analyzed optimal placement strategies for lockers using linear programming models (Kahr, 2022) and multi-criteria decision-making approaches (Moslem, Gündoğdu, Saylam, & Pilla, 2024). Other studies have investigated route optimization algorithms, such as Genetic Algorithms (GA) and Hybrid Q-Learning-Network-based Methods (HQM), to enhance delivery efficiency (Liu et al., 2023; Pan et al., 2021).

From an environmental perspective, research has demonstrated that integrating smart lockers with electric vehicle deliveries can reduce delivery costs by 23%, delivery times by 40%, and emissions by 53% (Bell et al., 2023). Moreover, customer adoption remains a critical success factor, with studies highlighting timeliness, 24/7 customer support, and reliability as key determinants for user satisfaction (Tang et al., 2021).

The Future of smart lockers is closely linked to technological sustainability advances, the integration with broader logistics systems. Research indicates that as smart cities continue to develop, smart lockers will play an essential role in last-mile delivery solutions (Popescu & Tulbure, 2024).

The expansion of smart locker networks is another anticipated trend, particularly in rural and underserved areas where access to efficient parcel delivery is limited. Modular and mobile lockers, which can be relocated based on demand, are expected to address this challenge. Additionally, the integration of smart lockers with e-commerce platforms, payment processors and other last-mile delivery innovations, such as autonomous

vehicles and drones, will further streamline logistics operations and reduce costs. The growing perspective on sustainability also predicts the use of solar energy as power supply (Popescu & Tulbure, 2024).

As e-commerce continues to expand, the role of smart lockers will become increasingly prominent in optimizing last-mile delivery, enhancing customer convenience, and improving logistical efficiency (Popescu & Tulbure, 2024).

3. METHODOLOGY

This dissertation implemented a methodological approach, outlined in this chapter, with the objective of investigating the decision behind the internal development of smart lockers at CTT. This research aims to answer two key questions: what factors influence the make-or-buy decision and how the characteristics of last-mile solutions influence and justify internal development.

The goal of this chapter is to outline and explain the research design, data collection and an overview of the company in research.

3.1 Research Design

Guided by the need to understand how an innovative solution emerges and how it is developed in logistics operators in response to increasing e-commerce pressures, this study adopts a qualitative and exploratory research design (Yin, 2016).

A qualitative approach was employed due to its capacity to capture subjective experiences, organizational perspectives, and the broader contextual factors. Qualitative research is particularly appropriate when the objective is to understand the phenomena through the participants' meanings and relations between them (Saunders, Lewis & Thornhill, 2016). A descriptive logic was followed, aiming to map and analyze the decisions, actors and stages involved.

The research method chosen is a single case study. According to Yin (2016), a case study is particularly suitable for investigating complex contemporary phenomena within their real-life contexts, allowing for a comprehensive and nuanced exploration. The case study from CTT represents a relevant and innovative example of last-mile logistics transformation, particularly in the Portuguese market.

3.2 The Data Collection

To capture complexity, data collection was carried out using primary sources, semi-structured interviews and secondary data, with the consultation of organizational

documents, online publications and author's personal notes. Data collection was carried out using both primary and secondary sources, following the principles of data triangulation (Baxter & Jack, 2008), which enhances the study's credibility and reliability by analyzing multiple perspectives.

Semi-structured interviews were conducted with key CTT stakeholders involved in the project to gather first-hand insights into decision-making processes, operational challenges, and strategic goals. According to Sahoo (2022), interviews allow to gather detailed, exploratory insights when understanding strategic choices and processes.

This choice was made to access insider knowledge that is not publicly available and to understand the rationale behind the project's evolution. Stakeholders were selected based on their direct involvement in the development and implementation of projects, ensuring their perspectives were relevant and informative.

In total, two semi-structured interviews were conducted with central figures involved in the project:

- Jorge Sales Gomes – Head of Engineer and Maintenance at CTT, and member of the board of Locky.
- Francisco Travassos – Head of Express and Parcel Products at CTT and CEO of Locky.

Both participants have been in this project since the beginning and are directly involved in Locker's deployment, scaling and strategy development. These interviews were conducted in April and May 2025, with a duration between 60 to 90 minutes. These interviews followed a semi-structured guide, and it is available in Appendix I.

After collecting the empirical work, the analysis began with the objective of responding to the research questions and extracting the key insights from the case study.

The following analysis considers the five steps outlined by Yin (2016): compiling, disassembling, reassembling, interpreting and concluding.

In the compiling phase, a comprehensive database was set with all information from interviews, notes and internal documents, to be able to carry out a real analysis.

Following the organization of the data, disassembling was the next step. This involved fragmenting the material based on research question's themes: (1) project conceptual and development; (2) phases of the development; (3) the creation of an agnostic brand: Locky and (4) developments and expansion.

The next step, the reassembling phase, segments were reviewed to identify the connection between all sources of information. In the interpreting phase researcher analyzed findings and examined them with theoretical frameworks developed in section 2- Literature review. It aimed to not only describe the sequence of events, but to interpret the underlying logic, tension, and strategies. Finally, a clear summary of the conclusions, and answers to the research questions were made.

3.3 Overview of the Company

CTT is the oldest Portuguese commercial group that operates as the national postal service in Portugal, tracing its origins back to 1520 under the reign of King Manuel I. Over the years, CTT has evolved from a traditional postal operator to a diversified service provider with subsidiaries operating in e-commerce, banking and diverse postal services (CTT, n.d.)

Following a long history as a state-owned entity, CTT underwent full privatization between 2013 and 2014. In 2013, 70% of the company's capital was sold through an initial public offering, with the remaining shares divested the following year. This marked a turning point to CTT's strategy and business orientation (CTT, 2014).

In recent years, the company has focused its strategy on becoming a leading e-commerce logistics operator in the Iberian Peninsula. This transformation is reflected in its strong performance in 2024, when it reached €1.107 billion in total operating revenues, a 12.4% increase compared to 2023. The main driver of this growth was the Express & Parcels segment, which achieved €479 million in revenue, growing by 40.6% year-over-year (CTT, 2025). This expansion was supported by record parcel traffic, increased automation, and investments in last-mile infrastructure.

CTT entered the Spanish market in 2005 with the acquisition of Tourline Express, but it was reinforced in 2019 with the rebranding to CTT Express (ICEX, n.d.). In the last year, CTT executed two major strategic initiatives to improve its logistics capabilities. Firstly, with the acquisition of Cacesa, a company specializing in customs clearance and e-commerce logistics. Second, it entered a partnership with DHL, aimed at capturing international parcel flows and expanding operations (CTT, 2025).

Overall, in recent years, we have seen CTT as an innovative and transformative brand, looking towards the future as an Iberian logistics operator, focused on e-commerce.

4. DATA ANALYSIS AND DISCUSSION OF RESULTS

4.1 Project Conceptual and Development

During the interviews, the adoption of smart-lockers solutions was described not as the desire to follow a trend in the market but as the result of meeting internal organizational needs and external market pressures. Together, they created the conditions for a turning point in the approach to last-mile delivery.

The adoption of smart lockers appears to address operational inefficiencies and adapt to the accelerating demands of e-commerce, as mentioned in the interviews. In 2018, e-commerce growth 17%, 60% of online shoppers reported at least one purchase per month. Urban Centers such as Lisboa and Porto showed the highest concentration of online shoppers with expectations to grow even higher and faster (CTT, 2019).

CTT identified a growing pressure on its last-mile delivery network, particularly the challenges of failed home deliveries, increased parcel volumes, and limited scalability in dense urban areas. As the interviewee explained, “we couldn’t keep up with the volume and expectations brought on by e-commerce using traditional methods.”

At the same time, advances made by international players such as Amazon, InPost and DPD have increased. These players demonstrated this new potential of smart lockers, a self-service solution for last-mile that improves delivery efficiency and customer convenience. As referred by the interviewers, this presence highlighted the risk of stagnation and the need for fast action before the competitors become mainstream in the Portuguese market. It was clearly a gap in the Portuguese market that CTT could fill if moving early.

Among the internal drivers, the structural transformation from a traditional postal company to a modern integrated logistics operator changed the organization's position, in 2019 CTT started seeing a decrease of traditional mail which was offset to growth in the express and parcels (CTT, 2019). This trend was expected in the coming years. The adoption of a locker network emerged as an instrument of this transition, to align CTT

with the demands of an economy based on e-commerce, convenience and operational efficiency.

While external dynamics were pushing towards change, the adoption of this new way of last-mile delivery occurred back in 2019. The adoption of these lockers started with a pilot project involving twenty lockers from a third-party supplier. Around twenty units were installed in Lisboa and Porto. Although the test showed promise in terms of customer usage and locker access flexibility. It quickly became clear that relying on external technology revealed limitations. The interviewee explained that this solution was revealed as a closed system, which limited customization, delayed resolution, had very high costs and lacked long-term strategy.

“We weren’t satisfied with the limitations we faced when working with external platforms—especially in terms of control and customization.”, what appeared to be a quick and easy solution to an operational challenge revealed the limitations of outsourcing, reinforcing the need for internal innovative capabilities.

This led CTT to rewrite their strategy and start considering building an in-house solution tailored to specific operational needs. The interviewee described this turning point clearly: “We launched an internal challenge with a bold goal — build a Smart locker for half the price, and with full ownership.” Concluding on an internal challenge launched with a very clear and ambitious goal: Develop CTT smart lockers that would be cost-effective, fully controlled by the company and scalable. The core objectives were to reduce production costs by 50% and to maintain or exceed the performance compared to the market options.

This decision reflected a broader organizational vision, it meant accepting higher upfront complexity and risk, but also securing long-term autonomy, adaptability and competitive resilience. This strategic leap was only viable because of the firm’s scale and size, as CTT being the national logistics leader made it possible to drive.

With the pilot phase, outsourced lockers served their purpose, proving that this locker model worked, but also highlighted the inflexibility of this approach. CTT had no influence over the design of the roadmap and could not guarantee alignment with future strategic goals.

4.1.1 Phases of the development process

After this strategic decision, CTT began designing a solution from the ground up. The goal was not to develop a device, but to define how it would be produced, controlled, deployed and scaled. The focus was on cost and long-term control and flexibility. The interviews allowed to organize and identify several distinct phases in this process, from the initial identification of the problem to its industrialization and creation of a network.

Understanding the process made it clear that the development of the project was not just a technological exercise but rather a systemic response to a series of operational, strategic and even ideological constraints. The objective of this section is to present and analyze the main stages that marked the development of CTT lockers.

The development process was defined and composed by: (1) Strategic challenge that redefined the locker as an internal asset; (2) the assembly of a national ecosystem of specialized suppliers; (3) prototyping; (4) small-scale pre-series; (5) industrialization; (6) creation of a CTT locker network (Appendix II).

With the realization that an internal last-mile infrastructure was necessary to align with the strategic needs and autonomy, CTT proceeded with the structure and development of an in-house self-service system. The project focused on some core ambitions for this solution: Reduce unit cost compared to available market options, ensure full integration with CTT's operations, and long-term adaptability for additional services.

Once the ambition was clear, and the decision to internalize this solution was made, the organization faced a fundamental challenge: how to assemble and organize a wide number of technological and industrial capabilities required to execute such a complex challenge. The paradigm change, and the goal was to create an ecosystem rooted in national capability, architectural control and collaborative development. The decision was to make a distributed innovation ecosystem, composed with Portuguese firms, each contributing to a specific part of the solution.

“It works very much on the basis of what we call an ecosystem – as if it were a large company made up of small companies”, where every external partner contributes within a well-structured and defined scope and under internal coordination, like a virtual factory, a term used by the interviewee.

This phase of the project was marked by the careful selection of the partners involved. The choice was based not only on technical criteria, but also on ethical and relational aspects. Partners had to align themselves with the projects and the company vision, mission and values.

The development of this ecosystem includes 5 technological partners, each with different roles and responsibilities:

- Cubotónico: A metalworking company responsible for the design and fabrication of the physical structure of the lockers. Is a Portuguese company specialized in sheet metal transformation.
- TecnoCrimp: A company specialized in cabling and electronic component integration, responsible for internal wiring, assembly of the lockers and ongoing maintenance services.
- MICRO IO: A tech spin-off from the University of Aveiro, focused on electronics and software. Their role is for the development of the initial electronics and software.
- HFA: An electronics manufacturing company, responsible for electronics components.
- Polarazing: A software engineering and IT integration company, responsible for the development of the software.

Later, and in a second part of the project, the academic ecosystem was activated, with the involvement of higher education institutions and research centers. The goal of this collaboration was above all to support new developments, exploration projects and involve students in the incremental innovation process.

The universities that are a part of this ecosystem are ISEL, ISEC and FCT NOVA. They play a role as experimentation laboratories, allowing them to test new ideas, validate concepts and explore functionalities that could be integrated in the future. This type of collaboration made it possible to explore new ideas, test functionalities with less risk and it is recognized as an important asset for innovation.

The development of the ecosystem was organized into two complementary layers: a technical-industrial layer, with specialized companies and an academic-experimentation layer with universities that contribute knowledge and applied research projects. At the center of this ecosystem is the CTT internal team, especially from the Engineering and Maintenance area. As described, by fostering long-term, trust-based relationships, CTT

was able to accelerate coordination, priorities and ensure commitment and transparency between partners.

During Pre-Series and Pilot testing, the design moved beyond the functional validation, to a long-term architecture of the locker system. The decision to adopt a modular design became central and critical to the project's future trajectory. Rather than treating the locker as a unique and fixed unit, the team develops a flexible system that could be expanded or reconfigured depending on the context.

To achieve this goal, the development team introduced a two-tier modular system: The master module, which includes the control system, PC, display, communications hardware and locking mechanism; and the slave module which provides additional sets but does not contain any onboard electronics, it's totally managed by the master.

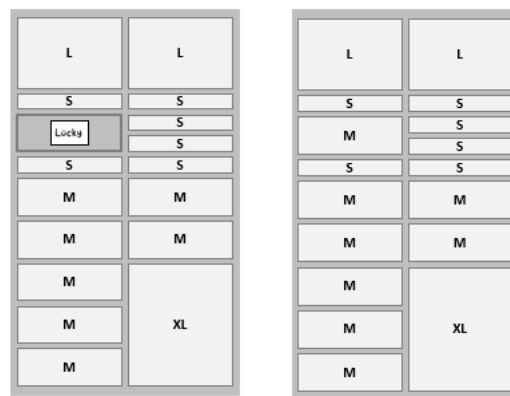


Figure 1- Master and Slave module | Source: Locky

This approach also results in cost reductions, as these slaves' modules did not need the expensive components that otherwise they would need "This second cabinet was significantly cheaper because there were a bunch of devices that no longer existed and didn't need to exist."

Not only cost reduction, but this approach also helped in gaining a scalable system, as it could start with one single Master and add Slaver modules progressively and flexibility for custom functionalities needed. As said by the interviewee, "The modularity of the equipment gives us great flexibility [...] we can assemble the operation with the functions

we want [...] and swap modules according to demand.” What modularity gave in the long-term, was greater flexibility in the business.

The technical validation phase culminated with the installation of the first locker in the real environment on May 8th 2020, this moment represented the formal start of testing in a real-world environment.



Figure 2- First CTT Smart Locker installed | Source: CTT

This milestone confirmed the technical viability of the solution and paved the way for the next phase of industrialization and network expansion. With this functional and modular system, the industrial phase started and was focused on coordinating all the ecosystem already established during earlier phases. The need for technical autonomy, cost efficiency and preserving flexibility was key in this stage.

In the final phase, CTT already had a functional solution (Appendix II), which made it necessary not only to expand to the installation points but also to build an internal network of lockers. However, this goal points to a strategic challenge: since CTT is a logistics company, building a brand under it would make it difficult for other operators to join.

It was in this context that in 2022, it was decided to make an autonomous solution with the creation of Locky, a separate company but owned by CTT. The mission was to manage all network. "We created an agnostic network and a back office to allow any operator to join. CTT is just another Locky customer". This change in the model and identity was essential to scale the project and respond to the desire strategic position: "Creating an independent brand was an essential step for us to be able to scale."

4.1.2 The creation of an agnostic brand: Locky

In 2022 Locky, with official name Open Lockers, was founded as an agnostic brand with the goal of managing and expanding the locker network and ensuring interoperability between different logistics operators.

This choice was strategic for several reasons: a clear international trend, the need for better efficiency in logistics, and easier negotiation with different logistics companies for being an open network.

By the end of 2024, Locky had already implemented 1,032 lockers, of which around 15 were in Spain, also marking the start of its international expansion. These Lockers are in residential and business areas with focus on high traffic locations such as shopping centers, retail chains, offices and business centers, gas stations, parking lots and other convenience points.

Locky offers three main models of Lockers:

- Public: accessible to all e-buyers, supplied by CTT.
- Private: located within the partner network (e.g. companies, condominiums), with restricted access and supplied by CTT.
- Click & Collect: used for the delivery of online purchases made directly on the partner's website and supplied by the partner itself.



Figure 3- Types of Lockers: Public, Private and Click & Collect

As the locker network expanded territorially, new operational and contextual limitations began to emerge. The infrastructure needed to adapt to different realities. The first development came from the need to overcome constraints associated with placing lockers

in public or private places. The idea results from taking advantage of the existing CTT network of stores, eliminating the need to rent or negotiate for some places. Through-the-wall (TTW) solution stands out as a configuration that consists of installing the lockers directly on the façade of the building.



Figure 4- TTW locker model installed in a CTT Store | Source: Locky

Another limitation found as the network grew was the difficulty of finding electricity in certain locations, although some locations were considered strategic, the access was non-existent, complex and economically unviable. This led to the need for an autonomous solution, a locker model powered by solar energy, designed to reinforce environmental sustainability and extend the possibilities of installing the network in places without electricity.



Figure 5- Locker powered by solar energy | Source: Locky

4.1.3 Developments and Expansion

With the Locky network already consolidated and the technology under full control, CTT began to look at lockers not just as a parcel collection and delivery point, but as a strategic

platform for reinventing the way they offer their services. Until now, lockers had been thought of mainly as a response to last-mile logistics. However, the fact that it was an agnostic, flexible and scalable network, lockers could be an alternative channel to the physical store, with clear advantages in terms of convenience, costs and autonomy.

"CTT stores are only open during office hours. What if we could offer the same services outside those hours, using the lockers we already have installed?" This came from a concrete need: the stores faced traffic peaks, were wasting a lot of time with low-value services, and had seen a growing demand for self-service solutions.

In the past, CTT had already tried to automate small services- the stamp vending machines (Appendix IV). However, they lacked modernity, flexibility and centralized infrastructure that would allow them to integrate various services at a single point. Lockers solved this problem.

The idea was to start seeing the lockers as Self-Service Machines (SSM): digital terminals that would allow customers to access multiple postal and logistics services autonomously, out of hours and without human intervention. These Lockers could become an extension of CTT stores.

Some of the features already implemented illustrate this functional and strategic transition:

- The sale of stamps directly through the locker interface, allowing the user to complete simple postal processes without having to go to a physical store. This feature was preceded by the old stamp vending machines;
- The automated vending function, including envelopes, packaging and shipping materials, reinforces the autonomous nature of the user experience;
- Integration with post office box logic, enabling customers to designate a locker as a personal box, accessible 24/7;
- The creation of shipping modules with built-in scales, allowing parcels to be weighed directly on site and shipping labels to be generated in real time;
- The development of deposit receptacles, allowing the delivery of objects.



Figure 6- Locker as a Self-Service Machine | Source: Locky

The evolution from a simple collection structure to a complete self-service terminal reflects a more profound change in the way the customer is thought of. Far from their original function, lockers have shown a capacity for adaptation and autonomy that has allowed them to replicate - in different contexts - services that were previously exclusive to physical shops.

Following the success of the development of these CTT lockers and different developments, CTT created a new company, ModFlex, with the specific purpose of commercializing smart lockers. This strategy move reflects CTT's intention to monetize its innovation and scale production by opening new commercial channels. The company has already shown international growth in countries like Spain and France, and major retailers such as El Corte Inglés. This enables CTT to operate not just as a logistics provider, but as a supplier of smart infrastructure.

4.2 Discussion of Data

The main objective of this study was to understand how a company responds to internal and external pressures through last-mile innovation, and how that led to the choice to internalize locker development rather than buying a ready-to-use solution. This section discusses the findings of the case study in relation to the research objectives.

The collected data showed that the decision to adopt innovation in the last mile stemmed from clear strategic pressures and drivers identified on logistics innovation (Holl & Mariotti, 2022). The adoption of smart lockers represents a specific form of logistics innovation by adopting a new way of delivering for the customer. CTT's large operation scale and logistics know-how, the growing market of e-commerce and competition pressure are revealed as critical drivers in the adoption and the need to modernize their

last-mile. The exponential increase in deliveries, operational inefficiencies and the rise of the customers' expectations created also the need for adoption.

However, the case reveals a layer of internal motivation. CTT Rather than reacting only to market pressures, this adoption was framed as a part of a broader strategic repositioning. CTT started to see the adoption of Lockers not as a service enhancement but as a step towards critical infrastructure development, with the main goal of control, national relevance and long-term scalability. This can show that the adoption of this innovative solution could be not only responsive but transformational.

The solution to the adoption of smart lockers was clear, but a second, more strategic question was raised: Why did the company decide to develop the solution rather than purchase one on the market?

The adoption of smart lockers started with the use of a third-party supplier. This test showed complications, high cost, difficulty in controlling and lack of flexibility. This first turning point was clearly driven by practical constraints and operational inefficiencies. This decision emerges from adaptive response to failure, economic pressure and the need to control, as described by Nujen et al. (2015).

Primarily driven by practical constraints, the decision reflects deeper strategic considerations. The locker system was very specific and connected to the logistic operation of the company, the market solutions did not guarantee flexibility or future development, and the utilization was high-frequency and scale-dependent, as it was only successful if it could be implemented nationally. All these combined would reveal a high dependency on the supplier. This is justified by the TCE criteria developed by Williamson (1975, 1985).

This decision can also be supported by Barney (1991), with the RBV once CTT started seeing this solution as a critical infrastructure seen as capable of generating competitive advantage for the company. Overall, while the initial trigger for internalization was the high cost and lack of flexibility, the decision went beyond financial reasons. This internalization decision also considered broader aspects of keeping knowledge and control in-house as described by Nujen et al. (2015).

CTT, a logistics operator and postal services company, did not retain all the industrial resources that were necessary to produce all the physical equipment that was necessary

to produce lockers. But the need to control the architecture, the design, software and production were critical. For this to happen, the creation of a national ecosystem of technological and industrial partners was made. With this, CTT made a solution by 50% of the price, it was made by the third-party supplier.

CTT kept critical knowledge, design and technological integration under its own governance and turned into external partners for specialized tasks. This form of stable but distributed control is consistent with what Bustinza et al. (2019) point out that the cooperation and collaboration with specialized partners can favor access to external capabilities, without compromising the strategic control.

By keeping the design and knowledge, one of the internal decisions was to adopt a modular system architecture, separating the technological core (Master) from expandable, low-cost units (Slaves). As highlighted by Nujen et al. (2015), combining modularity with internal know-how and design control helps companies regain flexibility and protect critical knowledge. This modular system reduces costs, allows experiments and creates conditions for long-term evolution of the infrastructure.

The locker adoption was seen as a critical infrastructure for the company, and not just as a product or technology. This solution was made as an agnostic platform capable of supporting not only the operational objectives of CTT, but to repositioning CTT in the national last-mile logistics. As described by Yuen et al. (2019), Vakulenko et al., (2018) and Chen et al, (2017), smart lockers represent an effective way of dealing with operation inefficiency, promoting flexibility and convenience and reducing the environmental impact in last-mile logistics.

Data also showed that CTT was beyond functional logic, by creating its own separate network, Locky, and later a locker commercial company (ModoFlex). The company has adopted a long-term vision towards interoperability between operators, technological independence and economic scalability. This decision shows how innovation in logistics can be lever for structural transformation.

According to Popescu & Tulbure (2024), smart lockers are becoming more and more sophisticated, with improvements on usability, integration with e-commerce platforms, and other innovations in last-mile logistics. The need for territorial expansion and environmental solutions. This evolution is consistent with the plans drawn up in this case

with the adoption of modularity, sustainability, interoperability and with the creation of a self-service machine on the lockers.

5. CONCLUSION

This dissertation examined the rationale behind the internal development of smart locker infrastructure at CTT, exploring how the adoption of innovative last-mile delivery solutions can shape decisions. Drawing on case study methodology, the analysis integrated semi-structured interviews, analysis of internal documents and online publications.

According to the first objective of this study, **what are the factors influencing the make-or-buy decision in logistics innovation?** the findings showed that the decision to develop CTT lockers was driven by a combination of economic, operational, strategic and technical considerations. High market costs, the need for asset specificity and system integration, as well as the need to control and gain autonomy, aligned closely with make-or-buy literature. The solution was not seen as a service component, but as central to future competitive advantage and positioning. The adoption of collaborative technological and industrial partnerships made possible the need to gain ownership and control over design, architecture and technological integration. Additionally, the decision was reinforced using a modular design, which reduced complexity and investment risks while enhancing scalability. This allowed the company to build a flexible infrastructure and maintain governance and knowledge.

Referring to the second objective of the study, **how did last-mile solutions shape and justify the decision to internalize development?** data demonstrated that the locker project was conceived as an infrastructure-level innovation, not just as a functional add-on. This locker solution required customization, control and the ability to integrate these lockers with all last-mile ecosystem. The need for operational efficiency, flexibility, convenience and positive environmental impact in the last mile in an increasing and competitive environment aligns closely with the literature on the importance of smart lockers in addressing these challenges. Meeting all these challenges required a system that could be continuously improved, easily scaled and shared. In this case study, the internal development was seen as the viable path to build this infrastructure. These confronts not only motivated the adoption of the innovative solution but also defined its structure and the decision to internalize.

This research contributes to the existing literature on logistics innovation and strategic sourcing, showing how make or buy decisions can be driven by a combination of

pragmatic response and long-term strategic goals. In this context, internal development was a way to reduce costs, gain control and flexibility but gradually became involved in a process to create competitive advantage while building control, enabling scalability, and treating the solution as a differentiating infrastructure. This dual rationale confirms that make-or-buy decisions can emerge from both tactical challenges and strategic positioning.

In the make or buy dilemma, it confirms the relevance of the TCE in explaining why firms may reject external solutions when asset specificity, uncertainty, and transaction frequency are high. Also, the findings support RBV by showing that internal development may occur to protect and create strategic sources of advantage. At the same time, it involved broader questions of flexibility and knowledge retention.

This study also shows that hybrid sourcing models, where firms retain the design, governance and knowledge while relying on external partners for production, can be effective in achieving both the control needed and operational and economic efficiency. The use of modular design for these lockers also revealed to reduce complexity and costs and allowed the company to scale the system gradually and adapt installation according to different locations and customer needs.

Finally, the case offers a broader contribution on how these solutions are conceptualized. It shows how these last-mile solutions, when internally developed and governed, can go beyond normal functionality and act as a source of competitive advantage, adaptability and differentiation. The multifunctionality seen in these lockers reinforces that last-mile infrastructure can become a platform for strategic transformation.

For logistics and postal operators, with the study of these case can see the success of the internal development align with modular design and reliable external partnerships. By creating this, CTT was able to reduce costs, gain control and technical autonomy, and increase flexibility, demonstrating that innovation can be governed internally while relying on external partners.

This case is also relevant to understanding the importance of treating last-mile innovations as a part of a long-term infrastructure strategy. CTT developed a system that is interoperable, scalable, and neutral and that supports new functions.

As with other qualitative studies, this dissertation has limitations that should be acknowledged. First, the study is based on one single company, which may limit the generalization of the findings. Second, the study focused on the strategic and organizational dimensions of the innovation process, leaving aside financial modelling, customer acceptance metrics, or detailed technical analysis of the locker system. These elements, while outside the scope, may offer important insights into a more holistic evaluation.

Despite the limitations, the study provided useful insights on how innovation and internalized decisions are deeply connected, particularly in the case of postal companies responding to digital and operational transformation.

Further investigations would be interesting to study, a comparative case study involving other postal or logistics companies, those that opted for internal development and those that outsource, could shed light on alternative strategies. Another perspective, further studies could be on the commercialization and internationalization of technological solutions, as exemplified by CTT with the creation of ModFlex.

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APPENDICES

Appendix I- Interview Script

This work aims to understand the strategic motivation behind the internal development of Lockers by CTT drivers, the factors that influenced the make-or-buy decision, the governance model adopted, and the observed benefits and performance indicators of the solution.

This interview is part of the final master's dissertation in Management and Industrial Strategy, under the guidance of Professor Manuel Laranja.

The interview will be conducted in a semi-structured format, using open-ended questions to encourage discussion. With your permission, the session will be recorded for accuracy. All responses will be treated confidentially and anonymized unless you choose otherwise

1. General Information

- Interviewee's role and department
- Years of experience with CTT
- Role in the Locky project

2. Beginning and strategic rational for the adoption of Smart lockers

- What problems or opportunities were the lockers intended to address?
- What internal or external pressures influenced the decision to adopt a locker solution?
- How was the initial decision made between buying or developing the locker solution in-house?

3. Development and Implementation Process

- How was the development process of Locker structured? (e.g., phases, teams, technologies involved)
- What departments or partners (internal/external) were involved in the design and launch?

- What were the biggest challenges during the development or implementation stages?

4. Strategic Drivers and Innovation Context

- What were the main motivations behind developing the Locker solution?
- How does Locker fit into CTT's broader innovation or digital transformation strategy?
- In your view, what differentiates Locker from other last-mile delivery solutions in the market?

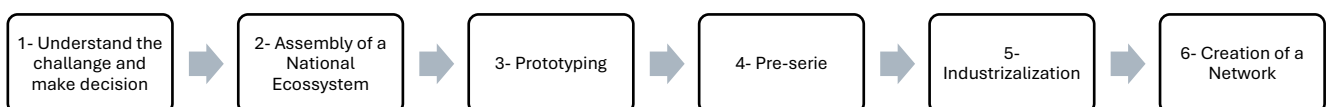
5. Strategic, operational and sustainable reflection

- What operational benefits have been observed since the implementation of Locker? (e.g., fewer failed deliveries, optimized logistics routes)
- Has Locker contributed to reducing the carbon footprint or urban congestion?
- Are there plans for expanding or upgrading the Locker system in the near future?

6. Final Reflections

- In your opinion, what has been the most valuable outcome of the Locker initiative so far?
- Is there anything else you think is important for understanding the impact of Locker on CTT's operations or the logistics industry?

Appendix II- Development Process Flow of the Locker Project



Appendix III- Smart Locker by CTT



Appendix IV- Stamp Vending Machine

