UNIVERSITY OF LJUBLJANA
SCHOOL OF ECONOMICS AND BUSINESS

MASTER'S THESIS

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OPTIMIZING THE REVERSE LOGISTICS PROCESSES IN COURIER DELIVERY COMPANIES

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Ljubljana, September 30th, 2024 Author's signature:

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LIST OF ABBREVIATIONS

3PL – Third Party Logistics
ABC – Activity-Based Costing
AI – Artificial Intelligence
B2B – Business-to-Business
B2C – Business-to-Customer
CO2 – Carbon Dioxide
CO2e – Carbon Dioxide emissions
CSCMP – Council of Supply Chain Management
CSP – Customer Service Provider
ERP – Enterprise Resource Planning
GDP – Gross Domestic Product
ICT – Information and Communication Technologies
IoT – Internet-of-Things
KPI – Key Performance Indicator
ML – Machine Learning
OEM – Original Equipment Manufacturers
RL – Reverse Logistics
SC – Supply Chain
SCM – Supply Chain Management
SOP – Standard Operation Procedure
TEN-T – Trans-European Transport Network
WEEE – Waste Electrical and Electronic Equipment

1 INTRODUCTION

Nowadays, with the significant increase in e-commerce and increasingly demanding customers, it is necessary for transport companies, especially last-mile delivery companies, to reinvent themselves or improve their current processes to become the entity that helps optimize the Reverse Logistics (RL), a concept that has gained strength during the last two decades. The role of courier companies in this transformation is critical, as they are often the last contributors in the forward supply chain (SC), as a final touch-point with the customers and the first physical point of contact in the case of the RL.

The increase in the past years in online shopping, boosted by the COVID-19 pandemic, has drastically changed the consumer behavior, leading to higher expectations for fast, reliable, and flexible delivery services. This change on the customer's behavior have exposed the importance of optimizing the RL processes, not only to manage returns efficiently, but also to improve the customer satisfaction and operational sustainability (effectiveness). In this context, the courier companies would certainly appear as a critical player to ensure the efficient and effective RL operations due to their direct involvement in the final physical stage of the forward logistics (delivery) and the first stage of the RL (collection).

The rapid growth of e-commerce has revolutionized the retail industry, presenting new challenges and opportunities for the logistics and the supply chain management (SCM). One of the most significant challenges that appeared with the growth of the e-commerce is the management of product returns efficiently, which is a critical part of the RL. The product returns can be very complex and costly, given that it involves multiple steps such as collection, inspection, sorting, and final disposition. This complexity is made even worse by the high return rates in the e-commerce sector, where customers tend to return their products due to size issues, defects, or simply because they change their mind.

Courier companies are critical in this process. Unlike other third party (3P) logistics providers, courier companies are the primary point of contact between the retailer and the customer during the return process. They begin to get involved as soon as a customer requests a return and finish their involved only when the product reaches the retailer or the designated processing/inspection center in the case of e-commerce. This unique position of the courier companies, certainly gives to them the perfect advantage to influence the effectiveness and efficiency of the RL processes.

The importance of focusing on courier companies within the broader e-commerce SC lies in their potential to streamline and optimize the returns. The courier delivery companies can have a great impact in the customer satisfaction, which can be achieved by providing pickups on time, transparent and precise tracking, and efficient handling of the returned products. Additionally, they could leverage their key location within the reverse SC to assess the condition of returned products and determine the appropriate next steps (such as refurbishment, resale, or recycling) in order to help the SC to reduce costs and reduce the environmental impact. The current RL is setup in a way that leads to several “unnecessary” transportation steps during the return of the products. Such redundancy of transportation steps is caused by the decentralization of the activities involved in the RL. The purpose of this master thesis is to present different strategies in order to optimize the RL processes in courier delivery companies, which would be achieved by improving the role or level of participation of the courier companies in the overall RL, by increasing the centralization of the RL activities within the courier companies, whilst targeting to increase the level of effectiveness and efficiency factors of the RL activities.

Throughout the thesis we will target to answer two research questions concerning the role of courier delivery companies in e-commerce supply chains:

- How can we improve the effectiveness and efficiency of the RL?
- How can the achieved improvements be sustained in the long-term?

These questions are essential to understanding both the initial setup and the necessary change to maintain an efficient RL process within a dynamic e-commerce sector.

The method used in this thesis involves the research and analysis of both scientific and non-scientific sources, the analysis of case studies, and the elaboration of a set of simulations for the current RL setup and two different scenarios in which the courier companies will have a stronger participation in the RL against the status quo. We will give an answer to the first research question using the results of the simulations, specifically connected to the costs, and the environmental impact. Although we are not going to simulate aspects such as resource utilization and speed, these can be implicitly interpreted from the chart flow configuration of the different scenarios.

These simulations are needed to help answer the first research question of this master thesis, whilst addressing the hypothesis that courier companies can support with the optimization of the RL. We could explain how the suggested changes would have an impact in the effectiveness and efficiency of the RL, but nothing speaks louder than numbers, reason why we consider that presenting approximate data of the impact will constitute a stronger support to the different scenarios analyzed on this master thesis.

To answer the second research question, we will focus on the theoretical inputs obtained during the research of the factors impacting the effectiveness and efficiency of the RL, and how the different authors suggest that the achieved improvements can be sustained over the long-term. While the simulation of the status quo and the other two scenarios will help us to answer part of the first research question, to analyze the impact of the centralization of some of the RL activities within the courier companies, over the factors impacting the effectiveness and efficiency of the RL, as well as the sustainability of the improvements, we will still depend on the theory and empirical approach. Thus, we will need to find information that provides enough evidence to support the expected improvements through the centralization of RL activities.

2 CONCEPTUAL FRAMEWORK

This chapter provides an overview of key concepts such as logistics, SCM, and the RL. It goes through their definitions, their scope, and the relationship between each other, offering some meaningful insights into their evolution and their importance.

2.1 Logistics and Supply Chain Management

The thesis has its background in the fields of Logistics and SCM. The logistics deals with the efficient movement and storage of goods, services, and information from the point of origin to the point of consumption. However, different scholars and organizations emphasize various aspects of this definition.

The Council of Supply Chain Management defines logistics as the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from the point of origin to the point of consumption to meet customer requirements (CSCMP, 2020). This definition focuses on the critical parts of the planning, implementation, and control, showing how important it is for any company to meet the customer needs. Similarly, the Cambridge Dictionary (2020) defines logistics as the process of planning and organizing to make sure that resources are in the places where they are needed, so that an activity or process happens effectively (Cambridge Dictionary, 2020). While both definitions are highlighting the importance of the planning and resource management, the Cambridge Dictionary makes strong emphasis on the organizational aspect, focusing on the allocation of the resources and timing.

Expanding on these concepts, Pfohl (1998) includes the transformation of goods in terms of time and space, quantity, assortment, and manipulation properties. Pfohl focuses his definition on the importance of having a coordinated execution to allow an efficient flow of goods from origin to consumption (Pfohl, 1998). This view introduces the dynamic nature of logistics, involving various transformations to optimize the flow. In comparison, Logistix Partners Oy (1996) defines logistics as a business planning framework for the management of material, service, information and capital flows. It includes the increasingly complex information, communication and control systems required in today’s business environment (Logistix Partners Oy, 1996). This definition shows the complex nature of logistics, which requires sophisticated systems to manage diverse flows of goods and information, making this definition different from Pfohl’s one that focuses on the transformation processes.

Essentially, logistics involves the efficient management of the flow of goods, services, and information from the point of origin to the point of consumption. It deals with planning, implementation and control. Additional considerations are given to resource allocation, process transformation, environmental impacts as well as strategic management. These definitions have intersections with each other in terms of basic logistics components but are still separated in relation to planning and organization, transformation of goods, multidimensional flows of information, environmental issues as well as scientific approach, and integration with suppliers.

Turning to SCM, it encompasses a broader scope that includes logistics but extends to sourcing, procurement, conversion, and collaboration with partners. The CSCMP defines SCM as “the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities” (CSCMP, 2020). This definition focuses on the integrated nature of SCM, focusing on collaboration across the SC.

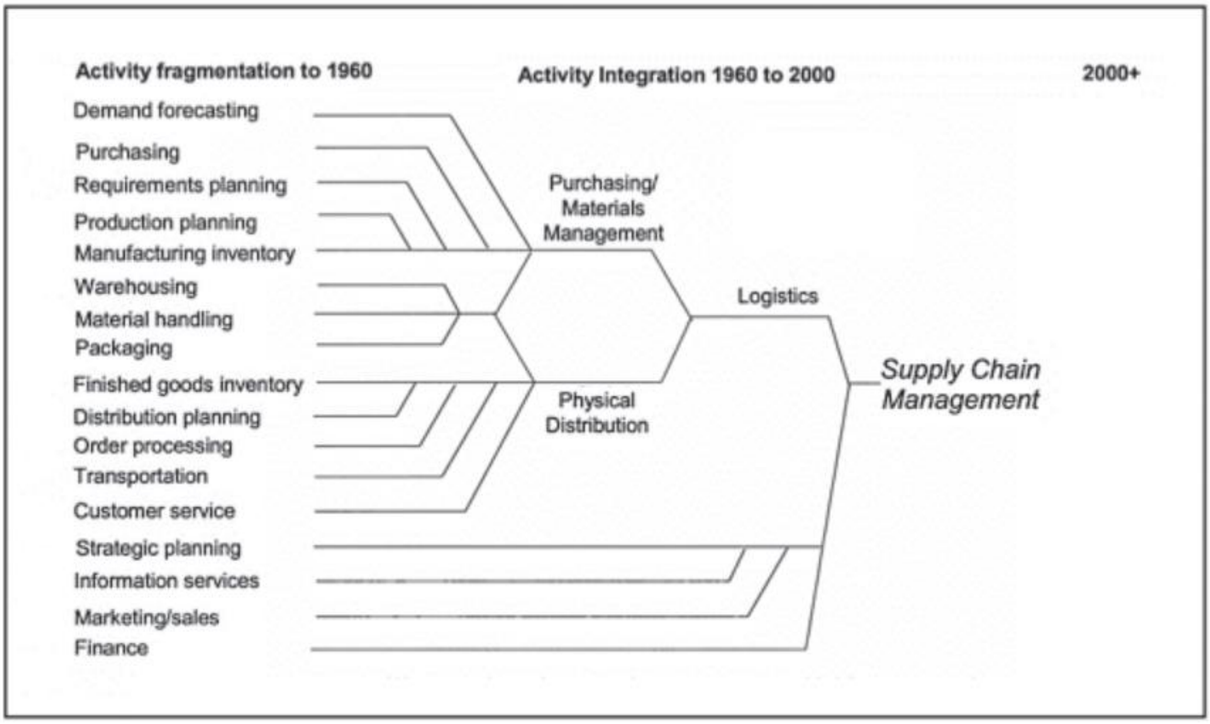
Chopra and Meindl (2019) bring to attention the strategic aspect of SCM by describing it as the management of all the supply chain assets and flows (financial, information, and product/materials) and should have as a main goal the maximization of the supply chain surplus, the overall value generated (Chopra & Meindl, 2019). This perspective focuses on the strategic aspect of assets and flows. Similarly, Fawcett et al. (2007) describe SCM as the design and management of seamless, value-added processes across organizational boundaries to meet the real needs of the end customer (Fawcett et al., 2007). This definition, which was later adopted by the Institute of Supply Chain Management, describes cross-organizational integration and customer value creation, which directs the attention toward the importance of smooth processes.

By combining these definitions, the SCM can be understood as a holistic approach of handling the movement of products, services, and information across the whole SC, ranging from the raw materials to the final customers. What stands out, is the united efforts regarding the strategic planning, and the process integration in order to create value and meet the customer needs.

In summary, logistics focuses on the efficient flow of goods and information within the SC, while stressing on the planning, resource management, transformation, and control. The definition of SCM expands the definition of logistics by including additional concepts such as sourcing, procurement, conversion, and collaboration with partners; all of this with the objective to achieve a proper integration and value creation across the SC. Understanding these different points of view can allow organizations to optimize their logistics and SC operations, by improving their effectiveness and efficiency.

Already having defined the logistics and SCM concepts, it has become a priority to understand how these concepts/practices have evolved over the time, transitioning from traditional logistical activities to more complex, and integrated SC systems. Over the years, there have been important events that have driven the development of logistics and SCM from basic logistics practices, to contemporary, technology-driven SCM as can be appreciated on the Figure 1.

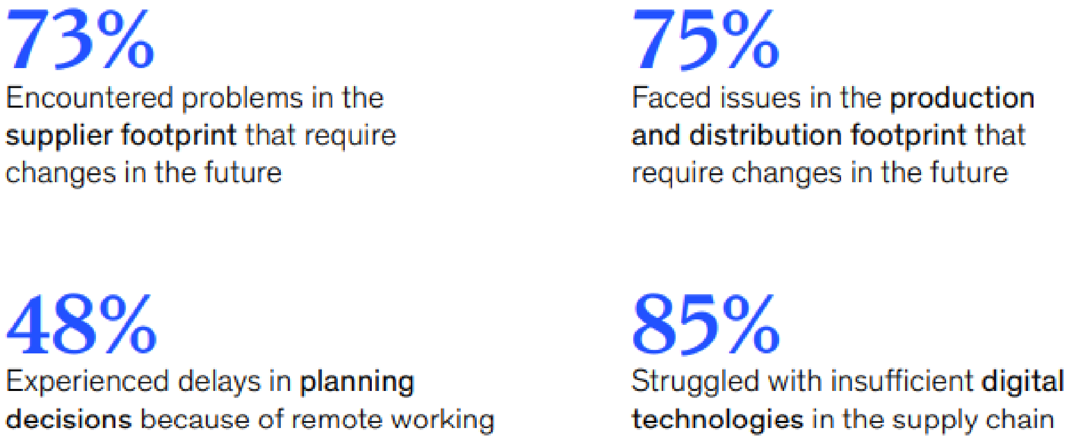
Figure 1: Evolution of Logistics to Supply Chain Management



Source: Ballou (2006).

From as early as 2,900 to 2,800 BC, logistics, which was still not formally named, was primarily performed in military affairs, where the provision of resources, raw materials, and components was critical and definitive for the success or failure of military campaigns. As time passed, the Industrial Revolution brought considerable changes in the production and distribution. By the 1950s, production and sales capacities had completely outrun the distribution capabilities, something that led to difficulties in the timely and efficient delivery of the resources. In the 1960s, the logistics went through important transformations, driven by the development of the first appearance of distribution centers and advanced transportation methods. The 1980s brought further improvements to the logistics field, such as deadlines for the deliveries and the management of the resources gaining critical importance. As logistics continued to evolve, it gradually integrated in the early 21st century into what is nowadays known as SCM. The rise of e-commerce giants like Amazon and the challenges posed by the COVID-19 pandemic highlighted the necessity for innovation and resilience in logistics processes. The pandemic exposed existing problems in SCs, which, according to a McKinsey survey, with its key results presented in the Figure 2, revealed weaknesses that companies are now working to address (Alicke et al., 2020). Although consumer demand has stabilized post-pandemic, companies continue to struggle with accurate forecasting and strategic planning, showing that logistics remains crucial for meeting customer demands and adapting to rapidly changing global markets.

Figure 2: Supply chain leaders on issues revealed by COVID19



Source: Alicke et al. (2020).

Having understood the historical evolution of logistics towards SCM, it is time now to explore what is happening in logistics, especially in Europe, where logistics plays an important role within the global economy, providing over 11 million jobs and representing 14% of the GDP. Europe leads the global contract logistics market, which is expected to grow at a compound annual growth rate (CAGR) of more than 3.23% from 2024 to 2029 (MordorIntelligence, 2023). Six of the top ten logistics companies worldwide are European, highlighting the region's strength in logistics and SCM.

The European logistics sector has demonstrated extraordinary resilience and adaptability, particularly at the beginning of the COVID-19 pandemic. According to the European Logistics & Sustainability Report (2022), post-COVID-19 SCs were characterized by sustained high international freight rates, resulting from capacity constraints and operational imbalances in global air and ocean markets. Together with highly competitive warehouse markets, rising costs, not least for fuel, energy, and labor and geo-political uncertainty, the threat of subdued economic growth remains (Panattoni & HFW, 2023). The globalization and opening of new markets at an international level, mixed with industrial relocation and competitiveness, have made transport flows and distances covered bigger. European logistics needs to adjust to these new dynamics by expanding operations on a global scale. The logistics infrastructure in Europe is currently one of the strongest worldwide, and it has a big impact on the economic growth of European countries and increases demand for transport operations. The EU's long-distance transport strategy focuses on the Trans-European Transport Network (TEN-T), which aims to strengthen social, economic, and territorial cohesion in the EU (Rudolph, Riach, & Kees, 2023).

The growth of the European logistics market has been driven by various factors, among those we can find the rise of e-commerce, the development of the logistics technology, and the increasing demand for efficient SC solutions. The COVID-19 pandemic made even faster than expected the shift of the consumer behavior towards e-commerce, with a significant increase in online shopping (CBRE, 2022). This fast shift has created the need for more robust logistics and fulfillment operations to handle the bigger volume of orders and make sure deliveries happen within promised dates. Europe is firmly committed to developing its logistics infrastructure, which, combined with the endless search for better logistics practices, has made Europe one of the leading logistics markets in the world (European Comission, 2017).

To summarize, it can be appreciated that the European logistics sector is an important part in the global economy, given the millions of jobs that it offers to the region and its contribution to the Gross Domestic Product (GDP). The region's dense logistics infrastructure, commitment to infrastructure development, and efficient logistics practices position Europe as a leader in the global logistics market. Europe's commitment to building its logistics infrastructure will secure the dominance of global logistics and SCM industry. This is evidenced by the efficient logistics practices, strategic infrastructure investments and a commitment to maintaining strong relationships with suppliers and partners that Europe has made over the past years.

2.2 Reverse Logistics

The RL is an important part within the SCM, which involves as a main activity the process of moving the goods from their final destination backwards to their point of origin, done with the purpose of capturing as much value as possible or having a proper disposal of the returned products. There have been multiple scholars and institutions that, up to date, have provided several definitions to explain the RL concept.

According to Rogers and Tibben-Lembke (1999), RL refers to "the process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal" (Rogers & Tibben-Lembke, 1999). This definition shows the importance of managing the flow of the products back through the SC to capture value or a proper disposal of these products. The focus of this definition is on the range of activities that are involved in the RL process, making particular emphasis both on the economic and the environmental benefits. By including activities such as the repairs and the refurbishing, this definition brings to the attention the true potential for extending product life-cycles while minimizing the amount of waste, which basically aligns with sustainable business practices.

In the case of DHL (2023), company leader in the logistics sector, they define RL as "the process of returning goods back up the supply chain to recapture value (reuse, recycling, etc.) or disposal. In other words, it's the logistics activities after the initial sale of a product to potentially extract value or end the product's life cycle. This includes the physical transport of the goods as well as the organizational and administrative elements, such as managing returns, exchanges, and recalls. In short: RL is the collective term for moving goods in the opposite direction than usual, from customers back to retailers, suppliers, or manufacturers" (DHL, 2023). This second definition is more focused on the operational parts of the RL, pointing out the physical and administrative tasks that are involved during the management of the returned products. DHL's statement puts a lot of attention on the level of difficulty required to deal with the RL processes, which clearly requires of an efficient coordination and management in order to be able to handle the movement of the returned products back through the whole SC. By focusing both on the physical transport and the administrative processes, this particular definition points out the need of having robust systems to manage the reverse flow of goods effectively.

Olariu (2013) defines RL as "the flow and management of products, packaging, components and information from the point of consumption to the point of origin. It is a collection of practices similar to those of supply chain management, but in the opposite direction, from downstream to upstream. It involves activities such as reuse, repair, remanufacture, refurbish, reclaim and recycle" (Olariu, 2013). Their view makes a lot more emphasis on the different activities that are involved in the RL and the importance of such activities in the overall SC. Something that draws the attention from Olariu's definition, is that they state that the RL process has a similar level of complexity and coordination to the one of the SCMs, but just in the opposite direction. When they point out activities such as re-manufacturing and recycling, this third definition tries to show the potential on the creation of closed-loop systems that support the improvement of resource efficiency and sustainability.

If we analyze these definitions together, we can see the inter-connection between each other. Carter and Rogers definition is focusing on the broad scope of the RL, including a range of activities from product returns to resource recovery. Their definition gives small insights of the economic and environmental benefits of managing returns effectively. Their point of view aligns with Olariu's definition, which also highlights a wide number of RL activities but places a stronger focus on the systematic management and flow of the products, packaging, components, and information in a direction opposite to that of the traditional SC. Then DHL's definition provides a more detailed operational perspective, focusing this time both on the physical and administrative aspects of the RL. This definition shows how complex it is to manage the product returns and the need for having a proper coordination across different stages of the SC.

Something important to notice at this point, is how DHL try to pay a closer attention specifically to the transport and the categorization of the returned products, which is complementing the overall activities pointed out on the other two definitions, and helps to show the bigger picture of the RL.

Having analyzed a few definitions of RL, it is moment to move to its history and evolution throughout the years. The concept of RL appeared for the first time in 1992 by James R. Stock, and it was not until 1998 that this concept was expanded by them on the book "Development and Implementation of Reverse Logistics Programs". Since that moment, the RL started to become more a need than just something that the companies would like to have (Ribble, 2023).

In the first years of the 21st century, governmental regulations as well as the rapid technological development pushed forward the progress of the RL field, especially with the boom of the mobile phones. The introduction of the Waste Electrical and Electronic Equipment (WEEE) Directive in the European Union (2003) was a critical moment for the use of the RL, as this directive set targets for the recycling of electronic goods, focusing on the critical need for companies to have effective RL mechanisms to manage their electronic waste. At this point it started to be mandatory for companies to create processes that could handle the increasing volume of electronic waste, ensuring their proper disposal and recycling. This regulatory push not only advanced RL practices but also shown the importance of the sustainability in the SCM.

The arrival of the e-commerce in the early years of the 21st century brought with it a lot of new challenges and opportunities for the RL. In the case of Amazon and eBay, they found themselves in the need to create similar type of mechanisms to manage the returns, repairs, and the recycling of the returned products just like those they had already in place to manage their forward logistics, something that was possible for these companies as they leveraged the technological advances such as improved tracking systems and data analytics to improve the overall efficiency.

Having defined the RL concept and understood its short but important historical evolution, it is the time now to dive deep into some literature to gain deeper insights on its practical applications and its theoretical foundation. These books, articles, and thesis on RL will provide some valuable perspectives on the strategies and frameworks considered as needed for the effective implementation of this process. These literature sources will not only contribute to our understanding of RL but will also bring to our attention the different approaches and methodologies that can be employed to optimize RL systems.

Rodrigues et al. (2013), describe in their article some important reasons to implement RL, considering environmental and economic benefits, and also critical success factors that companies should verify when implementing RL in their system (Rodrigues et al., 2013). Their study shows how complex the RL is. They do this by specifically pointing out that in order to have a successful implementation, such process needs to take into consideration the environmental and the economic aspects. The authors provide a detailed overview of the factors that drive companies to implement RL, including regulatory pressures, cost savings, and the potential for improving customer satisfaction. By doing a thorough examination of these factors, companies can better understand the benefits of the RL and use that information to develop business strategies to integrate these practices into their operations in an effective way, and these particularly have a great importance within the effectiveness and efficiency of the RL.

Suyabatmaz et al. (2014) propose the analysis of a RL network design of a 3PL under supply uncertainty in terms of quantity of returns with the use of two hybrid simulation/analytical models. The Problem Specific Method, validates a solution by checking if some problem specific performance criteria are met, when uncertainty is introduced. The analytical model and the simulation model, iteratively interact, until a solution that satisfies the performance criteria is found. The Generic Method is also an iterative procedure that finds a series of solutions, until one that satisfies the termination criterion is found (Suyabatmaz et al., 2014). This article reveals the complexity of the RL network design, particularly under particular conditions of uncertainty. The authors' use of hybrid models to address these challenges show how important it is to have sophisticated analytical tools whenever a company wants to develop an effective RL system. Their work also serves to demonstrate that integrating simulation and analytical methods can provide a more robust framework for managing the RL networks, especially in situations when the companies are facing a lot of uncertainty.

Aït-Kadi et al. (2012) state in their book "Sustainable Reverse Logistics Network" a framework for RL, where they explain the importance to have a correctly designed RL network due to the increasing environmental and social concerns. Later, they introduce the types of returns, the RL process, the shipping and/or distribution system, the importance and impact of information systems, the way to coordinate a RL, and how to measure the performance for RL processes (Aït-Kadi et al., 2012). On this book the authors are showing how important it is to do careful planning and management in the RL. It points out the different parts that need to work together to create an effective RL network, and provide a clear guide on how to design and manage these networks, putting additional focus on the need to consider the environmental, social, and economic factors, which are also important for the effectiveness and efficiency of the RL, but not all will be specifically considered within this master thesis.

Wang (2011), closely considers the factors that affect the performance of RL, employing his effort on answering the main question: Why does a company need to optimize the Logistics and Supply Chain System? Whilst doing so, he focuses on explaining important concepts related to logistics, SCM and RL. He also indicates the importance to understand the relationship between 3PLs so companies can easily identify problems in the process. He states that "The relationship between 3PLs and return services is a critical part in return/RL services, because the individual customers involve considerable uncertainties. According to observations, there is significant trend that 3PLs companies try to improve and develop the relationship between 3PLs and return receivers to reduce the uncertainties" (Wang M. , 2011). His findings help to prove that having effective RL practices can result in a significant improvement of the overall SC performance, by reducing some of the waste and recovering value from the returned products, which is precisely what we will be trying to achieve with this master thesis through the centralization of some of the RL activities. By making observations of the dynamics between 3PLs and return services, Wang's thesis is offering value added insights into the critical role of partnerships and collaboration, which is an important factor for the effectiveness of the RL.

Analyzing these articles, books, and theses reveals a comprehensive view of RL, emphasizing both the theoretical and practical aspects of its implementation. The articles by Rodrigues et al. (2013) and Suyabatmaz et al. (2014) show the critical factors and complex network designs that are needed in order to have an effective RL process. These studies serve to reinforce the hypothesis of the importance to have both environmental and economic considerations and the use of advanced analytical tools to address uncertainties in RL networks. The book by Aït-Kadi et al. (2012) provide detailed frameworks that serve to design effective RL networks. These works are focused on the importance of having systematic planning and the integration of the performance elements of the RL, such as information systems and measurement of RL key performance indicators (KPIs). Wang's (2011) thesis complements the previous authors' views by focusing on the critical role of 3PL relationships and the need for optimization in RL. Together, these documents are providing an extensive understanding of the RL, bringing special attention to the importance of carefully planning, coordinating, and managing the overall process, in order to achieve successful implementation.

Having gone in depth through different definitions, the historical evolution, and scholarly literature about the RL, it is now important to go through the regulatory frameworks, which are key to have a successful implementation of RL practices. Understanding these regulations is critical in order to be able to develop an effective RL network that is able to promote sustainability and efficiency, whilst being compliant with the legal requirements.

The legal and regulatory framework plays an essential role in order to build a robust RL. Various regulations have been launched in order to promote sustainability and ensure good practices during the waste management. The "Closing the loop – An EU action plan for the Circular Economy" (COM(2015) 0614 final) focuses on the importance of recycling and reuse stages of the RL in order to create a sustainable economy. This action plan has important impact on the RL process, by motivating companies to develop systems for the efficient recovery and recycling of their returned products. By promoting circular economy practices, this regulation supports the development of RL practices that can help companies to effectively manage the lifecycle of their products and materials.

The Directive 2012/19/EU on WEEE sets the rules for the proper disposal and recycling of the electronic waste. This directive has led to the continuous development of robust RL processes in order to manage the increasing volume of electronic waste. The directive's impact on the RL can be considered as something very significant, as it requires for the companies to establish specific processes for the collection and the processing of their electronic waste, which helps them to ensure that the valuable materials are recovered, and the hazardous substances are properly managed. By pushing towards stricter recycling targets and responsibilities for the manufacturers, the WEEE directive has significantly impacted the development of RL practices in the electronics industry.

The Directive 2005/20/EC, amending the Directive 94/62/EC on packaging and packaging of waste, is mainly focusing on the reduction of the environmental impact of packaging materials. This regulation has forced companies to develop RL processes for collecting and recycling packaging materials, which results on the minimization of waste and promotion for the recovery of resources. Such a focus on recycling and reusing is aligned with the broader goals of RL to extend product lifecycle and reduce the impact on the environment. By motivating companies to keep in mind the recyclability of the packages during their design, this directive is supporting the integration of RL into packaging management strategies.

The Directive 2000/76/EC on waste incineration sets the specific standards for the incineration of waste, including requirements for gas emissions and waste management. This directive has a direct impact on the RL process, as it keeps companies motivated to find alternative solutions for the disposal of the waste, such as recycling and reuse, rather than incinerating. This regulation clearly pushes for better RL practices, by encouraging a more sustainable waste management. Broader environmental goals are met when companies are motivated to develop their RL systems, focusing on recycling and resource recovery, rather than on incineration.

The Directive 2000/53/EC on end-of-life vehicles focus is to reduce the impact caused to the environment by the vehicles that are at the end of their life cycle. This directive makes mandatory for manufacturers to have specific processes for the collection, treatment, and the recycling of the end-of-life vehicles, with the goal to ensure that valuable materials are recovered and all hazardous substances are managed in the right way. The regulation’s focus on recycling and reuse supports the objectives of RL to minimize waste and maximize resource recovery. By setting clear targets and responsibilities for manufactures of vehicles, this directive has pushed forward the development of RL processes in the automotive industry.

The Integrated Product Policy (COM(2003) 302) is focused on the inclusion of environmental considerations into the design of the product and the management of their lifecycle. This policy forces the companies to develop products that are easier to recycle, repair, and reuse, which supports the goals of RL. By including such environmental considerations into the design of the products, the companies can create more sustainable products and reduce the impact that they cause to the environment through their operations.

This policy is aligned with RL by promoting the design of products that make it easier to perform the recovery and recycling of the returned products, which in consequence leads to improve the efficiency and effectiveness of the RL process.

In conclusion, the RL is a critical part of the modern SCM, which involves a wide range of activities with the goal to capture as much value as possible and ensure a proper disposal of the returned products. The evolution of RL from military applications to being a critical component of the commercial SCs reflects its importance in promoting sustainability and economic efficiency. The definitions provided by Rogers and Tibben-Lembke (1999), DHL (2023), and Olariu (2013) show the complex scope of the RL and the need of having an effective management of the products returns. The historical development of RL, coupled with insights from academic literature and the impact of the regulatory frameworks, shows the critical role of RL in achieving sustainable SC practices.

3 LOOKING INSIDE THE REVERSE LOGISTICS

3.1 Reverse Logistics Process and Reverse Logistics Management

The RL involves a series of processes and roles that are critical to perform the management of the flow of the goods from their final destination to the point of origin, and understanding each one of these is a minimum requirement in order to improve the effectiveness and efficiency of the RL operations and thus optimize the overall RL.

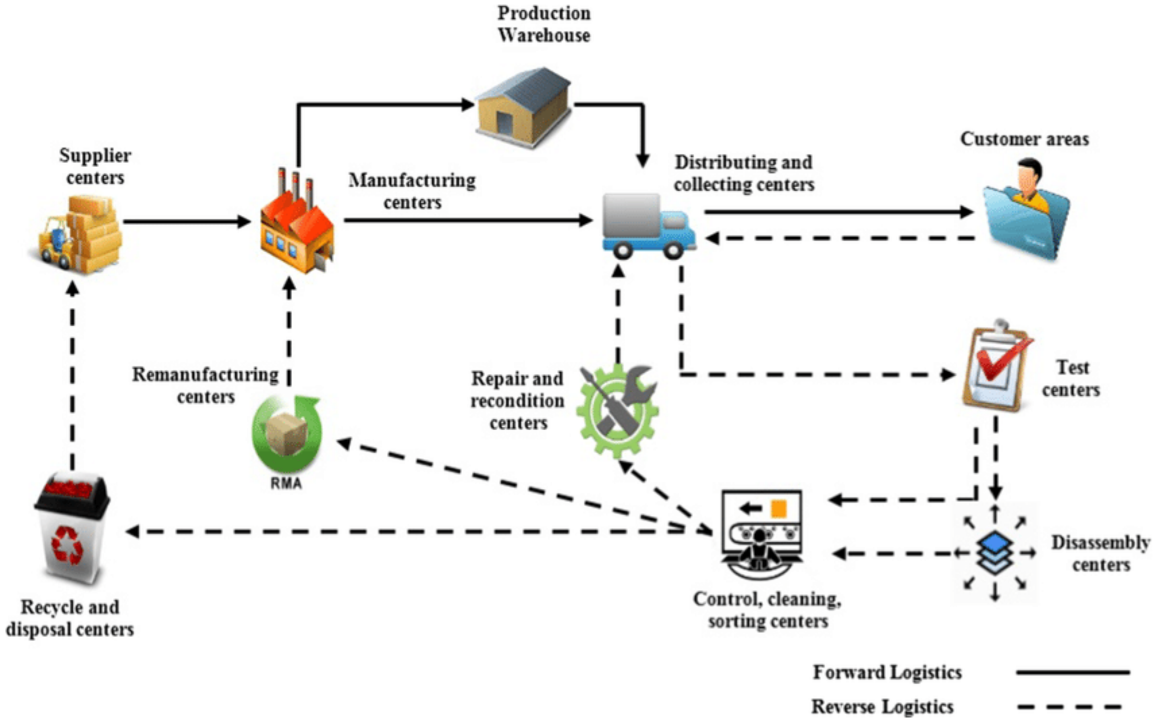
The RL starts with a series of processes with the goal to efficiently manage the returned products. These processes include several key activities that ensure products are collected, assessed, and either recovered or disposed of properly, as can be appreciated in the Figure 3 (Zarbakhshnia et al., 2020). De Brito explains that recovery is just one of the activities in the RL, with other processes including customer request for return, collection, inspection/testing, selection, and sorting (de Brito, 2004).

The first step in the RL process consists on the customer, client or user actually requesting the return of the product, taking it back to the store or throwing the product away.

Once the return request is made, the next step is the collection, which basically consists on retrieving the products from the customers, client or initial disposal location and transporting them to a recovery point.

Following the collection activity, the products undergo inspection and testing in order to categorize the returned products according to their quality and condition. This step is needed so that companies can find out what is exactly the appropriate recovery category for each product. This process involves multiple checks, among which we can find the functionality check, the wear and tear check, and the defects check.

Figure 3: Flow diagram of forward/reverse logistics activities



Source: Zarbakhshnia et al. 2020.

Following the inspection and testing phase, the products need to be actually categorized accordingly, thus the selection and sorting process becomes critical in order to en-route the returned products to the next steps. Products are sorted into different categories based on their condition and the most suitable recovery method. Understanding the different available recovery categories is very important as we are looking to maximize the value recovered from the returned products. According to De Brito, the recovery process has two alternatives, the direct recovery and the process recovery. The direct recovery includes activities such as reuse, resale, and redistribution, which help extend the lifecycle of products and reduce waste. If products pass the inspection phase and can be considered "new," they can be directly recovered through these methods (de Brito, 2004). On the other hand, the process recovery requires of additional processing in order to recover value from the returned products. Such additional processing can include repairing, refurbishing, remanufacturing, retrieval, recycling, and incineration (de Brito, 2004).

Having a thorough understanding of these activities allow the companies to develop effective processes for the management of their returns, as each one of these activities requires specific processes and expertise to ensure that the maximum possible value is effectively recovered from the returned products. While the direct recovery methods like reuse, resale, and redistribution help minimize waste and extend the lifecycle of the products, the process recovery methods like repair, refurbishing, remanufacturing, retrieval, and recycling contribute to sustainable business practices by promoting resource recovery.

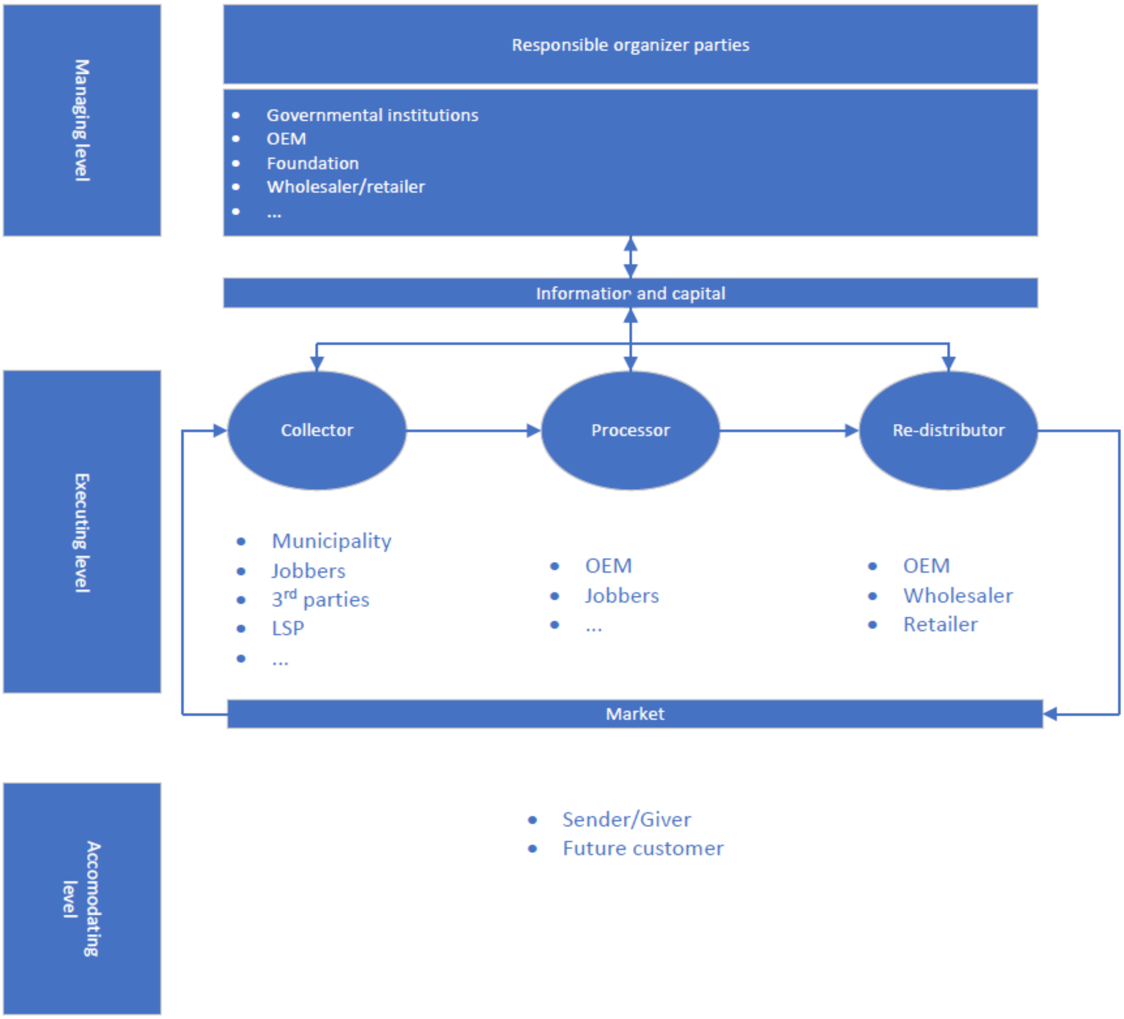
To implement these processes effectively, it is important to understand the different actors and roles involved in the RL process. Some of those actors play critical roles in the RL process, each one of them with specific responsibilities and functions. De Brito organizes these actors into three different levels (Figure 4): managing/organizing, executing, and accommodating (de Brito, 2004).

Figure 4: Actors and roles involved in the RL process

Source: Adapted from *Managing Reverse Logistics or Reversing Logistics Management?* by M. P. de Brito, 2004, Erasmus Research Institute of Management.

As it can be appreciated on the Figure 5, the first level of managing/organizing, we can find those parties responsible for organizing the RL network, which includes the governmental institutions, Original Equipment Manufacturers (OEM), wholesalers, and retailers. Understanding these roles is helpful for companies trying to develop a complex RL strategy that aligns with regulatory requirements and the industry standards. At the executing level, we find the entities responsible for the operational aspects of the RL, including the collectors, the processors, and the redistributors (de Brito, 2004). These specific roles help to ensure that each step of the RL process is handled by the right resources according to their field and level of specialization. At the accommodating level, the returner (customer) and the future client play the key roles. While the returner starts the RL process by requesting the return of their products, the future clients benefit from the recovery of these same products (de Brito, 2004). The courier companies often play roles as collectors and processors (transportation) in the RL process. By recognizing and understanding these roles, the companies can ensure to have their entire RL process properly coordinated across all the parties involved, from the initial return request of the customers to the final recovery or disposal of the returned products.

Figure 5: The actors – roles connection in the RL



Source: Adapted from Managing Reverse Logistics or Reversing Logistics Management? by M. P. de Brito, 2004, Erasmus Research Institute of Management.

In summary, the RL process involves multiple activities, and roles that are critically important in order to manage the flow of the returned products from their final destination back to the point of origin. Having an effective management of the RL requires a high level of understanding of the roles and the interactions between the different actors within the RL network. Understanding the roles and responsibilities of the different actors within the RL network is essential for the management of the RL. By taking into consideration the different activities and the roles of the parties involved, the companies would have taken the first step towards the development of an effective and efficient RL.

3.2 Factors Impacting Effectiveness and Efficiency of the Reverse Logistics

We have already made a few mentions of the effectiveness and efficiency of the RL process, but what are the factors that impact such effectiveness, and how can we approach each one of them to create a positive impact? This section goes into detail through the different factors impacting the effectiveness and efficiency of the RL, which are critical for optimizing its operations, reducing costs, and to improve the level of customer satisfaction.

The effectiveness of RL involves the factors that determine how well the process meets its intended performance goals. On the other hand, the efficiency of the RL focuses on the factors that support the costs minimization and the maximization of the utilization of the resources. By understanding and properly managing each one of these factors both independently and altogether, the companies will have taken their second step to develop an effective and efficient RL.

This chapter provides an analysis of these factors, showing the importance of each one of them, and how they interconnect and impact on the performance (effectiveness/efficiency) of the RL.

3.2.1 Factors Impacting the Effectiveness of the Reverse Logistics

Having an effective RL process is critical for organizations looking to improve their SC performance and overall business success. Several factors influence the effectiveness of the RL, including customer service and satisfaction, product quality and condition, technology and information systems, resilience and uncertainty, regulatory compliance, partnership and collaboration, process standardization and flexibility, and circularity and sustainability. The list of factors presented here was identified and compiled by the author based on the relevant literature.

3.2.1.1 Customer Satisfaction Factor

Customer satisfaction could easily be the most determinant factor of business success, and it holds significant weight in RL. Customer satisfaction can be defined as the "extent to which consumer are happy with the products and services provided by any business organization" (Musafir, 2017). The customer satisfaction is basically a comparison between the product's perceived performance and the customer's expectations, leading to feelings of pleasure or displeasure. Within the RL, customer satisfaction can be heavily influenced by how returns and exchanges are handled, the ease and convenience of the process, and the speed with which issues are resolved.

Some authors highlight the importance of having a good advertising and accessibility in the RL process, showing how these factors explain a significant portion of the overall customer satisfaction. Specifically, accessibility, which alone accounts for 32% of the customer satisfaction (Jalil, 2019). These findings of Jalil's research are aligned with the concept of "ease of use" provided by Hong, Suh, and Hou in their article "Identifying the factors influencing the performance of reverse supply chains" in which their proved their first hypothesis that the ease of use positively influences the reverse SC performance (Hong et al., 2008).

According to Lysenko-Ryba, businesses should understand that returns are not only caused by inaccurate forecasting on Business-to-Business (B2B) and/or defective items on Business-to-Customer (B2C), instead they should consider that returns are also driven by the high flexibility on the return policies, and that customers are becoming more aware of the power customer satisfaction holds for companies even in the stage of product returns. By offering a smooth product return service, companies can retain their customers, get them to purchase again, and even recommend their products/services to their social circle (Lysenko-Ryba, 2017).

An effective RL has a notable impact on customer satisfaction. A positive returns experience can make customers more likely to order again and recommend the company to others. During the COVID-19 pandemic, the convenience of ordering, trying products at home, and returning unwanted items played a significant role in customer satisfaction. Furthermore, having good and clear policies and warranty services for the returns can help to reduce the customer frustration and even increase their satisfaction by ensuring that they perceive a smooth returns process. A well-managed RL system can shorten lead times for replacements or repairs, further improving customer satisfaction.

Customer service and satisfaction are essential for to the effectiveness of the RL. By prioritizing to have a clear communication, flexible return options, robust after-sales support, and quick processing times, the companies can improve the customer experience, which in return will lead them to achieve long-term relationships and the loyalty of their customers towards their brand. An effective RL management can help to transform a very frustrating process into a positive customer interaction, which ultimately contributes to the success of the business.

3.2.1.2 Product Quality and Condition Factor

Managing the quality of the product returns is very important, as poor-quality returns can make the overall process a lot more complicated. Contrarily, having high-quality returns can be processed more easily, which helps to improve the overall effectiveness of RL operations. Effective RL requires careful management of returned product quality, affecting the feasibility of reuse, refurbishment, or recycling (Nikolaidis, 2012).

The condition of the returned products directly affects the recovery value that can be extracted from them. The products that are in a good condition can often be refurbished or even resold with a minimal processing, thus maximizing the financial returns from RL activities. On the other hand, products that are very damaged or are recovered with a poor quality could require more elaborated repairs, or even worse, they could only be suitable to be disposed, which can in return impact negatively the profitability of the companies.

Having a robust inspection and sorting process is very important to achieve effective management of the quality and condition of the returned products. The inspection processes should be very thorough to ensure that the quality of the returned products is accurately assessed without causing unnecessary delays in the reverse SC. Accurate and timely assessment helps to determine the most suitable disposition method for the returned products, whether that is refurbishment, recycling, or disposal.

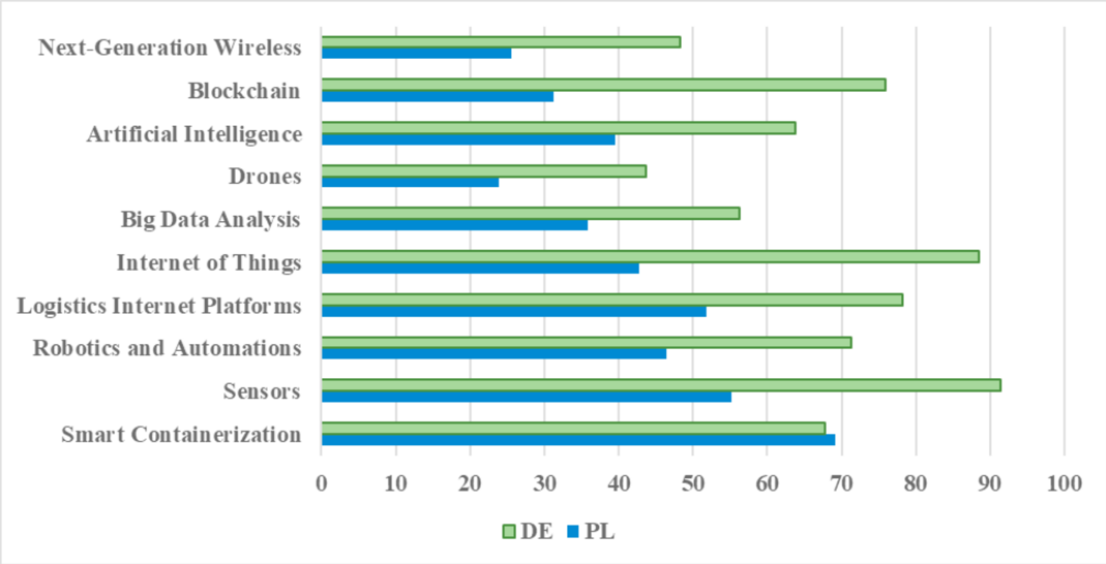
The design of products also plays a critical role in the quality and condition of the returned products (Nikolaidis, 2012). Designing products that can be easily disassembled, recycled, and reused can significantly improve the effectiveness of the RL. When a company designs products that are difficult to disassemble or contain within them hazardous materials, they will face important challenges during the return process, making it difficult to savage some of the value. Therefore, companies should consider RL requirements during the design of the products in order to ensure that their products can be easily returned, inspected, and processed.

Product quality and condition are very important factors that influence the effectiveness of RL process. Thus, companies that want to manage the quality of their returned products in an effective way, need to implement strong mechanisms for their inspection and their sorting processes, consider the RL requirements during the design phase of their products, and have a good collaboration with their suppliers. By focusing on these areas, the companies can improve the performance of their RL operations, contributing to the overall success of their business.

3.2.1.3 Technology and Information Systems Factor

The technological advancements and the integration of information systems represent the third factor, and these are critical for the optimization of the RL processes. Continuous innovation in tools, resources, and methodologies are essential for improving the business operations, given that information and Communication Technologies (ICT) can support in a big scale the RL process. A survey done by Starostka-Patyk & Grunt identified several ICT trends likely to be implemented by Polish RL companies (Figure 6), including smart containerization, sensors, logistics internet platforms, robotics and automation, Internet-of-Things (IoT), Artificial Intelligence (AI), and big data analysis (Starostka-Patryk & Grunt, 2022).

Figure 6: Declared implementation of ICT trends to support reverse logistics in Polish and German manufacturing enterprises



Source: Starostka-Patryk & Grunt (2022).

Having an advanced information system allow the companies to get into their hands real-time visibility of the whole RL processes, enabling them to track the returned products, monitor their inventory levels, and manage the logistics activities in a more effective way. These systems can also make it easier for companies to have a higher level of communication and collaboration among all the SC partners, improving their coordination and reducing the number and length of the delays.

For instance, the blockchain technology, which initially developed for digital currencies, nowadays has found applications in logistics and RL. It allows companies to have secure information sharing, real-time communication, and trust-building among SC partners (Kazancoglu et al., 2022). This technology can provide benefits such as traceability and real-time processing, and creates a transparent and unalterable record of the transactions, which can then improve the accuracy and reliability of the RL data. Such a transparency on the information can also help to prevent fraud and ensure that the company is compliant with the regulatory requirements.

Moreover, technology can improve the customer engagement in the RL process. The companies can use customer-facing platforms, such as mobile apps and websites, to keep providing to the customers real-time updates on their return status, offer self-service options, and make the communication a lot easier. These platforms can improve the customer experience, reduce the workload of the employees working on the customer service teams, and increase the customer satisfaction.

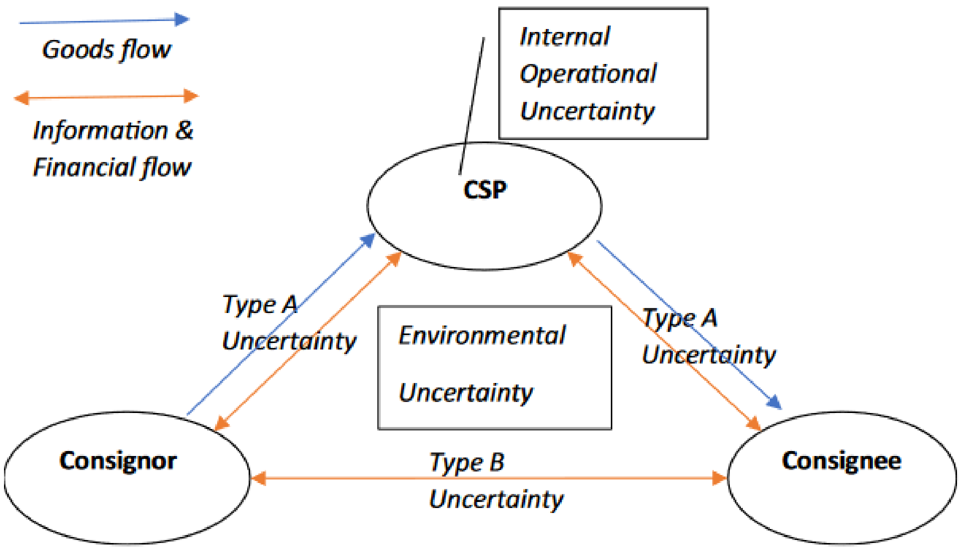
As can be appreciated, the technology and information systems are critical factors influencing the effectiveness of the RL process. The companies that want to improve the visibility, the decision-making, and in overall optimize their RL companies, should continuously innovate and integrate advanced technologies, such as blockchain, IoT, AI, Machine Learning (ML), and Enterprise Resource Planning (ERP) systems. By leveraging these technologies, companies can improve coordination, reduce costs, and enhance the overall effectiveness of their RL operations.

3.2.1.4 Resilience and Uncertainty Factor

The fourth factor which impact the RL effectiveness is all the uncertainty that surrounds it, and the companies' resilience to overcome the uncertainty. According to Wang et al. (2020), there are four types of uncertainty that cover all major uncertainties in the RL services. The first, Internal Operational Uncertainty, refers to the uncertainty regarding the internal processes of the customer service provider (CSP). The second type of uncertainty described by Wang et al. (2020) on their research paper "Reverse logistics uncertainty in a courier industry: a triadic model", is the uncertainty "Type A", which refers to the uncertainty between the CSP and the consignee, and between the CSP and the consigner. This type of uncertainty refers to 3 different inner uncertainties, the one concerning to the condition of the goods during the transportation between the CSP and the customers, affecting on this way the quality of the product and the delivery timelines, the one driven by inconsistencies or errors in exchange of information between the CSP and the consigner or consignee, potentially causing delays or misunderstandings, and the one related to financial transactions such as payments, refunds, or invoicing between the logistics provider and customers, impacting financial stability and trust in the process. The third type of uncertainty is the "Type B", which comes to pass between the consigner and the consignee. This type of uncertainty is mainly influenced by the financial flow, and the flow of information. As could be expected, communication challenges, payment discrepancies, and the refund procedures, are the main sources of this type of uncertainty. The fourth and last type of uncertainty is the Environmental Uncertainty, which refers to the uncertainty arising for external and uncontrollable factors, such as natural disasters, pandemic spreads, government policies, trade regulations (Wang et al., 2020). The interconnection between these types of uncertainties can be appreciated on the Figure 7.

In order to have an effective management of these uncertainties, the companies need to put together very strong risk management strategies, increase the flexibility of their operational procedures, and build effective communication channels which would be aligned within their RL operations. Proactively managing these uncertainties can improve the resilience and the effectiveness of the overall RL, thus the companies must make sure to develop a set of strategies to mitigate the impact of these uncertainties, such as diversify their sources of supply, implement strong quality control measures, and establish contingency plans for the different types of scenarios that could arise.

Figure 7: A triadic model of RL uncertainty



Source: Wang et al. (2020).

The resilience in the RL includes the ability to adapt to disruptions and being able to recover from them, and this resilience can be built in different ways, including the diversification of SCs, investment in flexible technologies, and the development of strong and strict contingency plans. When a company diversifies their SCs, this can help them to mitigate risks associated with single-source dependencies, given that by sourcing materials and products from multiple suppliers, the companies can reduce the impact of disruptions in any part of their SC; something from which they would not be able to benefit if they have one single supplier on the disrupted activity or source of material.

This fourth factor of resilience and uncertainty, can have a significant impact on the overall performance of the RL. The companies that want to improve the effectiveness of their RL operations and avoid unexpected bottlenecks on their reverse SCs, need to make sure to build strong strategies to manage the risk, invest in flexible technologies, and establish clear communication channels with their stakeholders in order to manage any type of uncertainty and achieve the desired level of resilience.

3.2.1.5 Regulatory Requirements Factor

The fifth factor, which consist on the compliance with regulatory requirements has also an important influence over the effectiveness of the RL. Businesses find their RL strategies being impacted by different regulations regarding the management of waste and environmental protections, thus they need to ensure to meet such complex regulations in order to be compliant according to waste disposal guidelines, recycling and recovery targets, and the proper documentations of their RL activities. Previously, in the section 2.2, some regulations for the RL process were described. If a company fails to comply with any of these regulations it could end up creating serious legal penalties and irreparable damage to their reputation. The regulatory compliance also drives the adoption of sustainable practices in the RL processes, meaning that the increasing legal requirements regarding environmental protection, imposing on economic units the obligation to effectively manage the product at every stage of its life cycle (Starostka-Patryk & Grunt, 2022), such as recycling, re-manufacturing, and responsible disposal of returned products; something that is clearly aligned with broader sustainability goals and improves the overall performance of the RL.

With that said, it is possible to re-affirm the importance of the regulatory compliance to achieve a positive impact on the effectiveness of the RL. Basically, the companies have the need to adopt complex regulations, implement very specific processes and procedures to manage returns of their products, and stay informed about any upcoming regulatory changes in order to adapt and strive. The compliance with the different regulations, impulses the adoption of more sustainable practices, encourages innovation, and influences the product design which shows the inter-connection between the factors discussed so far.

3.2.1.6 Partnership and Collaboration Factor

An effective RL often involves having a good collaboration with multiple partners, including the suppliers, the logistics providers, and the recycling firms, where a strong partnerships and collaboration helps to improve the effectiveness of the RL in overall. Having collaborative efforts allows companies to use for their benefit the expertise and resources from their partners. For example, the logistics providers can offer specialized services to handle the returned products, meantime the recycling firms can support to recover and process the materials. In a similar way, having an effective communication and coordination among all the partners is very important, as this allows o have a more robust RL process, given that this allows to drive innovative solutions, such as the development of new technologies, streamline processes, and improve the service level. Just by working together, the companies can ensure to address any type of barriers that they have in common, share information to help improve each other businesses, improve technology adoption, and jointly tackle the regulatory pressure (Rasool et al., 2023).

Creating strong partnerships throughout the whole SC can lead to the companies to achieve considerable benefits, such as reduce their costs, improve their overall operations, and a higher level of customer satisfaction. Let’s look at 3 different types of collaborations. First, if companies collaborate with their logistics providers, they can expect to have a better optimization of their transportation routes, achieve a substantial reduction of their shipping costs, and improve the speed at which the returned products are processed. Second, if they collaborate with the recycling firms, they can ensure that every single returned product is processed in a way that reduces the impact to the environment, which would lead them to meet the regulatory requirements and support their sustainability goals. Third, if they collaborate with their suppliers, they could receive useful information that they could use to improve the design of their products, the way in which they control the quality of their products, and the specific management of the different types of materials, which as consequence might result in an overall improvement of the quality and condition of the returned products. If companies can build a path to work together in a highly competitive environment, they will be able to develop multiple strategies to reduce the return of their products, improve their durability, and make them easier to dissemble and recycle.

Working together and teaming up plays a big role in the performance of the RL. This means that companies need to build strong relationships with their suppliers, shipping companies, and recycling businesses in order to be able to access into their know-how and resources. When everyone puts their heads together to come up with new ideas, it can lead to acquire better solutions and ways of doing things, which would make the RL process run smoothly; thus, by taking care of such partnerships and collaborations, the companies can improve their overall RL and create some win-win situations for all the parties involved.

3.2.1.7 Standardization and Flexibility Factor

The seventh factor influencing the effectiveness of the RL is Standardization and flexibility. According to Reflex Logistics, "standardizing reverse logistics implies rolling out harmonized, optimized, and automated processes for managing returned product flows" (Reflex Logistics, 2024). The process standardization involves establishing standard operational procedures (SOP) for the management of the returned products, including but not limited to the standardization of the different activities of the RL process discussed before, such as the inspection, the sorting, as well as the standardization of the processing methods according to the categorization of the returned products. Having a standardized process allows the companies to reduces the variability, to minimize the number of errors, and to improve their overall operations, while also making it easier to train new employees as they can provide them with easy-to-follow training materials, and enables scalability of the RL process. The standardization in RL can improve the predictability and reliability of return processes, leading to better resource utilization and cost savings. Standardized processes also enable companies to measure and improve performance more effectively.

On the other side, we can say that flexibility is equally important in order to accommodate diverse product types, meet the ever-changing customer preferences, and variability in the market conditions. Flexibility in RL networks is necessary for efficient response to complexities and uncertainties of the RL environment (Bai & Sarkis, 2013). Having a flexible RL is very beneficial for companies as this allows them to adapt their processes to any changes in the product demand, the volumes of the returned products, and the regulatory requirements which are parameters out of the control for the companies. Such adaptability is very important for companies looking to keep their responsiveness and customer satisfaction with high standards as it allows them to use customized solutions for different products and markets, which in return means a significant improvement of the overall effectiveness of their RL operations.

Achieving a balance between standardization and flexibility requires a strategic approach, so the companies must identify core processes that would bring to the table added value by standardizing them, while still leaving some room for customization and adaptability wherever and whenever it is necessary. Such a balance can be achieved by designing each process of the RL separately while still considering the process as a whole, then the standardized parts can be modified as needed without having any negative impact on the rest of them, allowing for adaptability in the overall RL process. For example, the companies can standardize the processes within the inspection and categorization, while allowing flexibility in the following activities based on the product type and its categorization.

As can be appreciated, the process standardization and flexibility are very critical factors for the effectiveness of RL, thus, companies around the world need to strategically balance their standardization and flexibility as this sometimes requires of trade-offs in order to create a robust and adaptable RL process. While when a company manages to achieve standardization, they can ensure to have consistency, which helps them to reduce variability, and have an easier integration of technologies, the flexibility will allow them quickly adapt their business to any changes in the market, accommodate their processes to the different product types, and continue to meet the customer expectations. By achieving a good level of balance, the companies can expect an improvement on the overall effectiveness of their RL operations and make a better use of their resources.

3.2.1.8 Circular Economy and Sustainability Factor

The final factor impacting on the effectiveness of the RL consists on the circular economy and sustainability. The RL plays a significant role in promoting circular economy practices as this enables the recovery, recycle, reuse, and the re-manufacture of materials; given that an effective RL system can highly contribute to sustainability by minimizing wastes and conserving resources. Despite the importance of RL in circular economy practices, significant quantities of resources are still landfilled. A returns management system that is properly organized and well-functioning may make the SC more effective. It can also increase a company’s profitability and competitiveness (Janczewski, 2019).

Two different types of loops in the RL are defined. The first one, the open loop, refers to the process in which the products are sent all the way back in the SC to the manufacturer or a third-party service provider either for recycling, re-manufacturing, or disposal. The main difference with the closed loop, is that once the products are returned, they do not enter the same SC for sale as a used or refurbished item. The second, the closed loop, refers to the process in which the returned products are sent to the manufacturer or a designated facility, where a refurbishment or repair process is performed on the product. Once the product is refurbished or repaired, the product can enter again the same SC for sale as used or refurbished item. On the Appendix 2, which is originally presented by Starostka-Patyk and translated by Janczewski, it can be appreciated that materials are recovered to be re-used in the production of new items without the original products re-entering the market, whilst on Appendix 3, it is visible that once the products reach the end of use, they can be processed in order to re-enter the same SC (Starostka-Patyk, 2016/2019). An example of an open loop is the recycling of automobile tires, where once the tires reach their end of life, they can be sent to recycling facilities where the rubber is shredded and used as raw material to create new products such as playground surfaces. The recycled materials from tires are processed and used for new applications, but the tires themselves do not re-enter the original SC as refurbished tires. On the other side, on the case of the closed loop, a clear example would be on the apparel industry, where clothing items are refurbished and/or repaired before being reintroduced to the market as used products. This closed loop system reduces waste, offers sustainable fashion choices, and extends the life cycle of clothing.

The circular economy is an economic system which aims to minimize the losses and exploitation of non-renewable resources. For that reason, this system assumes that individual elements should be designed in a way that allows for disassembly and re-use. The circular economy is also known as a closed economy, a closed loop economy or a “cradle to cradle” model. The circular economy is also referred to as closed circulation economy. The closed loop economy system keeps the added value of products for as long as possible and eliminates waste. It keeps resources within the economy. When the life cycle of a product comes to an end, it can be used again multiple times in a productive way, thus creating new value (Biancolin et al., 2023).

The specific relationship between RL and sustainability shows the need for modern business processes. With increased awareness of environmental concerns and demand for ecologically friendly products, effective RL practices are critical. Market dynamics, customer preferences, and economic concerns make the situation even more difficult, demanding a fair balance between economic and environmental factors. Companies are starting to understand the potential in the financial benefits by investing on sustainability. It is clear that developing green competency and establishing appropriate RL systems is critical for reducing environmental damage, decreasing waste, and encouraging conservation, which highly contributes to the effectiveness of the RL.

3.2.2 Factors Impacting the Efficiency of the Reverse Logistics

Having an efficient RL is essential for companies to manage their returns effectively, reduce costs, and maintain high the levels of customer satisfaction. There are several factors that impact the efficiency of the RL, including cost management, inventory management, automation, and resource utilization. These factors are deeply interconnected and collectively determine the success of the RL operations.

3.2.2.1 Costs Factor

According to Kovács and Rikhardsson (2006), cost transparency is essential for the management of a business process, as costs are the basis for many management decisions (Kovács & Rikhardsson, 2006), thus the need to have a detailed look into all the costs within the RL. They suggested a cost model for the RL based on the type of cost (personnel labor/training, materials, tools, consumables, capacity costs and other), and type of activity performed (collection, inspection, separation, reprocessing, disposal, and other/support activities), see Appendix 4.

Yang et al. (2017), describe a model with 2 primary activities (collection and transportation, and sorting and storage), and four secondary activities (refurbishment/remanufacture, recycle or repair, resell, and disposal). They state that before the entry of the returned product in the RL, we need to set up a system which will recognize this product, and that by using an Activity-Based Costing (ABC), the exact consumption can be identified, the allocated resources to each activity, and finally get to know the real cost of the value-added in the SC (Yang et al., 2017).

According to Deloitte, 10% of the revenue of the companies are spent as RL cost, and transportation cost along takes approximately a 60% of the total RL costs (Deloitte, 2014). Clearly transportation costs constitute the largest share among those activities involved in the RL process, which is further negatively impactful for the companies as transportation in overall does not add any value to the products, thus any significant reduction on the transportation costs would reflect as a positive outcome on the benefits of the companies. The products are usually picked-up at the customer location by a logistics provider, which transport them to their own sorting/consolidating facility, then they are transported to a testing/inspection facility, and from this facility they are transported further in the SC at least one more time depending on the returned product categorization. This means that every returned product is transported at least 3 times during the RL process, which in many cases is more than the number of times that products on the forward logistics are transported; clearly showing why the transportation costs are so high when compared to other RL costs.

Handling and processing costs are very significant in RL, typically accounting for approximately 20-30% of total costs. These costs include receiving returned goods, inspecting them for damage, sorting them based on their condition, and repackaging items that can be resold.

Disposal costs, which can usually range from 10-15% of total RL costs, are another critical area to consider. Usually, the products that cannot be resold or refurbished need to be disposed of in an environmentally friendly manner, which is particularly important for industries dealing with hazardous materials, such as chemicals or batteries, where regulatory compliance is a lot more complex, meaning additional processing costs.

While many companies fail to consider the costs associated to regulatory compliance, from my professional experience these can actually constitute a 5-10% of the overall RL costs. Compliance with environmental regulations and standards for safe disposal of waste is usually mandatory, and failing to adhere to these regulations can result on big fines and irreparable damage to the reputation of the companies, which means that they need stay updated with any regulatory changes as discussed on the previous section, and incorporate these costs into their overall cost management strategy.

A practical approach to managing the RL costs includes understanding the entire lifecycle of the products being handled. As Lambert et al. stated, having a clear understanding of the product lifecycle can help the companies to design a more effective RL process that minimizes costs and maximizes the value recovery (Lambert et al., 2011). For example, the companies can design their products in a particular way that makes them easier to disassemble and recycle, which in return helps to reduce the costs of disposing them and increases the potential for recovering valuable materials. By designing their products to be easily dissembled, they can reduce the costs to dispose the returned products, which clearly shows the significant potential for cost-saving (Zhou et al., 2018).

In overall, by leveraging advanced technologies, optimizing transportation and handling processes, ensuring regulatory compliance, and balancing cost savings with customer satisfaction, companies can ensure to achieve significant improvements in the efficiency of their RL operations. This shows how the cost management in the RL requires a strategic approach that considers all the different cost components involved.

3.2.2.2 Inventory Management Factor

According to Cash Flow Inventory, company dedicated to the development of inventory management software, "Inventory management is the process of managing the inventory levels of products throughout the supply chain to ensure that the right amount of stock is available at the right time to meet customer demand" (Cash Flow Inventory, 2023). Unlike forward logistics, where the inventory levels can be relatively "easily" predicted with a good level of accuracy, the RL deals with the unpredictability and volatility of the returned volumes, and their timings. Such uncertainty presents several challenges for the management of the inventory in any company. One of the primary challenges faced by many companies comes into sight when trying to manage the condition of the returned products. Returns can range from unused, perfectly resellable items to damaged goods that require significant refurbishment or disposal.

Implementing a robust inspection and categorization process for the returned products, can help to make it easier to classify them based on their returned condition and to determine the right following-up that should be applied on them, something that would streamline the management of the inventory, which in consequence will lead to cost savings.

Integrating RL and inventory management can help companies to recover value from returned products by refurbishing, repairing, or reselling them (Cash Flow Inventory, 2023).

Additionally, effective inventory management in RL involves understanding the entire lifecycle of the products being handled. This includes having knowledge about the specific patters of the returns (type of product, return reasons, time period, customer segment, sales channel, geographic region, processing time, order value...), the condition of the returned products, and the potential for the returned products to be refurbished or resold (Govindan et al., 2015). By having a complete view of the lifecycle of the products, the companies can design more efficient RL processes looking to minimize costs and maximize the value recovery.

3.2.2.3 Resource Utilization Factor

The last factor analyzed on this thesis impacting the efficiency of the RL refers to the resource utilization, as it involves the optimal use of the physical, financial, and human resources to manage the returned products and refurbishments while attempting to minimize the waste and reduce costs; in which critical part is to strategically allocate the physical resources, such as warehouses and distribution centers. Properly located facilities can reduce transportation costs and improve the speed of returns processing. Egri et al. (2023) emphasizes the importance of strategically placed RL facilities that are close to major return sources, which can significantly cut down on transportation time and costs (Egri et al., 2023).

Human resources are another vital component. A company can have standardized process, the best inventory management system from the market and even the best automated technologies, but they won’t be able to reach efficiency if they do not do a good training of their employees to make a proper use of such processes and technologies in order to improve the RL operations. Moreover, it is important for the companies to set a culture of continuous improvement, where employees are motivated to identify and implement structural solutions in the processes in order to boost efficiency (Filipe & Pimentel, 2023). In the logistics industry, training employees in the latest RL practices and technologies can improve operational efficiency and reduce costs.

Lastly, it is also important to leverage external resources from the partners (logistics providers, recycling firms...) in order to improve the resource utilization, as these can provide access to their expertise in the topic on hand, leading to more efficient and cost-effective RL operations. Moreover, the relationship between resource commitment and program performance shows how strategic partnerships can improve the overall performance of the RL operations (Dabo & Hosseinian-Far, 2023). Developing RL programs from a resource-based view can be essential for efficiency.

3.3 Products Returns

Product returns are basically the reason for the RL process. Understanding the reasons and types of returns is critical for the companies looking to improve their efficiency and effectiveness of their logistics RL and their overall SCM. This section goes through the product returns, exploring briefly the reasons for returns, the different types of returns, and the proportion of products typically returned across a few common industries; which can help the companies to better manage their RL operations, ultimately getting benefits both their bottom line and their environmental footprint.

There are several reasons for returns, most of the times, products are returned either because they do not succeed to satisfy customer expectations, the cause of the need for the product does not longer exist, or because the product lifecycle is over.

De Brito divides the reasons for return as an inverse order of the SC, i.e., since the normal SC phases start with the manufacturing process, goes through the distribution to finally reach the customer, they state the reasons for the return as: Manufacturing returns, distribution returns, and customer returns (de Brito, 2004).

Manufacturing returns happen due to 3 specific reasons. The first reason is due to raw material surplus i.e., raw material leftovers when the production is completed. The second can be associated to problems with quality control, and the third reason is related to the leftover of products of by-products (de Brito, 2004). Distribution returns occur during the distribution stage. The reasons for distribution returns are: Product recalls, B2B commercial returns, stock adjustments, and functional returns (de Brito, 2004). Customer returns are all those reasons that appear once the customer receives the product. Such reasons are: B2C commercial returns, warranty returns, service returns, end-of-use returns, and end-of-life returns (de Brito, 2004).

Going more into details, Saravanan et al., divide the B2C reasons for returns in 10 different reasons. According to them, products returns happen when: 1) The product has defects, 2) The wrong product have been delivered, 3) The size of the product is too big or too small, 4) The customer order many sizes of the same product with the intention to keep only one, 5) The customer cannot afford to keep the product, 6) The product is found for a cheaper price somewhere else, 7) The product is found faster somewhere else, 8) The product does not match the customer's style, 9) Impulsive purchasing behavior, and 10) The customer's need for the product has faded away (Saravanan et al., 2023).

As claimed by Fleischman, there are five types of returns. Some returns are associated with the mismatch of customer expectation at the retailer point (commercial returns), but there are other types of returns in the reverse flow of products (Fleischmann, 2000).

These are:

- Return of unused products;
- Commercial returns;
- Return of products under warranty;
- Wastes and products derived from networks activities (SC and RL)
- Packaging

Each type of return has its own characteristics and requirements towards the RL process, each one has its own way of testing and while some of them can be reused after a repair service, some of them will have to be recycled or disposed. Depending on the testing result, the returns will be sent to a part of the SC or join an alternative SC.

According to Aït-Kadi et al. (2012), each type of return requires specific treatment processes, and considering the product lifecycle can help to select the right treatment for each particular return.

Understanding these categories can help the companies to prioritize their efforts and focus on the right factors to improve the effectiveness and the efficiency of their RL processes, making them more sustainable and cost-effective by appropriately managing the returned products based on their condition and potential for reuse, refurbishment, or recycling; all of this, while having the added value of making the customers happy, and protecting the environment.

As described by KPMG International in their report “Future-proof your reverse logistics” in the chapter “Understanding the true 'cost to serve”, There are certain industry sectors like high-tech, automotive parts, pharmaceuticals, medical devices, and print media, where product and component returns are just a part of the everyday transaction cycle (KPMG , 2017). The following table shows the percentage of returns for some of these industries as a total of goods sold.

Table 1: Return percentages by industry

Industry	**Percentage**
Publishing and greeting cards	20%
Clothing retailers	10%
Automotive parts (US)	4-6%
Electronics, books and other hard-goods	8,8%

Source: KPGM (2017).

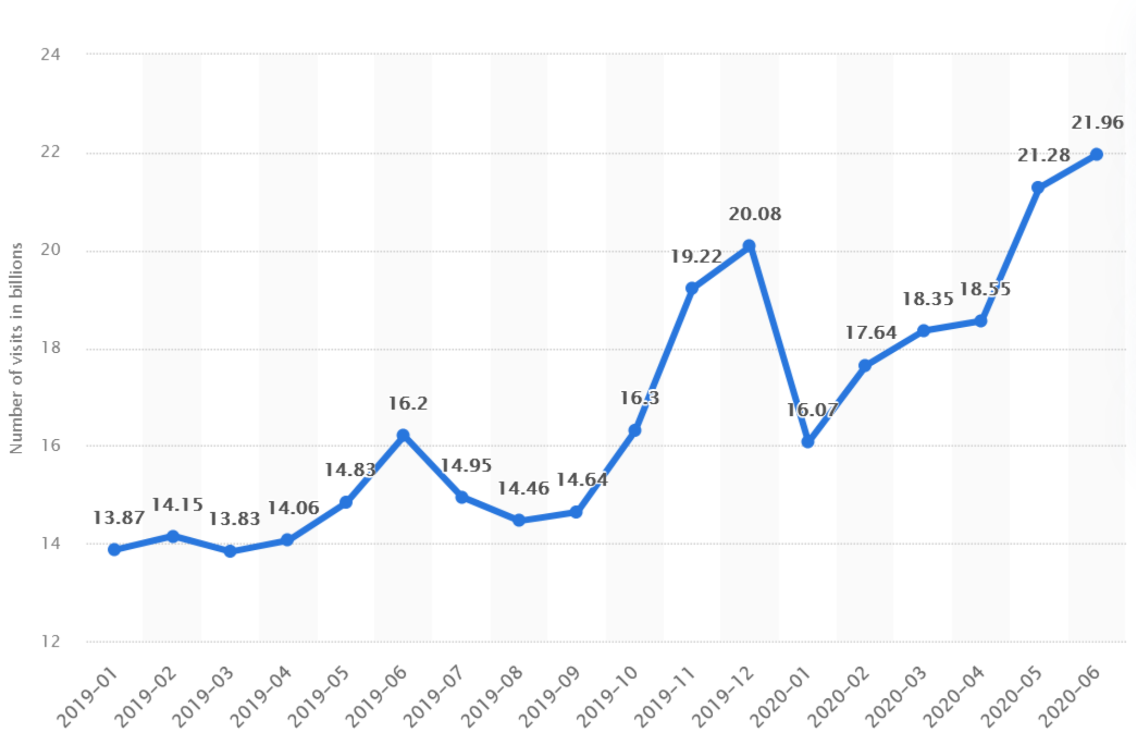
4 E-COMMERCE AND THE COURIER COMPANIES IN THE FIELD OF REVERSE LOGISTICS

The growth in the e-commerce during the past years, has not only changed the way that products are sold and delivered to the customers, but it has also introduced multiple and complex challenges in handling returns. As the customers increasingly expect struggle free returns, the role of the courier companies in making possible this process has become more critical than ever. The Chapter 4 goes through the relationship between e-commerce, the courier companies, and the RL related with product returns, focusing on why this interconnection is so important in order to maintain high levels of customer satisfaction and operational efficiency during the current times. By understanding all the different strategies and innovations that courier companies employ to manage the product returns, we gain insights into how the broader e-commerce industry can quickly adapt to the growing demands of the RL. This chapter shows the importance of this aspect of the SCM which is very often overlooked, and its impact on the future of the online retail.

4.1 Ecommerce and the Reverse Logistics

With the emergence of Covid-19, almost every aspect of online retailing has been impacted. From customer behavior and shopping patterns to the digital infrastructure and demand forecast.

Figure 8: Coronavirus impact on retail e-commerce website traffic worldwide as of June 2020, by average monthly visits



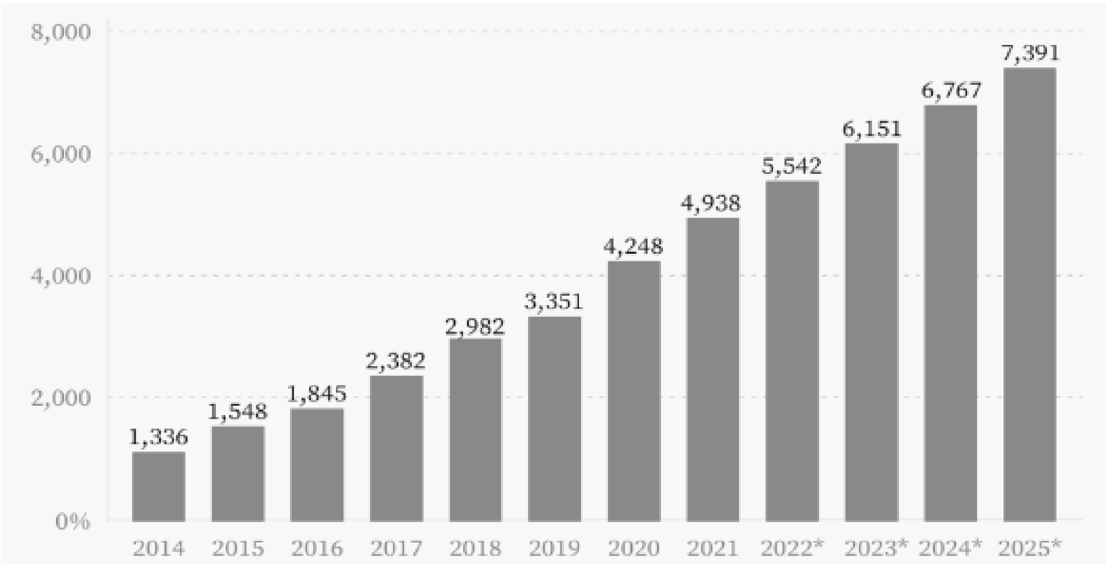
Source: Statista (2020).

As visible on the Figure 8, in June 2020, retail websites had 21.96 million visits against 16.2 million visits in June 2019 (Statista, 2020).

Online sales had a significant growth between March and June of 2020, breaking previous records. In 2020, the e-commerce industry reached a historic milestone with a total value of 4.2 trillion dollars, accounting for approximately 16.5% of global trade (Ciesielski, 2020).

Looking at the figure 9, it can be appreciated that by 2024 and 2025, respectively, it is anticipated that worldwide e-commerce revenues will total $6.7 trillion and $7.3 trillion (Fokina, 2024).

Figure 9: Retail e-commerce sales worldwide from 2014 to 2025 in billion U.S dollars



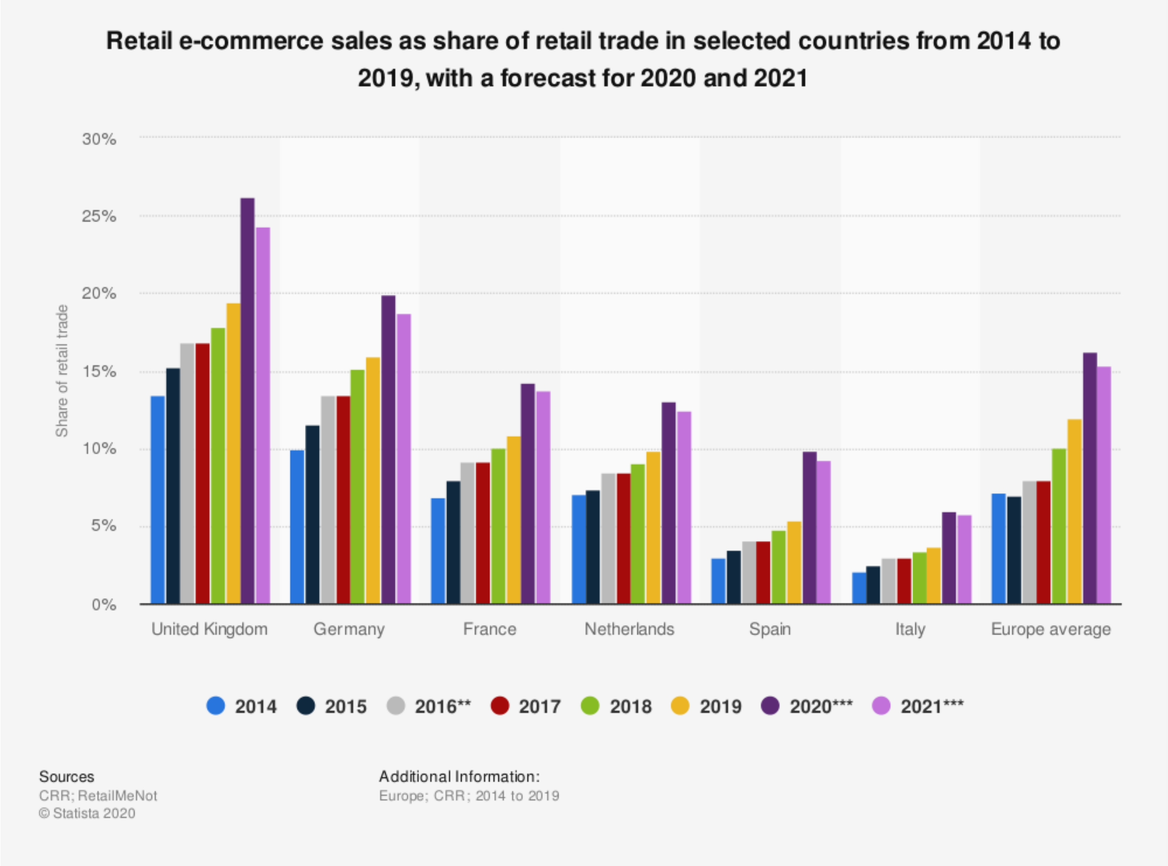
Source: Fokina (2024).

E-commerce was expected to be accounted for 12% on average of total retail sales in Europe in 2019 and is expected to account for 16,2% and 15,3% in 2020 and 2021, respectively, as can be appreciated in the Figure 10 (Coppola, 2020) .

We can also observe in the Figure 10, how Covid-19 completely fluctuated the e-commerce industry in the European countries. In Spain the e-commerce sales almost doubled from 2019 to 2020. Similarly in other countries of Europe, the e-commerce sales shifted from a linear trend year over year, towards an exponential trend.

The significant increase of e-commerce caused by Covid-19 brought with it some additional challenges for logistics companies, including courier companies. Among these challenges were the product availability, the raise of customer inquiries, ensuring the safety of employees working on the e-commerce fulfillment processes, cybersecurity risks due to increased online transactions, and regulatory compliance.

Figure 10: Retail e-commerce sales as share of retail trade in selected countries from 2014 to 2019, with a forecast for 2020 and 2021



Source: Coppola (2020).

According to ASENDIA, the impact of social media and digital advertising are changing the rules of the game. Additionally, consumers are driving demand for sustainability, inclusivity, and ethical practice. For e-commerce businesses that can act swiftly, engage audiences through digital channels, and leverage tech to drive efficiency, the future looks very bright indeed (ASENDIA, 2023). This change on the customers' requirements is pushing companies globally to have digitalization as well as sustainability, inclusivity and ethical considerations within their business models.

While introducing digitalization and e-commerce, it is inevitable to consider customer returns. According to ASENDIA, 25% of online e-commerce shoppers identify as "frequent returners", sending back at least 10% of the items bought online. In overall, online shoppers expect to have an easy return process, as close as possible to zero cost to them. Many retailers have moved to offer "try before you buy" service, which has led to 30% of consumers purposely to order in higher quantities than needed/wanted and return all those unwanted items (ASENDIA, 2023).

In order to minimize these returns, companies offering online retail can influence the customer experience by providing accurate product description, quality photography, and even videos to show the real fit of the items. Customer reviews is another important aspect that helps to mitigate returns.

As seen on the previous chapter, there are several factors the impact the effectiveness and efficiency of the RL, and specifically on E-commerce, the return rates are much higher compared to return rates of in-person purchases. Thus, the need for the companies in this sector to innovate on their RL strategies and find ways to improve the effectiveness and efficiency of their RL, reason why they should partner with courier companies and push them to increase their participation in the RL process.

4.2 The Courier Delivery Companies and the Reverse Logistics

The courier companies play a critical role in the RL process. This is due to their capability to manage such a complex task in an efficient way, and their ability to handle large amount of returned products. They offer a wide range of specialized services to support their contracting companies by addressing the unique challenges of the RL, such as picking up the returned products from the "unlimited" customers locations, transport those products to their consolidation or cross-docking facilities, and delivering them to the designated inspection or repair facilities specified by their contractors. These companies are able to provide the needed infrastructure and expertise to manage these specific requirements of the returns process quickly and effectively, which is particularly important in order to maintain high levels of customer satisfaction and operational efficiency in the e-commerce; something that is very challenging as the customers in overall see the returns process as a negative experience.

Traditionally, courier companies are characterized by delivering packages, messages, and mail, differentiating themselves from other types of 3PLs with factors such as: The ability to offer shorter delivery times, personalized services, and improved product protection. Some of the advantages of using the services offered by the courier companies are: 1) Door-to-door delivery, which ensures convenience and accessibility to all the customers, 2) Same-day delivery as a premium option, something that is highly valued by the most time-sensitive customers, 3) Courier companies are also recognized for their overall incredible efficiency in terms of speed as opposed to the inefficiency of regular mail delivery (Medium, 2023), which helps them to ensure fast and reliable delivery of the products, something that helps them to maintain good profit margins, regardless of the high costs from the last mile delivery sector. Courier companies also have the advantage when it comes to lower risk of package damages, personalized service, and extra care of the customers’ goods. In the other direction, there are some disadvantages of using courier services, such as the highest costs, and limitation in the dimensions of the packages.

On recent years, courier companies have made changes to their traditional courier system. These changes extend to various aspects of their service offerings, such as warehousing services, inbound freight, distribution, freight consolidation, order fulfillment, outbound freight, and RL. Especially RL is a process for which courier companies are so important, this, because they are generally the first direct contact with the customer at the time of collecting the product to be returned. The courier companies are usually involved on the following stages of the RL process:

- Pick-Up: The courier companies basically pick up the returned products directly from the customers. This initial step is very important as it marks the first the first physical moment upstream in the SC, and it involves the collection of goods from various locations, ensuring time convenience for the customer and efficient aggregation of the returns
- Transportation to Consolidation/Cross-Docking Facilities: Once the pick-up/collection have been completed, commonly the returned products are transported to initial/intermediate consolidation or cross-docking centers, where they are sorted and consolidated to be delivered to different locations according to the contractor instructions regarding the designated addresses
- Transportation to Inspection/Repair Facilities: Once the products are sorted and consolidated, they need to be transported to the specified locations by their contractors, which marks the final intervention of the courier companies in the upstream SC of the product returns
- Delivery Back to Customers: If the products are refurbished or repaired, then usually the services from the courier companies are once again required to perform the final step of delivering these products back to the customers, ensuring the entire RL cycle is completed.

The involvement of the courier companies in these stages of the RL process offers multiple advantages, among which we can find improved customer convenience, reduced turnaround times for returns, and improved overall efficiency in handling the RL operations in which they participate (higher level of expertise). Nevertheless, not everything is perfect, using courier companies bring also some trade-offs to the table, as it comes with some disadvantages, such as the higher operational costs due to multiple handling steps and the need for specialized infrastructure and technologies to be able to manage the different stages of the process in which they intervene effectively.

Regardless of their critical participation in the RL process, we can find also some stages where the courier companies usually do not participate directly and/or do not participate at all. These stages include:

- Inspection and Sorting: These activities are typically performed at the facilities of the retailers, manufacturers or specialized third parties, and not by the courier companies themselves

- Product Refurbishment/Repair: The courier companies often participate in the transport of the returned products to the refurbishment/repair's facilities, but it is the technicians of the retail company or the original manufactures the ones that do the actual refurbishment or repair, without any involvement at all from the courier companies on this stage
- Final Disposal: In the case of those items that cannot be repaired or reused, the final disposal is normally managed by waste management or recycling companies rather than by the courier companies themselves
- Inventory Management: The overall inventory management of returned products, including restocking and resale, is generally handled by the retailers or manufacturers.

Covid-19 boosted the growth of e-commerce as mentioned in the section 4.1, and this consequently created a growth opportunity for courier delivery companies by expanding into new markets. For example, in Packeta, the owner of Zásilkovna, doubled its turnover in 2020 to nearly 2.5 billion CZK and saw a 114% increase in the number of parcels transported, reaching nearly 40.5 million (Packeta, 2021). During Covid-19, courier delivery companies needed to quickly adapt to the variation on the demand, by investing on developing their courier delivery services, the flexibility of their services, and technologies; all of this while having to ensure the health of their employees. The courier companies responded to the disruption brought by the pandemic leveraging on the resources available to them, both internal and external. These included people, organizational skills, previous knowledge, existing assets and digital technology, which all played a central role in ensuring continuity (Garola et al., 2023).

As found by Garola et al., the size of the Logistics Service Providers companies and their resources and capabilities were an important factor for the responses triggered to the pandemic disruption. Logistics Service Providers with a very extensive and international network were able to understand the changes and revise their processes quickly, using the company's information and assets, while those with a less extensive network experienced a more complicated response due to the lower visibility on the event (Garola et al., 2023). These responses triggered for each of these companies, should always have the customer satisfaction (which includes the participation of courier delivery companies) as the center of the decision making. Failing to consider the customers on their decision-making process, might lead to the incorrect responses, and wasted of the companies' resources. This is directly connected with the recent developments in courier services identified by Ghazali (2023), as courier companies are improving themselves looking to stay competitive. These improvements include but are not limited to: Efficient delivery and pick-up times, digital billing, packaging, cash on delivery service, monitoring of pricing policy, introduction of intermodal transportation, new technologies, simple booking, track & tracing, and employee satisfaction (Kidwai & Maqbool, 2023), which at the end of the end have been led by thinking on their customers/clients.

Courier companies play a very important role in the last mile delivery and customer returns. These companies offer essential services that have a high impact the overall success and customer satisfaction for the e-commerce industry. On the last mile delivery side, courier companies offer efficient and timely delivery services, local expertise, scalability, technology integration, express delivery among other services. On the customer returns side, these companies have established networks and logistics infrastructure that enable them to handle the transportation of returned items efficiently, they provide real time visibility to the customers and retailers into the status and location of the returned items, multiple drop-off locations near the customers, and customer service support. For example, GLS offers a Return Service designed specifically for businesses and e-commerce, where the courier picks up the products directly from the customers and returns them to the seller or any other location of the choice of the contractor (eurosender, 2021). Similarly, UPS puts a lot of efforts to support sustainability by allowing the customers to reuse the old boxes for returning their products and/or for the disposal the products that they do not need anymore (eurosender, 2021).

UPS, FedEx, and DHL are the top 3 leading courier companies in the world (CompaniesMarketCap, 2024), thus it is worth it to go through the way they manage their RL services as a review of best practices for the RL optimization.

UPS provides to their customers a complete RL solution, that simplifies the return process, while improving the final customer satisfaction. The UPS Returns® Manager, a customer friendly online interface, allows their consumers to manage their returns with a variety of options customized to their specific needs, which includes direct returns to the retailers, exchange, repair services, or responsible disposal of products. This kind of technology, shows the company's focus on flexible solutions and customer-centric approach to manage the RL flows effectively (United Parcel Service of America, 2018). UPS also uses their Happy Returns subsidiary company to improve their return services with the use of more than 9.000 box-free return locations, free-label and free-box returns, and cardboard-free returns; the last one helping to reduce 120.000 lbs of greenhouse gas emission for each million returns (UPS, 2024).

FedEx focuses their strategy to optimize their RL operations by leveraging their return technologies, which offer to their customers large and scalable solutions, designed to make the return simpler (ease of use) both for the business and the customers. Proof of this is their collaboration with large platforms (Aftership, Easypost, Loop, Narvar, and Microsoft Dynamics 365), which allows easy print-return, and tracking systems to improve customer satisfaction, whilst streamlining the RL process. FedEx strategies to simplify the return process for the customers involves providing a return label, provide QR codes for no label returns, and offering a no-label/no-box return, cases in which the customers can just go with their QR code to a FedEx Office, FedEx Ship Center, or participating Walgreens location, where an employee will scan the QR code, print the label, and offer the customer a package to return the goods. FedEx also offers consolidated returns, which allows them to offers lower prices, and reduce waste (environmental impact) (FedEx, 2024).

DHL main focus is on sustainable practices, and they show this with their DHL GoGreen program, which is a proof of their strong commitments towards environmental responsibility practices by optimizing the lifecycle of their RL processes in orders to increase the recycling rates, and reduce waste. DHL avoids transport-generated greenhouse gas emissions, and invest on reduction measures; such as the purchase of sustainable fuel and electric delivery vehicles. DHL also offers more than 13.500 Packstations and Poststations which allows further carbon dioxide (CO_2) savings compared to doorstep delivery (DHL, 2024). On the consumer side, DHL offers 2 different options for the product returns. The first one is to deliver their products to a Service Point, and the second is to request a pick-up by a courier. Both options are only available with a label inside of the box (DHL E., 2024).

As can be appreciated UPS, FedEx, and DHL have each their strengths regarding their RL which is what makes them unique, while they together focus on efficiency, customer satisfaction, and sustainability. UPS leverages the use of technology and partnerships to provide flexible return options, including box-free returns that reduce environmental impact. FedEx focuses on partnering with different platforms to simplify the return process, which allows them to offer different solutions to improve the customer satisfaction, while they also streamline their RL process and minimize waste. And finally, DHL focuses sustainability, something that is evident given with their GoGreen program, their use of electric vehicles and Packstations to reduce CO_2e (Carbon Dioxide emissions); while at the same time they continue providing convenient return options for the customers. The combined efforts of these companies show how committed they are towards more efficient, customer-centric, and environmentally responsible RL practices.

Clearly there is an opportunity for the courier companies by getting more involved in some additional activities of the RL such as inspection and categorization, cleaning and repackaging, and disassembling. By integrating these activities into their consolidation centers, the courier companies could eliminate at least one transport step in the reverse SC. This integration means that the returned products could go from the courier consolidation/testing centers directly to the different stages of the SC according to the categorization of the returned products (e.g., refurbish, repair, reuse, re-sell, which means that some products would even go back from the consolidation centers of the courier companies to other customers. In the following chapter, we will attempt to prove how this change in the RL process, would impact on each one of the factors that affect the effectiveness and efficiency of the RL.

By incorporating some of the activities within the courier companies, the number of transports would be reduced. Also, the products that can be resold would not need to go to a different facility for inspection and categorization, instead they would be treated at the courier centers and send directly back to other customers. The expectations by doing this change and reducing the number of transports, we can expect to generate a reduction in the associated transportation costs, increase in the speed in the returns process, and reduction of the CO2e.

Banomyong & Supatn (2003), and Vieira (2017) unintentionally support the centralization of the RL activities within the courier delivery companies with their papers “Leagility in RL Process: A Case Study of Electronic Appliance Manufacturer” and “A Different Approach on RL: A Retailer’s Case Study” respectively. On one hand, Banomyong & Supatn focused their paper to answer the question on “how to apply a particular logistics strategy on the reverse logistic process to reduce costs and increase responsiveness to customer demand simultaneously?” (Banomyong & Supatn, 2003). The strategy used by the authors, was to introduce decoupling points (service shops) between the customers and the service center. This change had impact on 95% of the customers returns as these were directly repaired on the service shops. The lead time was reduced for these 95% of the products from 6-40 days to 1 day, the annual transportation cost reduced from $26.683 to $224, the customer satisfaction increased from low to high, and the responsiveness to customer demand increased from low to high (Banomyong & Supatn, 2003). This shows that having an initial assessment of the products closer to the customer location, can considerably reduce lead times, reduce transportation costs, and improve the customer satisfaction; which is where courier companies can enter the game to perform the initial assessment/classification of the customers returns, before they are sent to a processing center accordingly to their categories. On the other hand, Vieira (2017) focused their case study to answer mainly three questions. What is the decision model for reverse logistic decisions? What is the expected benefit? And how to turn processes more efficient and effective? To answer these questions Viera da Silva proposed a decision tree to identify the best RL model to apply to each type of product, and 2 major optimization models, the Stock Coverage Balancing Model (SCB model), and the End-of-Life-Stock Model (EOLS model). On this case, the tree and the two models suggested by Vieira da Silva, shows another opportunity for e-commerce companies to introduce into their RL as an additional categorization of the actions they take on their products to help maintain balanced inventories, and to recover a part on the cost of goods sold (COGS), by selling them at a salvaging price (Vieira, 2017). By associating with courier companies, these products do not need to reach completely upstream to the SC, instead they can be sent directly from the courier centers to other customers willing to accept the imperfection on the products by paying a low percentage of the original price.

Looking separately at the impact on each one of the factors that influence on the effectiveness and efficiency of the RL, at first sight it is evident the impact on the costs and the environment, linking directly to the cost factor and the sustainability factor. The customer satisfaction would be improved by the increase in the speed of the processing of the product returns. Product quality and condition would be impacted by reducing the number of transports and handling involved on each one of them, which mitigates the risk of damage or loss on each one of these steps as well as improves the utilization of the resources. By leveraging on the advanced technologies and information systems of the courier companies, we could expect a positive impact on this factor given the higher level of traceability and visibility of the returned products on each one of the stages. By incorporating these activities within the courier companies' operations, we would reduce the complexity of the RL by considerably reducing the number of transports and consolidating operations under a single specialized provider, which would also have a positive impact on the level of collaboration with these partners. By achieving a reduction of CO2e, the RL would be more likely to meet the regulatory requirements regarding environmental impact. Standardization and flexibility would also be positively impacted by having centralized activities in one single location, as it would allow to set standard processes for each one of the involved activities between the parties whilst allowing for flexibility. Having an earlier assessment of the products will allow for a faster value recovery according to the categorization, allowing an easier application of a closed loop and reduce the turnaround which positively contributes to the inventory management factor.

To validate the impact of some of these potential benefits from the inclusion of additional RL activities within the courier companies' operations, we will perform multiple simulations on the following chapter, specially to identify the impact on costs and CO2e by reducing the number of transports needed.

5 OPTIMIZATION PROPOSAL WITH THE USE OF COURIER DELIVERY COMPANIES

In order to understand the implications of incorporating additional activities of the RL within the courier companies on the cost and environmental factor, we will perform simulation on 3 different settings using the status quo and 2 different scenarios. These simulations will help to breakdown the impact of each one of the different scenarios regarding costs and CO2 (carbon dioxide) emissions.

5.1 Simulation and Scenarios Definition

5.1.1 Simulation design

For the status quo we will use the RL chart depicted by Zarbakhshnia et al. (2020) presented in Figure 3 in section 3.1, which was adjusted to simulate the impact on the RL costs (efficiency) and CO2e (effectiveness), generated by switching the ownership of the inspection, categorization, cleaning, and repackaging activities from in-house and/or spcecialized companies, to the courier delivery companies. Such change in the ownership of the described activities will be targetting the elimination of the existing redundacy of the transportation steps involved in the RL. Key parameters include the costs for the different transportation options (standard truck/trailer, 7.5ton trucks, and vans), as well as the in-house vs courier companies costs/charges of performing the activities in question. We will also account for the behavior of the returned products in terms of movement between locations and their potential categorization. This will help to simulate the potential benefits from reducing the transportation steps, which would help to reduce transportation costs, increase speed, and reduce the environmental impact, and therefore support to the optimization of the RL in the courier delivery companies and in consequence the RL as a whole by positively impacting its efficiency (cost and speed) and effectiveness (sustainability). The simulation will be performed for 10.000 units (packages) using the software Simul8. This software allows the user to simulate different type of real-life or hypothetical scenarios. For our specific case, we will need to input the statistical parameters at which the products are normally dristributed in the forward and RL. The data used to model the simulation have been obtained from online sources, such as in the case of the percentage of returned products and the percetage of returned products that are resold without additional processing, and from my own professional experience. With this simulation we will estimate the costs of the RL for the part of the network that involves the activities to be centralized. Whilst we expect the network to benefit from the centralization of the activities, and all the benefits that it brigs with on the overall effectiness and efficiency of the RL, the courier delivery companies will benefit from an increased income (due to the overcharges to perform these activities), and the potential for an increase on market share against those that do not integrate such activities within their operations.

The transportation costs are stimated values obtained from personal experience in transportation for 3 different companies, and adjusted to avoid non-diclosure-agreement (NDA) violation (Table 2). The units used in the simulation are dollar ($) and packages (units), and values are calculated as an avarage, disregarding the dimension of the packages or the complexity to handle/transport them.

Table 2: Transportation cost by vehicle type

Vehicle type	**Cost**
Standard truck/trailer	$0.26/unit
7.5ton truck	$0.60/unit
Vans	$0.96/unit

Source: Own work.

The costs for the different activities in-house are estimates form my personal experience and scaled down to avoid non-disclosure agreement infringement. Such scale also impacts on the results, so all improvements achieved with the model, can be expected to be expected to be higher in real life. In the case of courier companies’ charges, the costs were estimated based on the level of complexity given the additional tools, staff, trainings and steps that courier companies would need to incur in order to apply them. In the case of Inspection and categorization, and disassembling would be expected to have higher rates with the courier companies as these activities require a higher level of knowledge of the products thus, they could be managed more efficiently in-house. In the case of control, clean and repackaging, these are standardized task which the courier companies can perform at scale and leverage their automated systems, thus making it more cost-effective for the courier companies to take over them due to their efficiencies and economies of scale. These estimations can be appreciated on the table 3 and they might not reflect reality as they were purely personal estimates.

Table 3: Cost per activity, in-house vs courier charges

Activity	In-house Cost	Courier charges
Inspection and categorization	$1.10/unit	$1.30/unit
Dissembling	$1.62/unit	$1.80/unit
Control, clean and repackaging	$1.50/unit	$1.10/unit

Source: Own work.

The probability for the outcome of the manufactured products to be transported from the manufacturing center towards the warehouse and the distribution centers was set in the simulation software at 0.7 and 0.3 respectively, with a standard deviation 15% in both cases, meaning that 70% of the manufactured products is transported from the manufacturing center to the warehouse, and 30% is transported directly from the manufacturing center to the distribution centers. Personal experience was used to estimate these percentages, although they are not relevant for the analysis as they remain unchanged in all the three scenarios. The percentage of returned products in e-commerce according to Ecommerce News Europe is 20 to 30% and the products that are not resold is 44% (Europe, 2024), meaning that 56% of the returned products are resold. The remaining 44% of products that are not resold were divided in percentages using personal experience given the lack of sources giving the percentage for each specific activity. In the simulation each one of the products will go through the flows depicted in the appendixes 5 and 6 following the distributions from the table 4. E.g., a product is manufactured, then it has a probability of 0.7 of being moved to the distribution center, where then it will be transported to the customer. Then the customer will return the product with a probability of 0.3. Then the returned product will have a probability of 0.56 over the returned products of being resold without any repair or refurbishment performed on then. If the product is not resold (44% of returned products) it needs to be inspected and categorized in-house/courier, from which it will have a probability of 0.13 over the returned products of needing to be dissembled before moving forward in the RL. Then this product will re-enter the RL according to its categorization and would for instance be refurbished with a probability over the returned products of 0.14. Each product will follow the same sequence, probabilities and corresponding standard deviations with the simulation.

We modeled the current RL setup (status quo), and the scenarios 1 and 2, which can be found on the appendices 4, 5 and 6 respectively. Each one of the scenarios was simulated with

10.000 units (packages) and one single time due to license limitations (trial does not allow to obtain results for multiple simulations combined), which might have limited the accuracy of the model.

Table 4: Percentage of products by type of movement or activity

Movement/Activity	**Normally distributed**
Manufacturing center to warehouse	Mean = 30%, Standard deviation = 15%
Manufacturing center to Distribution and collecting center	Mean = 70%, Standard deviation = 15%
Returned products	Mean = 30%, Standard deviation = 10%
Resold products	Mean = 56%, Standard deviation = 10%
Dissembled products	Mean = 13%, Standard deviation = 5%
Repaired products	Mean = 9%, Standard deviation = 3%
Refurbished products	Mean = 14%, Standard deviation = 5%
Remanufactured products	Mean = 3%, Standard deviation = 2%
Recycled products	Mean = 10%, Standard deviation = 4%
Disposed products	Mean = 8%, Standard deviation = 3%

Source: Own work.

5.1.2 Description of the Scenarios

As described in the introduction of this master thesis, the courier companies are the first direct contact with the customers and the returned products in the case of RL, thus they possess a high potential for impacting the effectiveness and efficiency of the RL process.

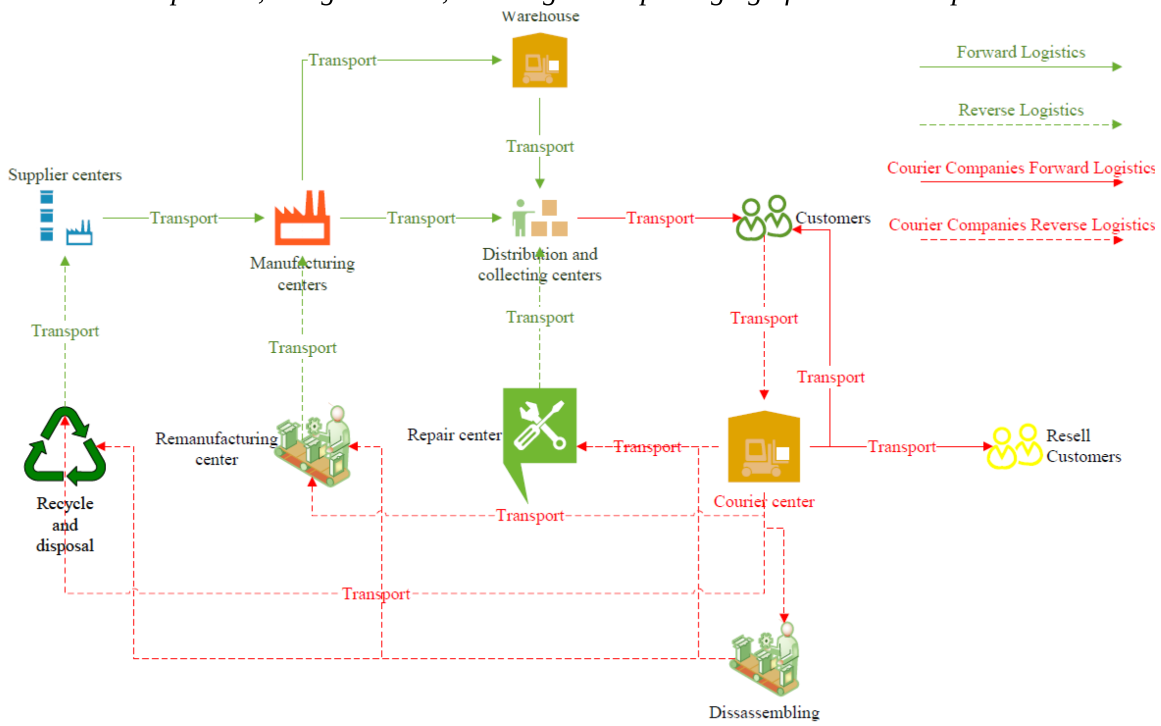
In the status quo, the inspection, categorization, cleaning, and repackaging activities are currently managed by specialized providers at different geographical locations, and these include the evaluation and classification of the returned products based on the quality, type, and returned condition (inspection and categorization), cleaning the items and packing them according to delivery requirements (cleaning and repackaging), and taking disassembling the items that require parts replacement or specific repairs (disassembling).

We investigate two scenarios in which courier delivery companies expand their role by integrating additional logistics functions into their consolidation/cross-docking centers. Traditionally, these functions—inspection, categorization, cleaning and repackaging, and disassembling—are distributed among specialized providers at various points in the SC. Centralizing these functions within the courier companies' facilities is basically looking to streamline operations and reduce the number of transports and handling involved in the RL process. By reducing the number of transports, we expect to achieve a reduction in the overall costs and CO2e, which will contribute both to the efficiency (cost reduction) and effectiveness (CO2e reduction) of the RL. On this section, we define the two proposed scenarios, focusing on the activities involved and the investments required.

The three scenarios can be summarized as follows:

- Status Quo: Decentralized RL activities – The RL activities are performed inhouse and/or by specialized service providers
- Scenario 1: Partial centralization – The courier delivery companies perform the inspection, categorization, control, cleaning and repackaging activities on the returned products
- Scenario 2: Full centralization of the RL logistics activities – The courier delivery companies perform the inspection, categorization, cleaning, repackaging and disassembling activities on the returned products.

Figure 11: Scenario 1 of reverse logistics process flow chart with courier companies performing the inspection, categorization, cleaning and repackaging of the returned products



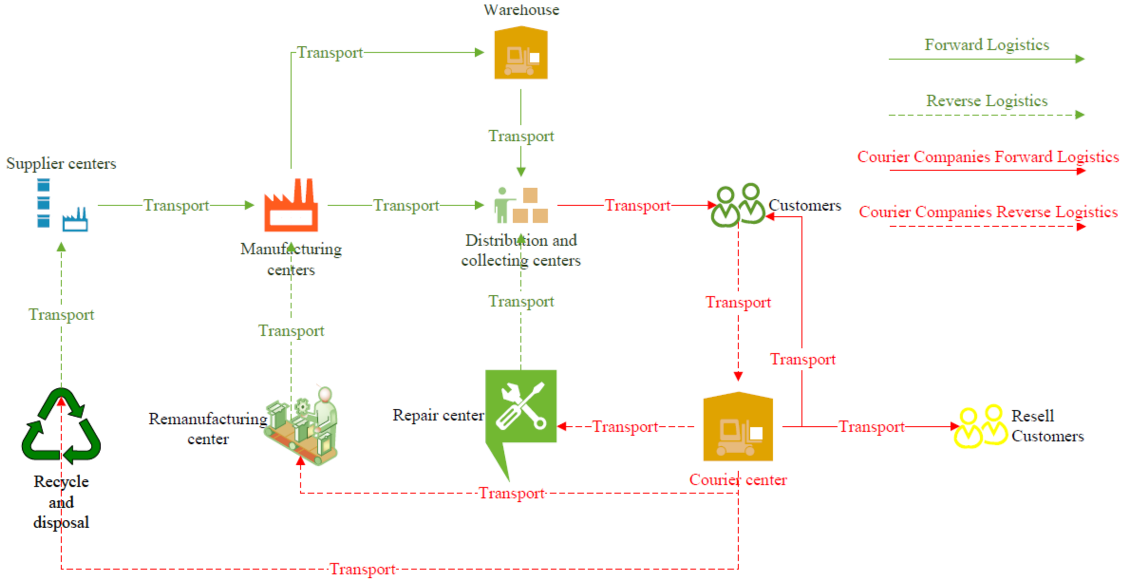
Source: Own work.

In the scenario 1 which can be observed in the figure 11, the courier delivery companies would basically integrate the activities of inspection, categorization, cleaning, and repackaging as part of their processes in the RL. This scenario involves establishing dedicated inspection units in the consolidation/cross-docking centers, equipping these units with necessary diagnostic tools, and training the personnel to conduct the corresponding inspections and accurate categorization of the items. A streamlined workflow would be implemented where items are inspected and categorized immediately upon arrival. With this scenario, there would be elimination of the transport between the Courier Centers and the inspection Center, and between the Inspection Center and the Control, Cleaning and Sorting Center. Instead, a share of the products would be transported directly from the Courier

Centers back to new customers (products that can still be sold as new), to “resell” customers (products with minor defects that can be resold for a lower price), to the Repair Center (products that need small repairs to re-enter the SC for a new or the original customer), to Remanufacturing Centers (mainly products that were dissembled and parts of them were savaged to produce new products), and to Recycle and Disposal Centers (products that cannot be recovered by any of the above processes). Another share of the products would need to go for dissembling before being transported further in the reverse SC.

The scenario 2, visible in the figure 12, expands on Scenario 1 by adding the activity of disassembling. Items requiring disassembly are typically handled by specialized centers, but in this case, they would now be processed within the courier companies' consolidation/cross-docking centers. In this particular case, it would additionally involve the creation of a disassembly unit within the consolidation/cross-docking centers of the courier companies, equipped with the necessary specialized tools and trained staff to disassemble the items that require parts replacement or specific repairs. Disassembly would be integrated into the initial processing stages to allow for targeted cleaning and repairs. In this case also the products that need to be dissembled can be transported directly from the courier centers to the corresponding facility (some parts might go to the Remanufacturing Center, and some would go to the Recycle and Disposal Centers.

Figure 12: Scenario 2 of reverse logistics process flow chart with courier companies performing the inspection, categorization, cleaning, repackaging and disassembling of the returned products



Source: Own work.

Implementing these changes will definitively require high investments from the courier companies. First of all, they would need training programs to equip the existing and new employees with skills needed for the inspection, categorization, cleaning, repackaging, and disassembly according to their contractor's requirements. Secondly, in the case of infrastructure, which is where most of the initial investment would be expected, they would need to include the new inspection, disassembly (for scenario 2), cleaning and repackaging units, which includes buying the specific equipment required for each one for these activities. Thirdly, they would need to perform investment on technology in order to bring together all these activities within one single facility, including but not limited to diagnostic tools for the inspection and categorization of the returned products, improve their cleaning and repackaging technologies to adapt to the bigger scale of products to handle, and make sure to acquire the required tools and equipment for disassembling the returned products in the case of the scenario 2.

Fourthly, the courier companies would need to redesign the whole flow of products within their facilities in order to streamline the new activities with the existing operations. Fifthly, they would need to put in place quality control mechanisms to ensure consistency with standards across all the activities. The inspection of the returned products is a key factor, as of this depends the categorization of the items, and any failure here would refer and an incorrect processing of the product on the further RL activities. For example, just think about a returned product being categorized for repairs, but the product could actually have been resold. If the product was directly resold, the courier company would only need to clean it, repackage it and send it to a "resell" customer, but given their incorrect categorization the product would be transported to a Repair Center, where they will discover that the product did not need any repair at all and would be put for resell, which clearly shows the product being transported unnecessarily, and the waste of the Repair Center resources.

The proposed scenarios redefine the role of courier companies within the reverse SC, positioning them as central hubs capable of performing multiple critical functions. By integrating these activities, the scenarios are looking to improve operational efficiency, reduce costs, and improve overall customer service.

5.2 Analysis of the Simulation Results

The analysis of the simulation result of the three scenarios, the Status Quo, the Scenario 1, and the Scenario 2, shows some of the differences in terms of costs, and CO2e, with each one of them having a significant impact on the overall effectiveness and efficiency of the RL process. Other parameters such as product handling (number of touches per returned product), implementation costs, and inventory holding costs. The strategic changes proposed on the previous sections, particularly the integration of courier companies by taking over some of the key activities, offer valuable insights into how to optimize the RL operations.

5.2.1 Simulated Cost Results

Starting with the cost analysis, the Status Quo scenario shows the highest total costs of the activities simulated on the three scenarios, accounting by $43,577.94 as detailed in the Table

5 These costs are driven primarily by the large number of transports required to move the returned products between the customers, the centralized facilities, and the different processing centers according to the type of returned product and categorization.

Table 5: Final costs simulation status quo of the reverse logistics for 10.000 units

Costs	$ 43,577.94
Transport to courier center	$ 1,181.70
Transport from warehouse to courier center	$ 1,419.34
Transport to customers	$ 10,803.60
Transport to courier reverse	$ 3,327.30
Transport to inspection center	$ 3,204.00
Inspection and categorization	$ 4,026.00
Transpoer to dissemble center	$ 1,383.30
Transport to Cleaning, control sorting center	$ 2,987.10
Dissemble	$ 2,431.62
Control, clean, and sort	$ 4,653.00
Transport to courier center RL	$ 2,082.60
Transport to repair center	$ 162.76
Transport to manufacturing center	$ 70.46
Transport to recycling and disposal center	$ 134.16
Transport to warehouse	$ 5,711.00

Source: Own work.

The simulation parameters give an indication of the importance and weight of the transportation costs among the operational costs in the RL, with rates such as $0.26 per unit for standard truck/trailer, $0.60 per unit for a 7.5-ton truck, and $0.96 per unit for vans. Additionally, the in-house (we referred to it as in house to differentiate between the activities being performed in the status quo where these are done by the e-commerce companies or outsourced to third party specialized companies, and the activities being performed by the courier companies) execution of RL activities, including inspection and categorization at $1.10 per unit, control, cleaning, and sorting at $1.50 per unit, and dissembling at $1.62 per unit, which further contribute the total costs. Such fragmented logistics process under the Status Quo, which requires multiple movement of the returned products between different sites, leads to inefficiencies and increased operational costs.

The Scenario 1 offers a considerable reduction in the costs, lowering the total RL costs for the simulated 10.000 units to $39,139.54 as can be appreciated in the Table 6. This represents a cost saving of $4,438.40 compared to the Status Quo, due to the consolidation of key activities within courier companies. By outsourcing with the courier companies the inspection, categorization, control, cleaning, and repackaging, the logistics process is more streamlined, resulting in a fewer number of transports for each one of the returned products, and a more efficient use of the resources. The cost of the inspection and categorization activities increases slightly by $0.20 to reach $1.30 per unit in Scenario 1, but this is offset by the savings in transportation and other processing costs. Specifically, the cost for control, cleaning, and repackaging drops to $1.10 per unit given the higher logistics expertise of the courier companies compared to most of the e-commerce companies, contributing further to the overall cost reduction.

Table 6: Final costs simulation scenario 1 of courier companies taking the ownership of the inspection, categorization, cleaning and repackaging activities for 10.000 units

Costs	$ 39,139.54
Transport to courier center	$ 1,184.04
Transport from warehouse to courier center	$ 1,417.52
Transport to customers	$ 11,286.90
Transport to courier reverse	$ 3,477.60
Inspection, categorization and cleaning	$ 11,214.00
Transpoer to dissemble center	$ 1,194.30
Dissemble	$ 2,097.90
Transport to courier center RL	$ 1,034.10
Transport to repair center	$ 298.74
Transport to manufacturing center	$ 70.46
Transport to recycling and disposal center	$ 161.98
Transport to warehouse	$ 5,702.00

Source: Own work.

The significant reduction in transportation costs, which accounts for 60% of the total RL costs as per Deloitte (2014), is driven by fewer movements of the returned products and a more efficient selection of the activities to be outsourced, puts the Scenario in the first position as the most cost-efficient option among the three different scenarios.

The Scenario 2 also achieves important cost savings compared to the Status Quo, with a total cost of $40,093.58 as can be appreciated in the Table 7. Although this is lower than the Status Quo, it is $954.04 higher than Scenario 1. The increased cost in Scenario 2 primarily arises from the outsourcing of the dissembling activity, which raises the per-unit cost from $1.62 to $1.80. Despite additional savings in transportation costs, the higher dissembling cost reduced on this scenario the overall cost-efficiency. This scenario, while still more economical than the Status Quo, does not achieve the same level of cost savings as Scenario 1, highlighting the trade-offs involved in further integrating specialized activities within the courier companies' operations. Here is important to remark that the simulation parameters used normal distributions, and some costs were higher on this scenario given the described variations on the Table 3, case in which products to be dissembled might have fallen on a lower range on the simulation performed for the scenario 1 compared to the number of products to be dissembled in the scenario 2.

Table 7: Final costs simulation scenario 2 for 10.000 units

Costs	$ 40,093.58
Transport to courier center	$ 1,185.08
Transport from warehouse to courier center	$ 1,420.90
Transport to customers	$ 11,277.00
Transport to courier reverse	$ 3,474.00
Inspection, categorization and cleaning	$ 11,205.00
Dissemble	$ 4,050.00
Transport to courier center RL	$ 1,179.00
Transport to repair center	$ 340.86
Transport to manufacturing center	$ 74.88
Transport to recycling and disposal center	$ 171.86
Transport to warehouse	$ 5,715.00

Source: Own work.

5.2.2 Simulated Environmental Impact Results

In terms of CO2e, the Status Quo generates the highest environmental impact, with total emissions accounting to 96,754.00 kg CO2e as detailed in the Appendix 8. This high amount of emissions is driven by a higher number of transports needed for each specific returned product, where each transport stage adds to the overall carbon footprint.

The Scenario 1 achieves a considerable improvement in the sense of environmental impact, reducing the total CO2e by 8,054.00 kg CO2e to 88,700.00 kg CO2e as can be observed in the Appendix 9. This reduction is primarily driven by the consolidation of the logistics activities under the courier companies, which reduces the number of trips required to complete all the steps required in the RL process. The lower carbon footprint is basically explained by the clear decrease in the total vehicle miles traveled, which indeed makes the scenario 1 the more environmentally friendly one when compared with the Status Quo, and the Scenario 2.

Scenario 2 achieves CO2e of 88,762.00 kg CO2e as detailed in Appendix 10, which, while an improvement over the Status Quo, it is slightly higher than Scenario 1 by 62.00 kg CO2e. Such increase in the CO2e might be due to the simulation setup (e.g., in the scenario 2 5705 products were transported from the manufacturing center to the warehouse, against 5692 in the scenario 1, which is reflected as 13 kg CO2e more for the scenario 2 against the scenario 1), and the case that each scenario was simulated only once due to license limitations, but in real life, in overall terms, we could expect the decrease in the number of the transports needed to be reflected as a reduction of CO2e. While we can still consider this as an important improvement over the Status Quo, the Scenario 2 is slightly less effective than the Scenario 1 in terms of the CO2e, which makes the Scenario 1 the most valued option according to the simulation results for the companies prioritizing environmental and sustainable practices.

Both scenarios contribute to the implementation of the open loop and the closed loop described by Starostka-Patyk (2016). By having the inspection, categorization, cleaning, and repackaging of the returned products at the courier centers, the products have a faster processing to re-enter a different supply chain in the case of open loop products, or the same supply chain in the case of closed loop products.

5.3 Effect of the Centralization and Consolidation of Reverse Logistics Activities over speed and the Effectiveness and Efficiency Factors

In order to continue building on the analysis of the simulation results, which highlighted significant differences in costs, and CO2e, across the Status Quo, the Scenario 1, and the Scenario 2, it is important to also explore how these changes impact the operational speed, and broader aspects of the RL process relevant to the topic of the master thesis such as the effectiveness and the efficiency of the RL. As described in the chapter 3, the effectiveness and efficiency of RL are not only determined by these direct outcomes but also by how well the system supports key factors such as customer service, product quality, technology integration, sustainability, cost management, inventory management, automation, and resource utilization. The following analysis checks in detail these specific factors, going through the deeper implications of the proposed changes and how they contribute to the optimization of the RL.

5.3.1 Impact on Operational Speed

operational speed, which also changes significantly across the different scenarios. In the Status Quo, the multiple transport stages and in-house processing delays result in slower turnaround times for handling returns. The extended time required for the returned products to be moved between facilities and processed through different stages means basically long lead times in providing feedback to customers regarding the status of their returns and completing the whole returns process, which negatively impacts on the customer satisfaction.

The Scenario 1 improves the operational speed by reducing the number of transports needed and by consolidating some of the key activities within the courier companies existing consolidation centers. By managing some key activities such as the inspection, the categorization, the control, the cleaning, and the repackaging closer to the point of return/customer, the returned products spend less time in transit and are processed faster. The streamlined operations/activities do not serve only to speed up the RL process but it also helps to improve the inventory management, which in theory should enable for the returned products to be reintroduced into the SC more rapidly. The simplification of the logistics network in Scenario 1 results in fewer coordination challenges and faster processing times.

The Scenario 2 further improves the operational speed by integrating dissembling into the courier companies' operations. This integration eliminates the need for additional transport stages associated with the dissembling, leading to the fastest processing times among the three scenarios. Companies aiming for high speed and a higher level of customer service such as Amazon, might consider this scenario as the best option given their customer centric approach. The ability to manage all the key activities within a single logistics facility leads to an important reduction of the lead times, ensuring that even the complex returns which require dissembling are processed fast and efficiently. The increased speed in processing not only boosts customer satisfaction by providing quicker resolutions, but also optimizes resource utilization, ensuring that the products spend the least amount of time in the RL pipeline. Such a logical and consistent coordination of a larger aggregated group of the RL activities in the Scenario 2 highlights the benefits of a fully integrated approach, where the efficiency and the speed are maximized.

5.3.2 Effect on the Factors Impacting the Effectiveness of the Reverse Logistics

5.3.2.1 Impact on the Customer Satisfaction Factor

The integration of courier companies in both Scenario 1 and Scenario 2 significantly improves the customer service and satisfaction by addressing key inefficiencies in the current RL process. In the Status Quo, it is often required several days for the customers to receive feedback on their returns due to the extended lead times caused by the times the products need to be transported between different sites. Such waiting time from the customer side, can lead to increased frustration with each waited day and negatively impact the overall experience of the customer during the return of their defective or undesired products. The Scenario 1 improves this situation by consolidating the inspection, categorization, control, cleaning, and repackaging activities within the courier companies' facilities, thus reducing the time products spend in transit (being transported between locations). This reduction in the lead time allows the company to provide faster resolutions of the return process to the customers, whether it is in the form of refunds, replacements, or even just repairs. The streamlined process not only speeds up the handling of the returns, but it also ensures that the customers receive accurate feedback in a timely manner, which leads to the improvement of their overall satisfaction with the return process and trust in the company, something that can be decisive for the customers decision of whether to use or not again the same e-commerce platform. In the Scenario 2, the integration of the dissembling activity into the logistics process further increases the speed of the handling of complex returns. By managing dissembling within the same logistics facility, the Scenario 2 ensures that even the most complex returned products are processed efficiently and faster. This particular approach leads to quicker resolutions and a more transparent process, further improving the customer satisfaction. The major impact on customer service and satisfaction in both scenarios comes from the reduced lead times and the improved reliability of the returns process. The customers benefit from a faster and more efficient service, which directly improves their perception of the company’s responsiveness and professionalism.

5.3.2.2 Impact on the Product Quality and Condition Factor

The quality and condition of the returned products as discussed on Chapter 3 are another critical factor in the success of the RL. In the Status Quo, by transporting and handling the returned products multiple times we have an increase of the risk to cause damage to products, given that each one of the movements between the facilities exposes them to potential mishandling or environmental hazards. The Scenario 1 mitigates these risks by reducing the number of transport stages and consolidating some of the key activities within courier companies’ centers. By centralizing those activities, the scenario 1 minimizes the amount of handling of the returned products, thus reducing the likelihood of any type of damage caused on them. The courier companies, can leverage their specialized equipment and expertise in order to achieve a better position to maintain the quality of returned products throughout the process, ensuring that more items remain in reusable or refurbishable condition as stated by Nikolaidis (2012). The Scenario 2 builds on these improvements by including dissembling within the logistics operations of the courier companies. Dissembling is particularly delicate, especially for complex products like electronics, where careful handling is critical to preserve the integrity of the reusable components. By integrating the dissembling with other RL activities, the Scenario 2 ensures that the products are handled under controlled conditions looking to minimize the risk of damage, leading to higher recovery rates and greater overall profitability. The reduction in the number of handling and transportation for each specific product in both scenarios directly correlates with a lower risk of damage, which results in a better preservation of the quality of the returned products and their condition.

5.3.2.3 Impact on the Technology and Information Systems Factor

Another factor discussed in the chapter 3 was related to the technology and information systems, which are vital for the efficient management of RL, enabling real-time tracking, data management, and consistent communication across all the stages of the return process. The Status Quo’s fragmented logistics operations often leads to challenges in the consistent and accurate management of the flows of data, something that from my experience increases the risk of errors, leads to miscommunication, and increases the number and time of the delays. The Scenario 1 addresses these issues by integrating the company’s technology and information systems with those of the courier companies, allowing for a more streamlined flow of information. With some of the key activities managed within a unified logistics center, real-time tracking becomes more accurate and robust, providing managers with the visibility they need to monitor the returns, manage the inventory, and optimize the logistics process. Such integration reduces the chance of any kind of errors from happening and ensures that the returned products are processed efficiently, with the customers receiving timely and accurate information about their returns. The Scenario 2 further enhances this integration by integrating the dissembling activity within the same logistics center as the activities integrated in the scenario 1, which provides an even more comprehensive view of the entire RL process. The deeper integration of the technology systems ensures that all those activities, including complex dissembling processes, are tracked and managed within a single platform, making it easier for the companies to have overall better coordination and an improved decision-making. The major impact on technology and information systems in both scenarios comes from the improved integration and streamlining of information flows, which support the overall effectiveness of the RL operation.

5.3.2.4 Impact on the Resilience and Uncertainty Factor

The resilience of the RL process is critical when trying to manage the uncertainties, such as fluctuating return volumes, varying product conditions, and unpredictable customer behavior. The Status Quo’s fragmented logistics operations make the system more vulnerable to disruptions, as the reliance on multiple transports and in-house processing increases the complexity of the logistics network. The scenario 1 improves the resilience of the RL by consolidating the already mentioned activities within the courier companies' facilities, which in overall have a more robust infrastructure and logistical expertise when compared to that of the e-commerce companies (with some exceptions). This consolidation makes more simple the logistics process, reducing the network's vulnerability to any kind of disruptions that may appear, and making it more adaptable to any unforeseeable fluctuations in the returned volumes or unexpected challenges. The courier companies can scale up and down their operations quickly in response to changes in the demand, ensuring that the RL process remains efficient even during the peak periods; given not only their facilities' capacity to adapt, but also due to their large portfolio of customers present on different markets/industries with different peak periods. The scenario 2 further improves the resilience of the RL by incorporating this time the dissembling activity within the operations of the courier companies, which reduces the number of transports, the separated handling stages and the potential points of failure in the overall logistics network. Such ability to handle also the complex returns within the same logistics facility increases the system's flexibility, ensuring that even the challenging returns are processed without any important delays. The major impact on the resilience in both scenarios comes from the reduced complexity and the increased capacity to manage any fluctuations happening in volumes of the returned products, making the overall RL process more reliable and adaptable, which can be evaluated as an improved effectiveness.

5.3.2.5 Impact on the Regulatory Requirements Factor

In regards to the regulatory requirements factor, as we have already explained in the chapter 3, this is very critical for the RL operations for several reasons, particularly given the increased complexity and number of environmental regulations, the products safety standards, and the consumer protection laws. Non-compliance with such regulations can lead the companies to receive very high penalties, legal challenges, and reputational damage. The Status Quo's fragmented logistics operations make it more challenging for the e-commerce companies to ensure to remain compliant across all the different stages and stakeholders of the RL operations, as multiple hand-offs between different facilities increases the risk of failing to comply with the regulations' requirements. The scenario 1 improves the regulatory compliance factor and thus the effectiveness of the RL once again by centralizing some key activities within the courier centers, which are better equipped to manage logistics-related regulations in most of the cases and they can be easily trained/coached for those in which they lack the expertise. The consolidation of such key activities within a single logistics center helps to ensure that the companies are consistently adhering to all the relevant regulations, which helps to reduce the risk of being non-compliant and receiving fines. The centralized tracking and data management systems in the scenario 1 also provides a greater transparency and traceability, which are essential to proof compliance and respond to any regulatory audits/inquiries performed to the companies. the scenario 2 can help to improve even more the compliance by integrating on this case the dissembling activity within the logistics operations of the courier companies, ensuring that complex regulatory requirements specific to this step of the RL are managed effectively within a single logistics center. The centralized management of all these RL activities simplifies the process of monitoring the compliance and provides a greater assurance that regulatory standards are consistently met. The major impact on regulatory compliance in both scenarios comes in the case of this factor from the centralized management of the integrated activities, which improves the company's ability to consistently meet regulatory standards and reduces the risk of receiving penalties and incurring any legal challenges.

5.3.2.6 Impact on the Partnership and Collaboration Factor

We already discussed how critical the factor of partnership and collaboration is for the effectiveness of RL. In short, strong partnerships enable better coordination, communication, and alignment of the goals between the companies and their logistics providers. In the Status Quo, the fragmented logistics process and reliance on in-house operations limit the potential for effective collaboration, leading to communication breakdowns and inefficiencies. The scenario 1 significantly improves the partnership and collaboration factor by switching the ownership of the mentioned activities towards the courier companies, which supports to the creation of a more integrated and united logistics network. Such switch in the ownership of the operations, promotes stronger relationships between the e-commerce companies and their logistics providers, as both parties would need to work closer to manage the RL process.

The centralized management of the already mentioned activities within a single logistics provider makes it easier to have a higher level of communication and coordination across the stakeholders, leading the involved companies to work together to remove their barriers, share information, improve the technology adoption as stated by Rasool, Greco, Morales-Alonso, & Carrasco-Gallego (2023); which in return will help them to have more efficient operations, and a continuous and sustained improvement. The scenario 2 takes the mentioned collaboration on the scenario 1 to an even higher level by integrating the dissembling activity within the operations of the courier companies, creating a more robust partnership between the companies and their logistics providers. The shared responsibility for managing key aspects of the RL usually promotes a stronger partnership, as both parties work together to achieve their mutual goals. The major impact on the partnership and collaboration factor in both scenarios comes from the consolidation and integration of those key logistics activities, which strengthens the relationship between the companies and their logistics partners and drive continuous improvement in RL operations, which in return leads to a continuous sustained improvement of the RL effectiveness.

5.3.2.7 Impact on the Standardization and Flexibility Factor

As discussed before, the factor of standardization and flexibility is very important in order to achieve consistency, efficiency, and quality process across all the activities involved in the RL, while also allowing the process to adapt to the ever-changing conditions. In the Status Quo, the fragmented logistics operations make it difficult for a high level of standardization to be achieved, leading to some variability in the way that the returns are handled given that most of the activities are performed at different locations and the standards might be different across the outsourced companies. The Scenario 1 improves the process standardization by consolidating some key activities within the courier centers, which allows for all these activities to be streamlined within one single location. For example, returned products are unpacked, inspected, categorized, cleaned, sorted and repacked to be sent to the corresponding location according to their categorization, which allows to directly standardize a good share of the RL activities and reduce the number of handlings at different locations. By outsourcing those activities to a courier company, the e-commerce companies can be sure that all the returned products are managed with a high level of consistency and efficiency across all the streamlined activities of the RL. At the same time, the courier companies are usually equipped with the flexibility to adapt to the changing conditions of the market, such as fluctuations volumes of the returned products or variations in the types of returned products. The courier companies operate with economies of scale at large volumes, so if there is a spike of volume in one specific region, they are able to shift personnel, vehicles and other resources needed from one location to another. Scenario 2 further enhances process standardization by integrating dissembling within the logistics operations, ensuring that even complex aspects of RL are handled consistently. The increased standardization in the Scenario 2 improves the quality and the efficiency, while it also reduces the risk of errors and inconsistencies. The major impact on the process standardization and the flexibility comes in both scenarios from the consolidation and the integration of the RL activities within the courier companies, which improves the consistency and adaptability in the RL process.

5.3.2.8 Impact on the Circularity and Sustainability Factor

Nowadays the circularity and sustainability factor are becoming more and more important which as discussed on the chapter 3, it makes it a critical factor for the effectiveness of the RL. The fragmented approach in the Status Quo creates challenges for circularity, with multiple transport steps between activities which increases the risk of product damage, thus reducing the potential for reuse or recycling of parts that might still possess value. Additionally, the current RL has higher levels of CO2e, which contributes to a major environmental footprint impact, something that most likely conflicts with the sustainability goals of the e-commerce companies. The scenario 1 mitigates these issues by reducing the transport steps, which directly reduces the CO2e, and additionally it reduces the risks for damages on the products during the transportation, which allows for more items to be resold or recycled. The scenario 2 improves the efforts of the scenario 1 by reducing 1 more transport step in the case of products that need to be dissembled, which further reduces the CO2e and in consequence also reduces the risks for damages on the returned products during that eliminated transport, which would allow even for more items to be resold and to recycle more valuable parts. Both scenarios significantly push towards the circularity and sustainability goals, with the scenario 2 going a bit further and reducing the need for one more transport step.

5.3.3 Effect on the Factors Impacting the Efficiency of the Reverse Logistics

5.3.3.1 Impact on the cost Factor

The cost management could be considered as the most critical factor regarding the efficiency of the RL, given that it directly affects the profitability and the sustainability of the companies' operations. In the Status Quo, the cost management faces multiple challenges caused by the inefficiencies that are clearly present in the fragmented logistics process, including multiple transports between different locations to separately perform each one of the activities, in-house processing without the sufficient expertise (lower economies of scale compared to courier companies), and the lack of integration across the involved activities. Such inefficiencies lead to higher operational costs, as each additional transport or handling during the RL process incurs into further expenses in terms of labor, transportation, and overhead on activities that will no add any kind of value to the products. The scenario 1 significantly improves cost management by streamlining the operations on the aggregated activities and by reducing the number of transports, which in consequence reduces the transportation costs. By considerably reducing the number of transports required and outsourcing activities such as inspection, categorization, control, cleaning, and repackaging, the scenario 1 reduces the overall cost of the RL, as shown with the lower total cost compared to the Status Quo. The specialization of courier companies in logistics also helps them to do things more efficiently through automation or just a higher level of expertise of their employees once again due to the economies of scale, which according to Reflex Logistics (2024) is indispensable to standardize the RL. The scenario 2, although it is slightly more expensive than the scenario 1 due to the additional cost incurred with the integration of the dissembling activity, still offers an important improvement in the cost management factor over the Status Quo. While the integration of the dissembling activity within the logistics operations of the courier centers allows for the e-commerce companies to have a better control over the costs associated with the returned products that require to be dissemble, the increase in the costs associated with this activity shows the complexity of this task, for which the courier companies would need to perform high investment given the level of expertise and resources required, such as specialized tools and machinery. In overall, both scenarios are offering an important improvement in the cost management factor by reducing the number of transports required (resource optimization), with the scenario 1 being the more cost-efficient option.

5.3.3.2 Impact on the Inventory Management Factor

The inventory management factor is significantly impacted by the structure and integration of the RL activities. In the Status Quo, the inventory management is complicated given the complexity of having to manage the inventory of products across multiple facilities at the same time (products at the courier center, products at the inspection center, products at the dissembling center, etc.). Such fragmented distribution of the inventory across different logistics providers could end up leading to delays in the processing times of the returned products, inaccuracies in the inventory levels, and increase the lack of control over the condition and safety of the returned products (higher risk of loss and damage). The scenario 1 improves the inventory management by reducing the number of locations where the products are treated, which in consequence increase the level of visibility and control over the returned products. Leveraging the real-time tracking from the courier companies and more accurate data, the e-commerce companies can better manage their inventory, ensuring that every single returned product is quickly processed, categorized, and moved forward in the reverse SC, which helps to improve the turnaround and mitigate the risks of stockouts, something that is supported by the definition of inventory management provided by Cash Flow Inventory (2023). Scenario 2 further strengthens inventory management by allowing for a more precise management of complex returns (products that require to be dissembled), as the dissembled components can be accurately tracked once again leveraging the courier companies real-time tracking (which would need to be adapted to parts and not only products). The improved inventory management in both scenarios not only increases the level of efficiency but it also reduces the risk of stockouts or overstocking, given that when returned products are processed fast, they can quickly replenish inventory, serve the same customer or a different one, contributing to a better overall resource utilization.

5.3.3.3 Impact on the Resource Utilization Factor

We have already discussed why the resource utilization is an important efficiency factor of the RL. In the Status Quo, the resource utilization is often not optimal due to the current fragmentation of the logistics process, which potentially can lead to inefficiencies in the use of labor, transportation, and in the use of the facilities. The scenario 1 improves resource utilization by allowing a better coordination, level of specialization, and optimization of the resources, something that is possible thanks to the reductions in the number of transport required and the consolidation of activities such as inspection, categorization, and repackaging, for which the courier companies can use their flexibility to switch their resources, such as their employees from one activity to the other according to the needs and increase their utilization rate, which in consequence helps to minimize waste, and maximize productivity, leading to a more efficient use of the available resources. Egri, Dávid, Kis, & Krész (2023) discusses specifically about the strategic location of the RL facilities to optimize the utilization of the resources, something that the courier companies already possess, as they are strategically positioned close to major urban areas. The scenario 2 takes the resource utilization one step further by adding dissembling into the logistics operations on the courier centers, which ensures that all the initial activities of the RL are managed within one single location. such integration reduces the duplication of efforts (e.g. unpacking and packing of the products on each one of the different locations where they are processed) and as explained in the scenario one, it allows an increase in the utilization rate of the resources.

5.4 Summary of the findings

In summary, both the Scenario 1 and the Scenario 2 are offering important improvements in the effectiveness and the efficiency of the RL. By addressing key factors such as the customer service, product quality, technology integration, sustainability, cost management, inventory management, and resource utilization, these scenarios can help to optimize the overall performance of the reverse logistic.

While Scenario 1 is the more cost-effective option, Scenario 2 offers additional benefits in terms of handling complex returns and further integrating RL activities. Each scenario presents distinct advantages that can be leveraged depending on the company’s priorities and goals, ultimately contributing to a more resilient, efficient, and sustainable RL network. The table 8 shows the potential benefits that could be achieved with the implementation of the Scenarios 1 and 2. As can be appreciated on the table, regarding costs and sustainability the Scenario 1 represents the best option according to the simulation results. Meantime Scenario 2 constitutes the top choice with reference to circularity due to a lower risk of damage and higher chances to recover more value from the returned products, customer satisfaction due to the increased speed in the returns process resolution, product quality and condition also directly connected to the lower risk of damage to the returned products, technology and information systems due to the data integration, regulatory requirements due to the centralization of the process and providers, partnership and collaboration which is caused by the lower fragmentation and easiness for a closer collaboration with fewer strategic partners, standardization and flexibility which is achieved by the highest RL integration, inventory management due to the lower number of locations, and resource utilization which is directly connected with the fewer transportation steps, thus less employees and trucks needed for handling such task. In the case of investments clearly the Status Quo "does not require any", thus it could be considered as the most favorable option on these regards. Then concerning the resilience and uncertainty factor, there is no sufficient evidence to support that it will improve when switching from the Scenario 1 to the Scenario 2, but in both cases, it would provide higher benefits than the status quo given the lower complexity in the network by removing transportation steps.

The findings of the simulations directly address the first research question: how can RL processes be optimized with the use of courier delivery companies? The key point here is to expand the current responsibilities of the courier companies beyond their traditional role of just collecting and trainspotting the returned products from the customers to the following processing facilities. This master thesis suggests that courier companies could also take on additional activities, such as the inspection, the categorization, the cleaning, and the repackaging of the returned products. Such shift would allow for the courier companies to further streamline these initial activities of the RL, reducing the number of transport steps, minimizing associated transportation costs, and speeding up the overall process.

The scenario 1 suggests that courier companies integrate inspection, categorization, cleaning, and repackaging activities within their existing logistics centers. By doing so, the courier companies could handle these key tasks immediately after they collect the returned products from their customers and bring them to their courier centers (currently done only for sorting and consolidation), significantly reducing the time and resources required to transport these items to separate facilities for their further processing. This approach not only makes considerably shorter the RL cycle, but also reduces the risk of damaging the returned products by minimizing the number of transport steps involved, and the corresponding handling involved on each one of the transports steps. The early recovery of the products is also a key advantage of the scenario 1, as it allows a faster reintegration of the returned products back into the forward supply chain, either through resale, refurbishment, or recycling. The integration of these activities also improves the quality control, as items are inspected, categorized, and cleaned earlier in the process, which is very important in order to maintain their value. Furthermore, by reducing the number of transportation steps needed in the RL process, this scenario directly addresses one of the main goals of the master thesis, which is to optimize the RL with the use of courier companies, on this particular case by reducing transportation costs. Having a fewer number of transport steps do not only lower

Table 8: Summary of potential benefits of the 2 scenarios against status quo

Factor	Status Quo (SQ)	Scenario 1 (S1)	Scenario 2 (S2)
Cost (10.000 units)	$ 43,577.84	$ 39,139.54	$ 40,093.58
Sustainability (KgCO2 emissions - 10.000 units)	96754.00	88700.00	88762.00
Investment	No investement required	Middle-high level of investment	High level of investmenet
Circularity	High number of transport/handling High risk of damage of returned products Low circularity	Middle-Low number of transport/handling Middle-Low risk to damage the returned products Middle-High circularity	Low number of transport/handling Low risk to damage of the returned products High circularity
Customer Satisfaction	High time in transit High RL lead time Low customer satisfaction	Middle-low time in transit Middle-low RL lead time Middle-High customer satisfaction	Low time in transit Low RL lead time High customer satisfaction
Product Quality and Condition	High number of transport/handling High risk of damage of returned products Low quality and condition	Middle-low number of transport/handling Middle-low risk of damage of returned products Middle-High quality and condition	Low number of transport/handling Low risk of damage of returned products High quality and condition
Technology and Information Systems	High number of suppliers Low data integration	Middle number of suppliers Middle-low data integration	Middle-Low number of suppliers Middle data integration
Resilience and Uncertainty	High network complexity Middle resilience to disruptions and uncertainty	Middle-High network complexity Middle-High resilience to disruptions and uncertainty	Middle-High network complexity Middle-High resilience to disruptions and uncertainty
Regulatory Requirements	Multiple hand-offs Risk of non-compliance with regulatory requirements	Middle-High level of RL integration Better compliance with regulatory requirments	High level of RL integration Easiest to achieve compliance with regulatory requirements
Partnership and Collaboration	High fragmentation Complex and limited partnership and collaboration	Middle-Low RL fragmentation Improved collaboration via integration	Low RL fragmentation Deepest collaboration, all activities integrated
Standardization and Flexibility	Low RL integration High number of suppliers Low standardization	Middle-High RL integration Middle number of suppliers - Streamlined processes Middle standardization	High RL integration Middle-Low number of suppliers - Further streamlined processes Middle-High standardization
Inventory Management	High number of locations Low control Middle-Low inventory management	Middle number of locations Middle control Middle-High inventory management	Middle-Low number of locations Middle-High control High inventory management
Resource Utilization	High number of trucks/employees needed Low resource utilization	Middle number of trucks/employees needed Middle resource utilization	Middle-Low number of trucks/employees needed Middle-High resource utilization

Source: Own work.

the overall costs, but it also decreases the impact on the environment associated with transportation CO_2e.

The Scenario 2 builds on the recommendations of the Scenario 1 by suggesting that courier companies could also include the disassembly activity into their operations. By adding disassembly into the logistics operations of the courier companies, they could further streamline the RL process and reduce the need for additional transport between facilities. This scenario focuses on the importance of sustainability in the RL by reducing the transport steps once more on the case of products that need to be dissembled, and by making easier the recovery of valuable components earlier in the process, thus reducing CO_2e and waste, and aligning with broader circular economy practices. The integration of disassembly, just like with the earlier activities proposed, also reduces transportation costs by centralizing more of the RL process within the courier's centers. This reduction or elimination of transportation steps contributes to faster processing, reduced risk of damage during loading/unloading and during the transport, and a more efficient recovery of valuable parts.

The second research question of this study focused on how these improvements in reverse logistics could be sustained over time. Sustaining these optimizations requires significant investment in infrastructure, as previously outlined. For instance, the implementation of inspection, categorization, cleaning, and repackaging units within the courier centers would

require to expand or acquire new facilities and equipment specifically designed for these particular tasks, some of which are completely new to the courier companies. Additionally, to integrate the disassembly activity, the courier companies would need to acquire specialized tools and machinery, as well as trained employees capable of dissembling even the complex products. These investments are critical to ensure that the proposed optimizations are not only implemented effectively but also sustained over the time, and it is something that could become a blocker or limitation for the courier companies to implement any of these strategies.

We also mention the importance of maintaining a strong focus on sustainability. By putting additional focus on sustainability in their RL operations, the courier companies would not only improve their reputation as leaders in sustainable logistics but they would also ensure that their optimizations stay relevant and valuable in the long term.

Finally, we also suggest that the obtained improvements can be supported and sustained over the time by promoting stronger partnerships and collaboration with their partner in the reverse supply chain. By working closer with their manufacturers, retailers, and third-party logistics providers, the courier companies can make sure to develop a more integrated and efficient RL. Such kind of partnerships would make it easier for all the parties involved to share their resources, knowledge, and innovations, which will further improve the sustainability and the effectiveness of the optimization achieved with the proposed solutions.

6 CONCLUSIONS

The objective of this master thesis was to explore the optimization of the RL with the use of courier delivery companies. With the growth of e-commerce, the volume of the returned goods has grown, which increased the pressure over the RL networks. Currently, what the courier companies do is primarily to collect and transport the returned products, playing a limited role in the overall process. This thesis identifies ways for courier companies to expand their role, and improve the effectiveness and efficiency in the RL, focusing on two key research questions: How can we improve the effectiveness and efficiency of the RL? And how can the achieved improvements be sustained in the long-term?

We provided a detailed analysis and proposed two improvement strategies against the current RL configuration. The key idea is to expand courier companies' responsibilities beyond just collecting and transporting returned products. Integrating activities such as inspection, categorization, cleaning, and repackaging within the courier centers has the power to streamline the RL, reduce transportation steps, minimize costs, and improve the speed of the overall process. By performing these tasks right after the returned products are collected, the courier companies would directly make shorter the RL cycle, reduce the risk of loss or damage of the returned products, and allow a faster reintegration of those products into the forward SC.

The second scenario suggested to include disassembly as part of the courier operations. Adding disassembly would continue to streamline the RL, reduce once again the number of transports, and ease the early recovery of valuable components for reusing or recycling; which aligns with sustainability goals by reducing CO2e and waste, and supporting the circular economy.

The findings can be considered as sufficient proof to show that by expanding the role of the courier companies we can significantly improve the effectiveness and efficiency of the RL. By taking on such additional responsibilities, the courier companies can reduce costs linked to multiple handoffs and transports, while improving the overall responsiveness of the logistics network.

Addressing the second research question, through chapters 3 to chapter 5 we have highlighted the importance of performing strategic investment on infrastructure, technology, and employee trainings in order to sustain these improvements over the long-term. Infrastructure investments are critical for expanding or acquiring new facilities and equipment for tasks like inspection, categorization, cleaning, and disassembly. Technological investments, such as advanced diagnostic tools, are also important for maintaining the high service standards. Continuous employee training programs focused on the latest technologies and best practices in RL are also indispensable to maintain the achieved results over the long term.

This master thesis makes important contributions to both theory and practice. Theoretically, it challenges and expands the traditional understanding of the courier companies' roles in the RL, which are expected to perform only the collection and the transportation of the returned products. By proposing that courier companies take on additional responsibilities such as inspection, categorization, cleaning, repackaging, and disassembly, this master thesis is demonstrating that these companies can be the key in the optimization of the entire RL process. When looking at the framework from de Brito (2004), the courier companies would maintain their role as collectors, but on this case their role as processors would be expanded and become more than just facilitators of product return logistics; they can actively streamline and improve the process, contributing to broader SC efficiency. The perspective brought with this master thesis is not only aligned with the existing theoretical frameworks in SCM, but it also expands on them by adding new possibilities to the ongoing research on sustainable logistics and circular economy practices.

Practically, the thesis contributes with actionable strategies for the courier companies to improve their operations beyond their traditional roles. By adding those activities within their existing operations, the courier companies can significantly reduce the number of transportation steps, lower the operational costs, and decrease the environmental impact through reduced CO2e. These strategies are very timely given the increasing pressure on the logistics industry to adopt more sustainable practices. Furthermore, this master thesis also provides a clear path for the courier companies to evolve their current processor role into leaders in the RL field, which as already described they can achieve by offering services that go beyond just transportation.

By demonstrating how the courier companies can play a more active role in the RL, this master thesis extends the current theoretical frameworks and offers practical solutions that could be implemented not only in the e-commerce sector but also potentially in other industries where the RL is critical, such as the manufacturing and retail industries. The findings on this master thesis open up new courses of action for future research and industry practices, suggesting that the involvement of courier companies in RL could be a key driver of innovation in the SCM.

While the master thesis is strictly focused on the courier companies within the e-commerce sector and this might have limited the generalizability of the findings, the insights that we have obtained still remain valuable/relevant. Future research could focus on the application of these strategies to other logistics industries, such as the retail industry. Future research could also investigate the long-term impact of the proposed strategies on the overall SC performance, including the calculation of the return on the investments (ROI), which would help to understand the long-term benefits. Additionally, relying primarily on public access articles, and the simulations from the two scenarios presented in the Chapter 5 might not fully capture the complexity of the logistics operations that companies face day to day in the real world. In the simulations we did not consider many external factors that could impact or become blockers for the implementation and sustainability of the scenarios given the lack of access to real life application. These limitations could have influenced the results and should be considered when applying the findings to different contexts. Thus, future research could focus more on the practical experimentation of the different scenarios.

In conclusion, this master thesis suggests that the RL can be optimized by expanding the role of courier companies to include activities such as inspection, cleaning, and disassembly. To sustain the obtained improvements over the long-term it is required to perform strategic investments, a focus on sustainability, and a high level of collaboration within the RL network. These strategies can significantly improve the effectiveness and the efficiency of the RL, something that can be considered as a major step towards the optimization of the RL with the use of courier delivery companies, which is the main subject of this master thesis. This thesis contributes with valuable insights and practical solutions that have the potential to drive future innovations in the broader field of logistics and SCM.

By reflecting on the research process, it is very clear that performing this master thesis has been both, challenging and rewarding on a higher level. The complexities involved in the optimization of the reverse logistics processes, specifically within the context of the courier companies in the e-commerce sector, required of a careful balance between theoretical background and practical applications. Additionally, the challenges encountered during the 2.5 years of research and writing of this master thesis, such as the switch on the logistics dynamics pre, intra and post-covid and the ever-evolving nature of the e-commerce logistics in overall, have provided me with an incredible contribution to my personal growth as a professional and as a person passionate about logistics.

REFERENCE LIST

1. Aït-Kadi, D., Chouinard, M., Marcotte, S., & Riopel, D. (2012). Sustainable Reverse Logistics Network: engineering and management. https://www.amazon.com/Sustainable-Reverse-Logistics-Network-Engineering/dp/1848213107.
2. Alicke, K., Gupta, R., & Trautwein, V. (2020). *Resetting supply chains for next normal*. McKinsey & Company. https://www.mckinsey.com/capabilities/operations/our-insights/resetting-supply-chains-for-the-next-normal.
2. ASENDIA. (2023). *The e-commerce market: Handbook 2023*. https://www.asendia.com/hubfs/Resources%20(eBooks,%20Reports,%20Infographics)/Asendia%20Own%20Resources/Asendia_General%20Retail_Guide_EN_UK.pdf.
3. Bai, C., & Sarkis, J. (2013). Flexibility in reverse logistics: A framework and evaluation approach. *Journal of Cleaner Production*, *47*, 306-318. https://doi.org/10.1016/j.jclepro.2013.01.005.
4. Ballou, R. H. (2006). *The evolution and future of logistics and supply chain management*. Production, 16(3), 375-386. https://doi.org/10.1590/s0103-65132006000300002.
5. Banomyong, R., & Supatn, N. (2003). *Legality in Reverse Logistics Process: A Case Study of Electronic Appliance Manufacturer*. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=6358503a9f66778b350f4f48a8f7fa51a8780505.
6. Biancolin, M., Capoani, L., & Rotaris, L. (2023). Reverse logistics and circular economy: A literature review. *European Transport/Trasporti Europei*, (*94*), 1-14. https://doi.org/10.48295/et.2023.94.7.
7. Cambridge Dictionary. (2020). *Logistics*. https://dictionary.cambridge.org/dictionary/english/logistics
8. Cash Flow Inventory. (2023, September 26). *Reverse logistics and inventory management: Benefits and challenges*. https://cashflowinventory.com/blog/reverse-logistics-and-inventory-management/.
9. CBRE. (2022). *European modern logistics: Primed for sustained growth*. https://www.cbreim.com/-/media/project/cbre/bussectors/cbreim/insights/articles/european-modern-logistics-primed-for-sustained-growth/european-modern-logistics-primed-for-sustained-growth.pdf.
10. Chopra, S., & Meindl, P. (2019). Supply chain management. Strategy, planning & Operation. *Das Summa Summarum des Management*, 265-275. https://doi.org/10.1007/978-3-8349-9320-5_22.
11. Ciesielski, M. (2020). E-commerce and fintech. *Interconnected vessel system report "300 Research".* https://static.300gospodarka.pl/media/2020/11/Raport_-Ecommerce-i-fintechy_System-naczy%C5%84-po%C5%82%C4%85czonych_2020-r..pdf.

12. CompaniesMarketCap. (2024). *Top publicly traded courier companies by revenue*. https://companiesmarketcap.com/eur/delivery-services/largest-courier-companies-by-revenue/.
13. Coppola, D. (2020). *Online share of retail trade in selected countries 2014-2021*. Statista.
14. Coyle, J. J., Langley, C. J., Gibson, B. J., Novack, R. A., & Bardi, E. J. (2008). *Supply Chain Management : A Logistics Perspective*. https://ci.nii.ac.jp/ncid/BB09656793.
15. CSCMP. (2020). *SCMP Supply Chain Management Definitions and Glossary*. CSMP. https://cscmp.org/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms.aspx.
16. Dabo, A. A., & Hosseinian-Far, A. (2023). An integrated methodology for enhancing reverse logistics flows and networks in industry 5.0. *Logistics*, *7*(4), 97. https://doi.org/10.3390/logistics7040097.
17. De Brito, M. (2004). Managing Reverse Logistics or Reversing Logistics Management? PhD,. *Erasmus university Rotterdam*. https://repub.eur.nl/pub/1132/EPS2004035LIS_9058920585_DEBRITO.pdf.
18. Deloitte. (2014). *Moving forward in reverse: Why reverse logistics needs a dedicated channel*. Deloitte Touche Tohmatsu Limited. https://www2.deloitte.com/content/dam/Deloitte/us/Documents/process-and-operations/us-cons-moving-forward-inreverse-091714.pdf.
19. DHL. (2023). *Return to sender? Reverse logistics explained*. https://www.dhl.com/global-en/delivered/ecommerce/what-is-reverse-logistics.html.
20. DHL. (2024a). *DHL GOGREEN - Climate-friendly shipping and receiving with DHL*. https://www.dhl.de/en/privatkunden/kampagnenseiten/gogreen.html.
21. DHL. (2024b). *Consumer: Send your package back*. https://www.dhlexpress.nl/en/consumer/returns.
22. Egri, P., Dávid, B., Kis, T., & Krész, M. (2023). Robust facility location in reverse logistics. *Annals of Operations Research*, *324*(1-2), 163-188. https://doi.org/10.1007/s10479-021-04405-5.
23. Europe, E. N. (2024, August 13). *44% of returned items never resold*. Ecommerce News Europe. https://ecommercenews.eu/44-of-returned-items-never-resold/.
24. European Comission. (2017). *Logistics*. https://transport.ec.europa.eu/transport-themes/logistics-and-multimodal-transport/logistics_en.
25. Eurosender. (2021, January 13). *5 reverse logistics examples: Importance of reverse logistics.* Eurosender. https://www.eurosender.com/blog/en/reverse-logistics#courier-companies.
26. Fawcett, S. E., Ellram, L. M., & Ogden, J. A. (2007). *Supply chain management : from vision to implementation. In Pearson Prentice Hall eBooks*. http://ci.nii.ac.jp/ncid/BA88237110.
27. FedEx. (2024). *Simplify returns for your customers*. https://www.fedex.com/e-us/shipping/returns/business.html.

28. Filipe, D., & Pimentel, C. (2023). Production and internal logistics flow improvements through the application of total flow management. *Logistics*, *7*(2), 34. https://doi.org/10.3390/logistics7020034.
29. Fleischmann, M. (2000). Quantitative models for reverse logistics. *Lecture Notes in Economics and Mathematical Systems*. https://doi.org/10.1007/978-3-642-56691-2.
30. Fokina, M. (2024, August 5). *Online shopping statistics: Ecommerce trends for 2024*. Tidio. https://www.tidio.com/blog/online-shopping-statistics/.
31. Garola, G., Siragusa, C., Seghezzi, A., & Mangiaracina, R. (2023). Managing COVID-19 disruption: The response of express couriers and lessons learned to improve resilience. *The International Journal of Logistics Management*, *34*(7), 121-141. https://doi.org/10.1108/ijlm-03-2022-0114.
32. Govindan, K., Soleimani, H., & Kannan, D. (2015). Reverse logistics and closed-loop supply chain: A comprehensive review to explore the future. *European Journal of Operational Research*, *240*(3), 603-626. https://doi.org/10.1016/j.ejor.2014.07.012.
33. HFW, & Panattoni. (2023). European Logistics & Supply Chain Sustainability Report 2022. *Analytiqa*. https://www.hfw.com/app/uploads/2024/04/004068-European-Logistics-Supply-Chain-Sustainability-Report-2022.pdf.
34. Hong, J. Y., Suh, E. H., & Hou, L. Y. (2008). Identifying the factors influencing the performance of reverse supply chains (RSC). *International Journal of Sustainable Engineering*, *1*(3), 173-187. https://doi.org/10.1080/19397030802511004.
35. Jalil, E. A. (2019). Customer satisfaction and reverse logistics in e-commerce: The case of klang valley. *9th International Conference on Operations and Supply Chain Management*, 15-18. https://www.journal.oscm-forum.org/journal/proceeding/conf_paper/customer-satisfaction-and-reverse-logistics-in-e-commerce-the-case-of-klang-valley.
36. Janczewski, J. (2019). Reverse logistics from the perspective of the circular economy. *Zarządzanie Innowacyjne w Gospodarce i Biznesie*, *1*(28), 143-155. https://doi.org/10.25312/2391-5129.28/2019_10jj.
37. Kazancoglu, Y., Ozbiltekin-Pala, M., Sezer, M. D., Luthra, S., & Kumar, A. (2022). Resilient reverse logistics with blockchain technology in sustainable food supply chain management during COVID-19. *Business Strategy and the Environment*, *32*(4), 2327-2340. https://doi.org/10.1002/bse.3251.
38. Kidwai, A. G., & Maqbool, A. (2023). Recent developments in courier services: a review. *Journal of Research Administration*, *5*(2), 1742-1758. https://www.academia.edu/109443990/recent_developments_in_courier_services_a_review.
39. Kovács, G., & Rikhardsson, P. (2006). Accounting for reverse logistics activities. *Corporate Ownership and Control*, *4*(1), 309-316. https://doi.org/10.22495/cocv4i1c2p7.
40. KPGM International. (2017). *Future-proof your reverse logistics*. https://assets.kpmg.com/content/dam/kpmg/id/pdf/2017/08/id-future-proof-reverse-logistics-2august.pdf.

41. Lambert, S., Riopel, D., & Abdul-Kader, W. (2011). A reverse logistics decisions conceptual framework. *Computers & Industrial Engineering*, *61*(3), 561-581. https://doi.org/10.1016/j.cie.2011.04.012.
42. Lambert, D. M., Cooper, M. C., & Pagh, J. D. (1998). Supply chain management: Implementation issues and research opportunities. *The International Journal of Logistics Management*, *9*(2), 1-20. https://doi.org/10.1108/09574099810805807.
43. Logistix Partners Oy. (1996). *Logistics*. *Logistix Partners Oy*.
44. Lysenko-Ryba, K. (2017). The impact of reverse logistics on customers satisfaction. *Przedsiebiorczosc I Zarzadzanie*, *18*, 137–146. https://www.ceeol.com/search/article-detail?id=719159.
45. Medium. (2023, September 2). *Courier services: The backbone of efficiency and beyond*. Medium. https://medium.com/@pinnaclecouriers0/courier-services-the-backbone-of-efficiency-and-beyond-314e15655e4.
46. Mordor Intelligence. (2023). *Europe contract logistics market*. Mordor Intelligence. https://www.mordorintelligence.com/industry-reports/europe-contract-logistics-market.
47. Musafir, S. (2017). Consumer satisfaction and consumer delight. *International Journal of Advanced Research in Management and Social Sciences*, *6*(5), 328-339. https://garph.co.uk/IJARMSS/May2017/24.pdf.
48. Nikolaidis, Y. (2012). Reverse logistics and Quality Management issues: State-of-the-Art. *Quality Management in Reverse Logistics*, 1-19. https://doi.org/10.1007/978-1-4471-4537-0_1.
49. Olariu, I. (2013). Conceptual issues regarding reverse logistics. *STUDIES AND SCIENTIFIC RESEARCHES. ECONOMICS EDITION*, (18). https://doi.org/10.29358/sceco.v0i18.218.
50. Owczarek, D. (2024, January 14). *Revolutionize your stock levels with machine learning inventory management*. nexocode. https://nexocode.com/blog/posts/inventory-optimization-machine-learning/.
51. Packeta. (2021, January 26). *Packeta v roce 2020 zdvojnásobila svůj obrat*. Packeta. https://www.zasilkovna.cz/blog/packeta-v-roce-2020-zdvojnasobila-svuj-obrat.
52. Pfohl, H. C. (1998). *Systemy logistyczne – podstawy organizacji i zarządzania*. Biblioteka Logistyka, 11-12.
53. Rasool, F., Greco, M., Morales-Alonso, G., & Carrasco-Gallego, R. (2023). What is next? The effect of reverse logistics adoption on digitalization and inter-organizational collaboration. *International Journal of Physical Distribution & Logistics Management*, *53*(5/6), 563-588. https://doi.org/10.1108/ijpdlm-06-2022-0173.
54. Reflex Logistics. (2024, September 9). *The challenges and opportunities of reverse logistics*. Reflex. https://www.reflex-logistics.com/en/blog/reverse-logistics-definition-management-and-advantages/.
55. Ribble. (2023). *Reverse logistics management*. Ribble. https://ribble-pack.co.uk/blog/reverse-logistics-management.

56. Vaz, C. R., Grabot, B., Maldonado, M. U., & Selig, P. M. (2013). Some reasons to implement reverse logistics in companies. *International Journal of Environmental Technology and Management*, *16*(5/6), 467. https://doi.org/10.1504/ijetm.2013.059447.
57. Rogers, D. S., & Tibben-Lembke, R. S. (1999). *Going Backwards: Reverse Logistics Trends and Practices*. http://ci.nii.ac.jp/ncid/BA53718225.
58. Rudolph, F., Riach, N., & Kees, J. (2023). Development of transport infrastructure in Europe: Exploring the shrinking and expansion of railways, motorways and airports. *T3 Transportation Think Tank & Wuppertal Institute*. https://greenpeace.at/uploads/2023/09/analysis_development-of-transport-infrastructure-in-europe_2023.pdf.
59. Saravanan, S., Jainullabdeen, A., & Sirajudeen, J. (2023). A Conceptual Framework for Reverse Logistics in Online Shopping. *International Journal of Research Publication and Reviews*, *4*(3), 1385-1393.
60. Silva, R. V. da. (2012). *A different approach on reverse logistics: A retailer's case study* (Master's dissertation). Faculty of Engineering, University of Porto. https://hdl.handle.net/10216/107505.
61. Starostka-Patyk, M. (2019). *Logistyka zwrotna produktów niepełnowartościowych w zarządzaniu przedsiębiorstwami produkcyjnymi* (Janczewski, Trans.). *Zarządzanie Innowacyjne w Gospodarce i Biznesie*. (2016 original work).
62. Starostka-Patyk, M., & Grunt, P. (2022). Future ICT trends as the opportunity for reverse logistics support. *Procedia Computer Science*, *207*, 4401-4408. https://doi.org/10.1016/j.procs.2022.09.503.
63. Statista. (2022, November 30). *COVID-19 impact on global retail e-commerce site traffic 2019-2020*. https://www.statista.com/statistics/1112595/covid-19-impact-retail-e-commerce-site-traffic-global/.
64. Suyabatmaz, A. Ç., Altekin, F. T., & Şahin, G. (2014). Hybrid simulation-analytical modeling approaches for the reverse logistics network design of a third-party logistics provider. *Computers & Industrial Engineering*, *70*, 74-89. https://doi.org/10.1016/j.cie.2014.01.004.
65. Szymonik, A. (2012). Logistics and supply chain management. *Technical University of Lodz Press*. https://www.researchgate.net/profile/Andrzej-Szymonik.
66. United Parcel Service of America, Inc. (2018). *Return services*. UPS. https://www.ups.com/assets/resources/media/en_US/UPSMI_Returns_Sales_Sheet.pdf.
67. UPS. (2024). *Happy returns*. Happy Returns, a UPS Company. https://happyreturns.com/.
68. Wang, M. (2011). *Reverse logistics optimization: A research to the uncertainties in the third party reverse logistics: Case of New Zealand Couriers Ltd* [Master’s thesis, Massey University]. https://mro.massey.ac.nz/bitstream/10179/3057/1/02_whole.pdf.
69. Wang, M., Wang, B., & Chan, R. (2020). Reverse logistics uncertainty in a courier industry: A triadic model. *Modern Supply Chain Research and Applications*, *3*(1), 56-73. https://doi.org/10.1108/mscra-10-2020-0026.

70. Yang, S., Taghipour, A., & Canel-Depitre, B. (2017). Cost optimization of reverse logistics. *Proceedings of the 7th International Conference on Information Communication and Management*, 44, 158-161. https://doi.org/10.1145/3134383.3134393.
71. Zarbakhshnia, N., Kannan, D., Kiani Mavi, R., & Soleimani, H. (2020). A novel sustainable multi-objective optimization model for forward and reverse logistics system under demand uncertainty. *Annals of Operations Research*, *295*(2), 843-880. https://doi.org/10.1007/s10479-020-03744-z.
72. Zhou, Z., Cai, Y., Xiao, Y., Chen, X., & Zeng, H. (2018). The optimization of reverse logistics cost based on value flow analysis – a case study on automobile recycling company in China. *Journal of Intelligent & Fuzzy Systems*, *34*(2), 807-818. https://doi.org/10.3233/jifs-169374.

APPENDICES

Appendix 1: Summary in Slovene

Glavni cilj magistrskega dela z naslovom »Optimizacija obratnih logističnih procesov v kurirskih dostavnih podjetjih« je, kot je navedeno v naslovu, optimizacija obratne logistike s centralizacijo nekaterih dejavnosti znotraj kurirskih dostavnih podjetij. Osredotočili se bomo na izboljšave učinkovitosti in uspešnosti obratnih logističnih procesov, ki jih generira centralizacija izbranih dejavnosti znotraj kurirskih podjetij.

Predlagamo, da kurirska podjetja razširijo svoje pristojnosti izven tradicionalnih, ki so omejene predvsem na prevzem in prevoz vrnjenih izdelkov. Priporočamo, da prevzamejo dodatne aktivnosti, kot so pregled, kategorizacija, čiščenje in prepakiranje vrnjenih izdelkov v svojih prostorih. Ta integracija novih funkcij bi omogočila zmanjšanje števila transportnih korakov, kar bi povzročilo nižje stroške, hitrejšo obdelavo in izboljšano kakovost storitev. Prav tako bi z zmanjšanjem rokovanja z izdelki na vsakem koraku transporta zmanjšali tveganje poškodb in izboljšali kakovost vrnjenih izdelkov.

Za optimizacijo procesov obratne logistike sta predstavljena dva scenarija simulacije. Prvi scenarij se osredotoča na integracijo pregleda in prepakiranja vrnjenih izdelkov v kurirskih centrih. Ta pristop znatno skrajša čas obdelave in stroške, povezane s prevozom, saj vrnjenih izdelkov ni treba poslati v več objektov, da bi se na njih izvajala drugačna vrsta dejavnosti. Drugi scenarij je sestavljen iz še naprednejše rešitve, kjer bi kurirska podjetja izvajala tudi demontažo izdelkov, kar bi omogočilo zgodnejšo obnovo dragocenih komponent in spodbujalo bolj trajnostne prakse, kar je v skladu s konceptom krožnega gospodarstva.

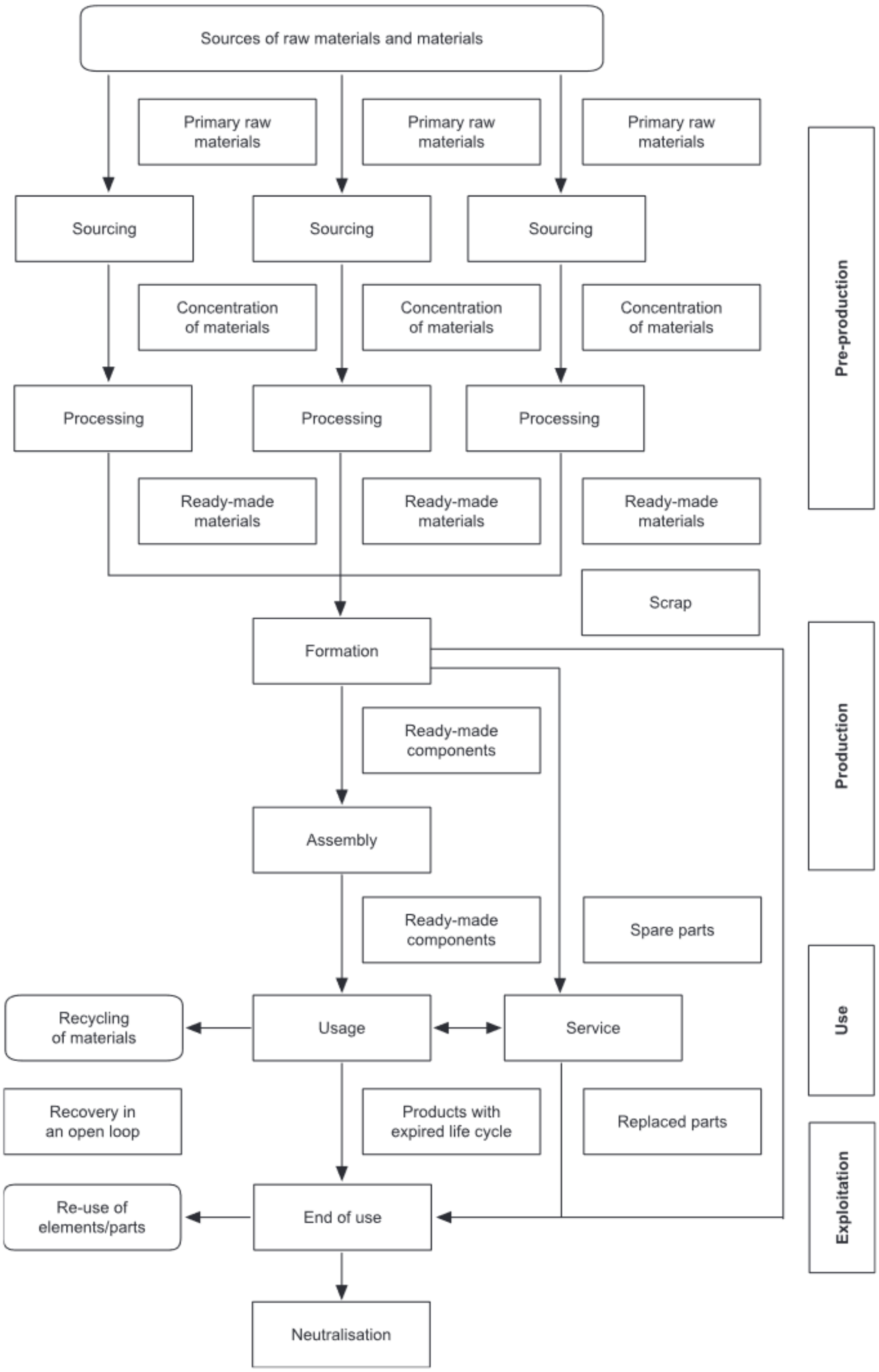
Rezultati simulacije kažejo, da oba scenarija ponujata pomembne prednosti v primerjavi s trenutno situacijo. Prvi scenarij se zdi najbolj privlačen, saj omogoča večje znižanje stroškov in časa obdelave. Po drugi strani pa drugi scenarij, čeprav je dražji z vidika začetne naložbe, ponuja dodatne prednosti v smislu povrnitve vrednosti, manjše tveganje poškodb vrnjenih izdelkov in večjo okoljsko trajnost z nadaljnjim zmanjšanjem emisij $CO2$.

Za dolgoročno ohranjanje doseženih izboljšav izpostavljamo nujnost strateških vlaganj kurirskih podjetij v infrastrukturo, tehnologijo in izobraževanje zaposlenih. Te naložbe so ključnega pomena za zagotovitev, da se predlagane izboljšave lahko ohranijo skozi čas in da lahko kurirska podjetja še naprej igrajo ključno vlogo v obratni dobavni verigi.

Magistrsko delo nakazuje, da lahko kurirska podjetja s prevzemanjem bolj aktivne vloge pri ravnanju z vrnjenimi izdelki pomembno prispevajo k optimizaciji povratnih logističnih procesov. Ta strategija ne le izboljšuje operativno učinkovitost, temveč tudi prispeva k zmanjšanju vpliva na okolje (uspešnost). S predlogoma, obravnavanima v tej nalogi, ponujamo jasno pot kurirskim podjetjem, da postanejo vodilna v obratni logistiki in spodbujajo bolj trajnostne prakse v celotni dobavni verigi.

Appendix 2: Open Loop of Reverse Logistics Movements

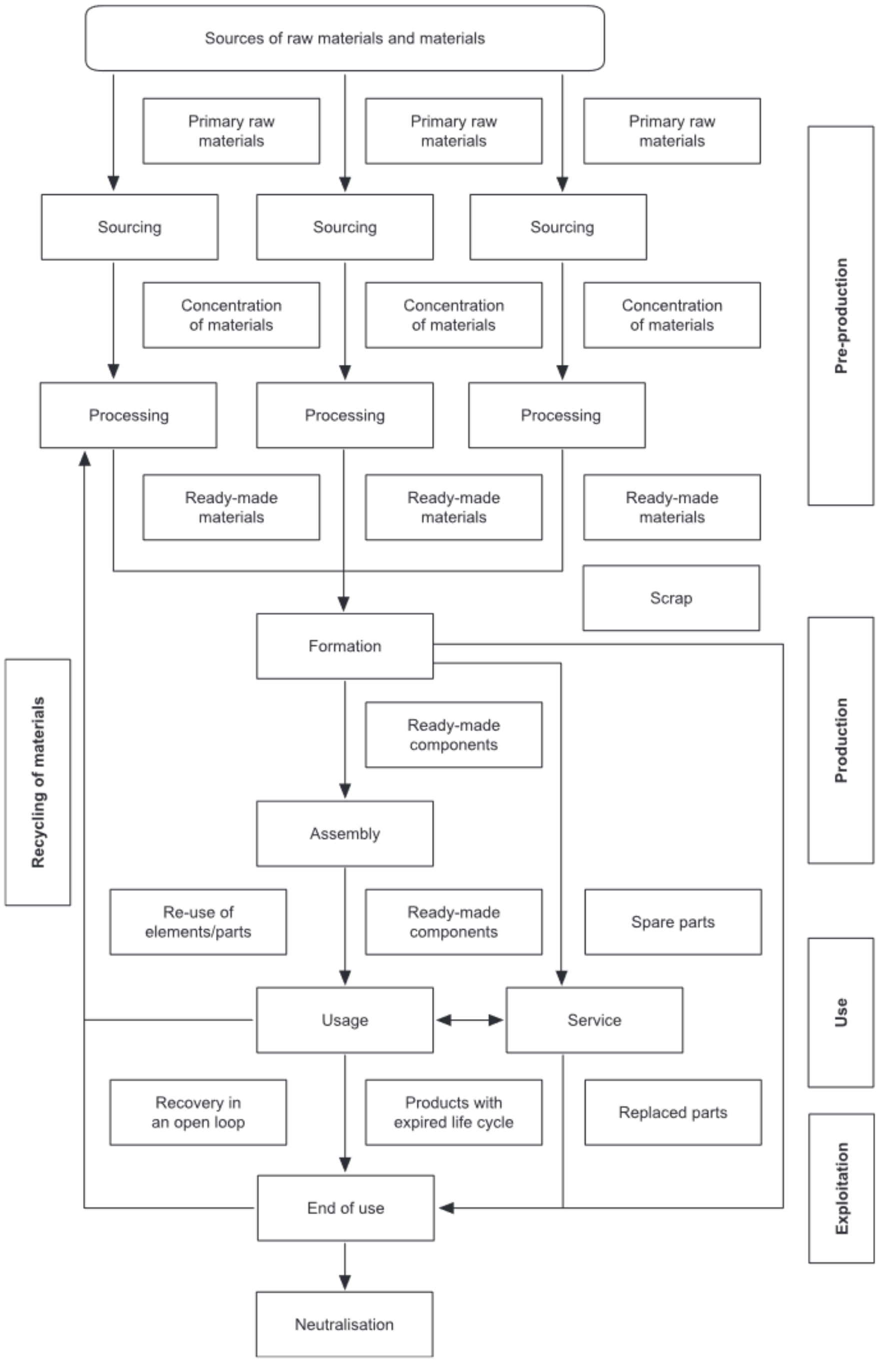
The table below is reproduced from the document titled "Reverse Logistics" by Janczewski (2013).



Note: This table is reproduced from "Reverse Logistics," by J. Janczewski, 2013, Zeszyty Naukowe Instytutu Zarządzania i Marketingu Akademii Humanistyczno-Ekonomicznej w Łodzi, 28, 104-117. Available at https://ziwgib.ahe.lodz.pl/en/system/files/ZIwGiB28_10%20JANCZEWSKI%20Reverse%20logistics.pdf.

Appendix 3: Closed Loop of Reverse Logistics Flows

The table below is reproduced from the document titled "Reverse Logistics" by Janczewski (2013).



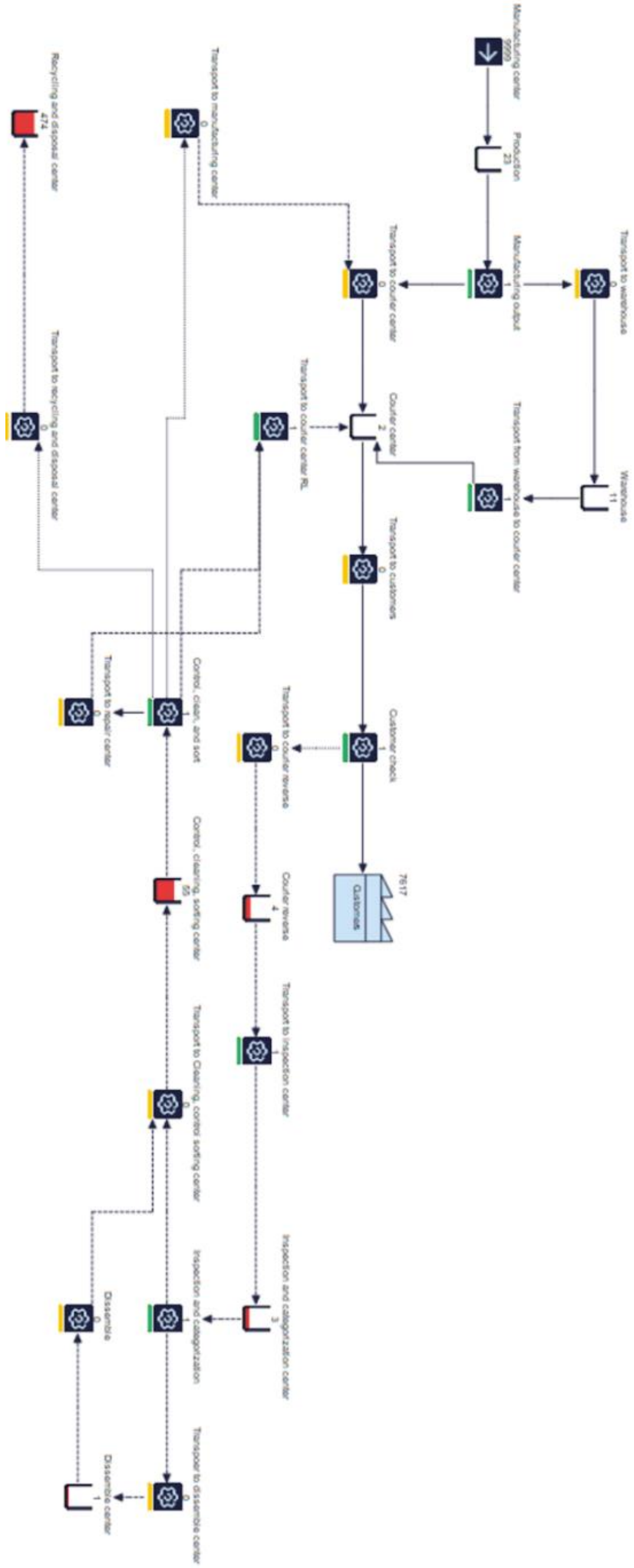
Note: This table is reproduced from "Reverse Logistics," by J. Janczewski, 2013, Zeszyty Naukowe Instytutu Zarządzania i Marketingu Akademii Humanistyczno-Ekonomicznej w Łodzi, 28, 104-117. Available at https://ziwgib.ahe.lodz.pl/en/system/files/ZIwGiB28_10%20JANCZEWSKI%20Reverse%20logistics.pdf.

Appendix 4: Costs Associated with Reverse Logistics Activities

Costs/Activities	Collection	Inspection	Separation	Reprocessing	Disposal	Other/Support activities
Personnel: Labour	Extra time needed to collect items	Time for registering items on arrival to facility Time for inspection of items Time for transportation of items from arrival facility to inspection facility	Time for separation of materials in item Time for registration of materials Time for transportation of items from inspection facility to separation facility	Time or reprocessing items and materials	Time for preparing items for disposal	Management and administrative costs including legal, accounting, personnel etc. management and administration Time needed to transport items and materials internally in the company between facilities
Personnel: Training	Special training of collection employees	Special training of inspectors	Special training of employees in separation	Special training of reprocessing employees	Special training for handling of disposal items	
Materials			Cost of materials needed for the separation processes	Cost of materials needed for the reprocessing processes	Cost of materials needed for the disposal processes	
Tools			Costs of tools needed for separation	Cost of tools needed for reprocessing	Cost of tools needed for disposal	
Consumables	Extra fuel due to weight of items or rerouted transport	Cost of transportation materials used such as palettes				
Capacity costs	Part of depreciation of trucks	Part of costs of storage capacity	Costs of separation facility or parts of facility costs if not separate from other facilities	Costs of reprocessing facility or parts of facility costs if not separate from other facilities	Costs of disposal facility or parts of facility costs if not separate from other facilities	Part of collective facility costs such as electricity, heating and lighting
Other	Take-back fees				Disposal fees	

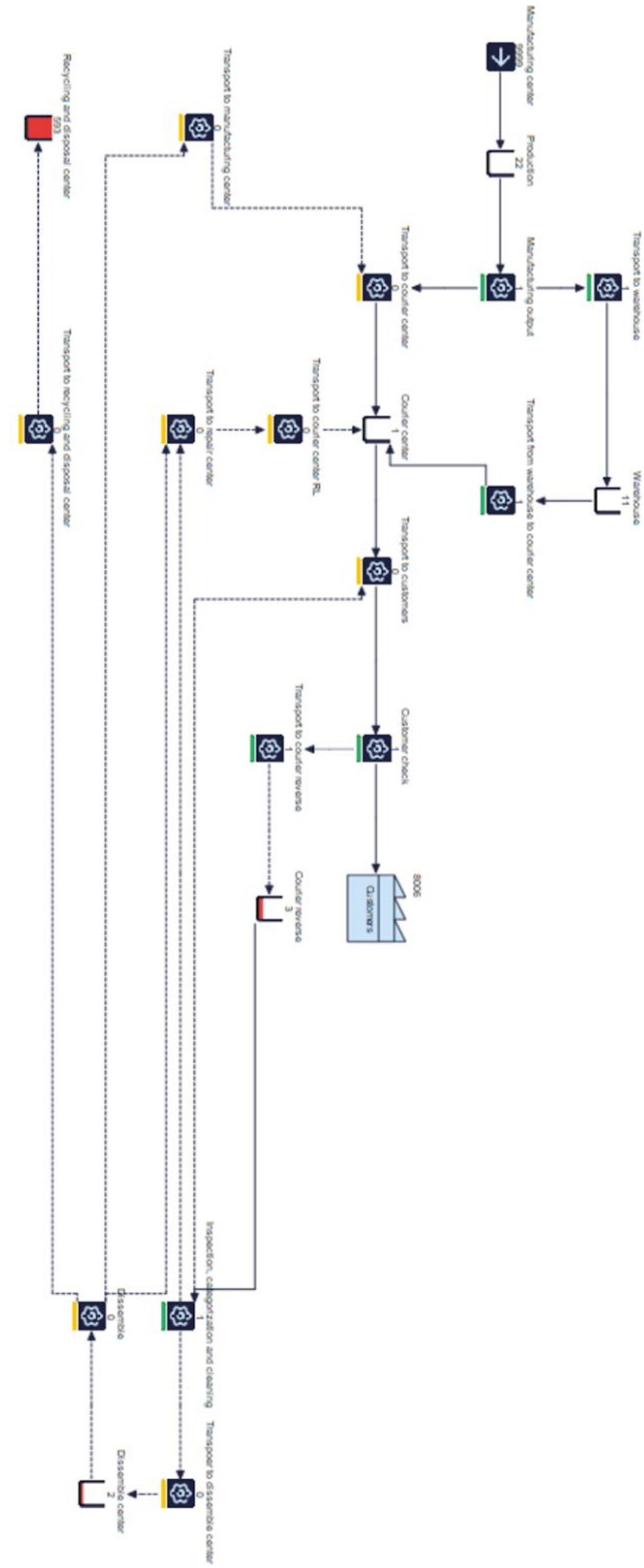
Note: This table is reproduced from "Accounting for Reverse Logistics Activities," by P. González-Torre, B. Álvarez, L. Sarkis, and A. Adenso-Díaz, 2009, International Journal of Production Economics, 113(1), 284-295. Available at https://www.researchgate.net/publication/40240391_Accounting_for_Reverse_Logistics_Activities.

Appendix 5: Simulation Chart Status Quo of Reverse Logistics



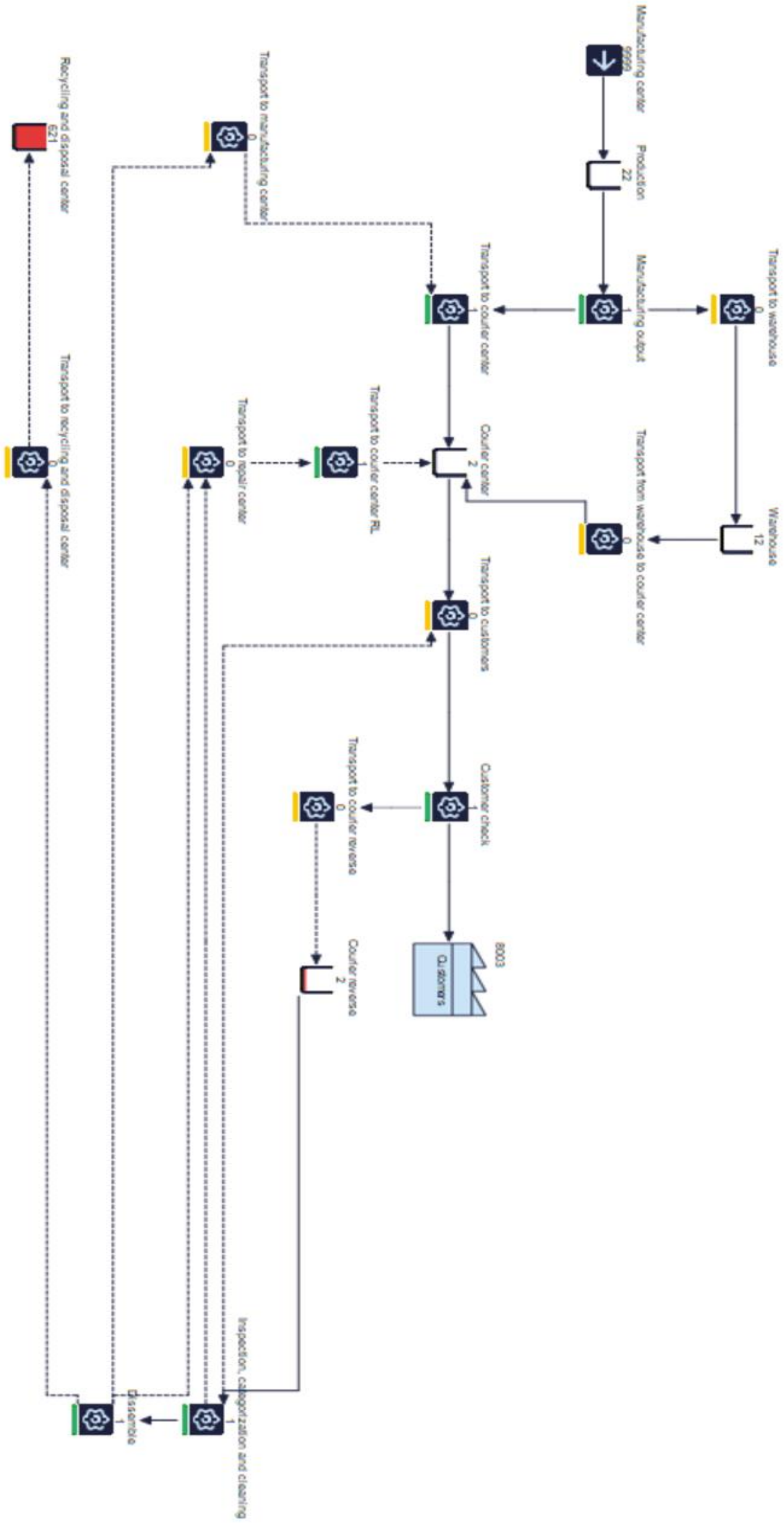
Source: Own work.

Appendix 6: Simulation Chart Scenario 1 of Reverse Logistics



Source: Own work.

Appendix 7: Simulation Chart Scenario 2 of Reverse Logistics



Source: Own work.

Appendix 8: Status Quo Simulation CO2 Emissions

Carbon Emissions	96,754.00 CO2e
Manufacturing center	10,009.00 CO2e
Warehouse	460.00 CO2e
Courier center	80.00 CO2e
Transport to courier center	4,555.00 CO2e
Transport from warehouse to courier center	5,469.00 CO2e
Transport to customers	12,014.00 CO2e
Courier reverse	190.00 CO2e
Transport to courier reverse	3,707.00 CO2e
Customer check	12,013.00 CO2e
Transport to inspection center	3,570.00 CO2e
Inspection and categorization center	200.00 CO2e
Inspection and categorization	3,365.00 CO2e
Transpoer to dissemble center	1,547.00 CO2e
Transport to Cleaning, control sorting center	3,329.00 CO2e
Control, cleaning, sorting center	3,015.00 CO2e
Dissemble center	110.00 CO2e
Dissemble	1,511.00 CO2e
Control, clean, and sort	3,112.00 CO2e
Transport to courier center RL	2,324.00 CO2e
Transport to repair center	636.00 CO2e
Transport to manufacturing center	281.00 CO2e
Transport to recycling and disposal center	526.00 CO2e
Recycling and disposal center	8,555.00 CO2e
Production	480.00 CO2e
Manufacturing output	9,985.00 CO2e
Transport to warehouse	5,711.00 CO2e

Source: Own work.

Appendix 9: Scenario 1 Simulation CO2 Emissions

Carbon Emissions	88,700.00 CO2e
Manufacturing center	10,009.00 CO2e
Warehouse	465.00 CO2e
Courier center	80.00 CO2e
Transport to courier center	4,564.00 CO2e
Transport from warehouse to courier center	5,462.00 CO2e
Transport to customers	12,551.00 CO2e
Courier reverse	225.00 CO2e
Transport to courier reverse	3,874.00 CO2e
Customer check	12,550.00 CO2e
Inspection, categorization and cleaning	3,748.00 CO2e
Transpoer to dissemble center	1,337.00 CO2e
Dissemble center	90.00 CO2e
Dissemble	1,305.00 CO2e
Transport to courier center RL	1,159.00 CO2e
Transport to repair center	1,159.00 CO2e
Transport to manufacturing center	281.00 CO2e
Transport to recycling and disposal center	633.00 CO2e
Recycling and disposal center	13,015.00 CO2e
Production	505.00 CO2e
Manufacturing output	9,986.00 CO2e
Transport to warehouse	5,702.00 CO2e

Source: Own work.

Appendix 10: Scenario 2 Simulation CO2 Emissions

Carbon Emissions	88,762.00 CO2e
Manufacturing center	10,009.00 CO2e
Warehouse	465.00 CO2e
Courier center	60.00 CO2e
Transport to courier center	4,568.00 CO2e
Transport from warehouse to courier center	5,475.00 CO2e
Transport to customers	12,540.00 CO2e
Courier reverse	215.00 CO2e
Transport to courier reverse	3,870.00 CO2e
Customer check	12,539.00 CO2e
Inspection, categorization and cleaning	3,745.00 CO2e
Dissemble	1,360.00 CO2e
Transport to courier center RL	1,320.00 CO2e
Transport to repair center	1,321.00 CO2e
Transport to manufacturing center	298.00 CO2e
Transport to recycling and disposal center	671.00 CO2e
Recycling and disposal center	14,090.00 CO2e
Production	515.00 CO2e
Manufacturing output	9,986.00 CO2e
Transport to warehouse	5,715.00 CO2e

Source: Own work.