UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Circular economy of spare parts and data-driven analytics

"Unlocking Sustainable Value: Analyzing Buyback Policy Circularity Performance in Volvo Group's Reverse Supply Chain - A Renault Trucks Case Study"

Vladyslav Zahladko

Supervisor: Johan Brink

Master's Thesis in Innovation and Industrial Management
Unit for Innovation and Entrepreneurship
School of Business, Economics and Law at Gothenburg University
Gothenburg, Sweden 2023

Circular economy of spare parts and data-driven analytics
Unlocking Sustainable Value: Analyzing Buyback Policy Circularity Performance in Volvo Group’s Reverse Supply Chain - A Renault Trucks Case Study
VLADYSLAV ZAHLADKO

Volvo Group supervisors: Ana Elsa Hinojosa Herrera, Philip Mårtensson
Academic supervisor: Johan Brink, Unit for Innovation and Entrepreneurship

Master’s Thesis in Innovation and Industrial Management, Unit for Innovation and Entrepreneurship, School of Business, Economics and Law at Gothenburg University, Gothenburg

Cover: Designed by the author. Truck image by Renault Trucks 2023, photo by Daniel Kainz on Unsplash.
Gothenburg, Sweden 2023

Abstract

To address the current environmental challenges, companies are steadily shifting from a linear to a circular model in their daily operations. This process implies supplementing the traditional forward logistics with a reverse flow, enabling the reuse, remanufacturing, and recycling of existing products. Yet, managing these reverse flows effectively poses a big major challenge for any firm. This factor necessitates the development of an efficient performance measure system, to achieve operational excellence.

This thesis aims to explore a specific type of reverse flows within the focal company known as a buyback policy. The key objective is to produce a data-driven analytical solution that will measure the circular economy performance of buyback operations.

To achieve this objective, mixed methods research was conducted, particularly a single case study. The process entailed deriving insights from findings obtained by qualitative research methods, such as literature review and semi-structured interviews. These findings were further used as a foundation for the quantitative analysis, which included establishing performance metrics and developing an analytical solution. The suggested solution was then validated by applying it to historical data related to selected groups of dealers with various profiles.

As a result, several challenges were identified in the current system setup of the buyback policy. The challenges became a backbone for determining six distinct metrics and supporting analytics. This combination shapes a complete analytical solution that covers all three principles of the circular economy notion: Reduce, Reuse, and Recycle.

Finally, the proposed analytical solution allowed to quantify the potential for optimizing the buyback policy within the focal company. This enables stakeholders to make data-driven decisions, providing valuable insights into the operational activities of buybacks. The solution presented fills the gap in the previously missing circularity performance measurement system for this return type within the focal firm. Furthermore, the findings of the thesis contribute to the theoretical understanding of circularity performance measurement in the context of reverse logistics in the automotive industry, as there is a paucity of existing papers on this topic.

Keywords: closed-loop supply chain; reverse logistics; buyback policy; circular economy; performance measurement; supply chain analytics.

Acknowledgements

I would like to express my sincere gratitude to my company supervisors – Elsa and Philip, for granting me the opportunity to complete this thesis. The immense support, guidance, and provision of essential knowledge, resources, and feedback you provided are invaluable. I had an incredible time working with you.

Moreover, I would like to extend my appreciation to all the interview participants and individuals who contributed to this thesis. A very special thanks go to Georges for his expertise, advice, and countless hours of collaboration, which have been immeasurable in the development of this thesis. I am also grateful to Laurent for his contribution, which greatly refined this work. Furthermore, I want to express my gratitude to everyone in the ARH DIM team for embracing me as a member from day one, and always helping whenever I needed it. The time we spent together, both within and outside the work environment, will always hold a special place in my memories. I would also like to acknowledge my academic supervisor, Johan, for his continuous guidance throughout my research.

My deepest thanks go to my girlfriend, Dana, as well as my parents and sister. Your love, encouragement, and unwavering belief in me have been instrumental to my success. Words cannot express how much I appreciate you.

I am also grateful to my friends at Graduate School for the incredible time we have spent together. Thanks for the memories.

Most importantly, I would like to express my deepest gratitude to all the heroes in my home country who sacrifice their lives in defense of freedom and democracy, not only for our nation but for the peace in the entire world. Слава Україні!

Vladyslav Zahladko, Gothenburg, May 2023

Table of Contents

List of Figures ... VIII

List of Tables ... IX

List of Abbreviations ... X

Chapter 1. Introduction ... 1
1.1 Background and Context ... 1
1.2 Problem Statement ... 1
1.3 Additional Background ... 2
1.4 Purpose and Research Questions ... 3
1.5 Theoretical Implications ... 3
1.6 Practical Implications ... 4

Chapter 2. Theoretical Framework ... 5
2.1 Circular Economy in Supply Chain ... 5
2.1.1 Closed-Loop Supply Chain ... 6
2.2 Reverse Logistics ... 7
2.2.1 Functions ... 7
2.2.2 Driving Forces ... 7
2.2.3 Complexity and Constraints ... 8
2.2.4 The 3Rs Strategy ... 9
2.3 Supply Chain Management and Analysis ... 10
2.4 The Performance Measurements ... 10
2.4.1 Strategic Objective ... 10
2.4.2 Terminology ... 11
2.4.3 Classification ... 11
2.4.4 The Method for Establishing Performance Measurements ... 12
2.4.5 Question Metric Approach ... 13
2.4.6 Circular Economy Indicators for Supply Chains ... 13

Chapter 3. Research Methodology ... 15
3.1 Research Philosophy & Approach ... 15
3.2 Research Strategy ... 15
3.3 Research Design ... 16
3.4 Research Method ... 16
3.5 Research Process ... 17
3.6 Data Collection ... 18
3.6.1 Qualitative Data ... 18
3.6.2 Qualitative Data Sampling ... 19
3.6.3 Qualitative Data Analysis ... 20
3.6.4 Data Masking ... 21
3.6.5 Quantitative Data ... 21
3.6.6 Quantitative Data Sampling ... 21
3.6.7 Quantitative Data Analysis ... 23
3.6.8 Literature Review ... 24

3.7 Reliability and Validity 25

Chapter 4. Qualitative Findings & Analysis 26
4.1 Distribution Structure 26
4.2 Dealer Inventory Management 26
4.3 Introduction to LPA 27
4.3.1 LPA Refill 27
4.4 Return Types 27
4.5 The LPA-Initiated Buybacks 28
4.5.1 Selection Criteria and Compensation Rules 28
4.6 Current state of buyback policy 29
4.6.1 Strategic Role 29
4.6.2 Factors That Are Driving Buybacks 30
4.7 Current Areas of Improvement 31
4.7.1 General Perception 31
4.7.2 Reuse Efficiency 32
4.7.3 Scrap Efficiency 33
4.7.4 Overview of Existing Analytics 34
4.8 Process of Performance Metrics Identification 35
4.9 Final Set of Performance Metrics 36

Chapter 5. Quantitative Findings & Analysis 38
5.1 Performance Metrics Calculation Methodology 38
5.2 Prevent 38
5.2.1 Buyback Value to Total Stock Value, Period-Over-Period *(P1)* 38
5.2.2 Buyback Part Quantity to Total LPA Pushed Part Quantity *(P2)* 39
5.3 Reuse 39
5.3.1 Buyback to Backorder Missed Demand in Value *(RS1)* 39
5.3.2 Proportion of Non-Returned Buybacks *(RS2)* 40
5.3.3 Buyback Pre-Planning Forecast Accuracy *(RS3)* 41
5.4 Recycle 41
5.4.1 Scrap Value to Total Buyback Value, Period-Over-Period *(RC1)* 41
5.5 Description & Application of Proposed Solution 42
5.5.1 P1 Analytical Solution 42
5.5.2 P2 Analytical Solution 43
5.5.3 RS1 Analytical Solution 44
5.5.4 RS2 Analytical Solution 44
5.5.5 RS3 Analytical Solution 45
5.5.6 RC1 Analytical Solution 45

Chapter 6. Discussion 47
6.1 Addressing Current Areas for Buyback System Improvement 47
6.1.1 Changing the Strategic-Level Approach to Buybacks 47
6.2 Strategically Concentrating on Preventing Buybacks 48
6.2.1 Revising the Policy Rules 48
6.2.2 Adjusting the Buyback Selection Criteria 50
6.2.3 An In-Depth Look at the Buyback Type 52
6.2.4. Anticipating the Obsolescence 54
6.2.5 Ensuring the Maximum Potential for Reusing Existing Inventory 56
6.3 Building the Efficient Recycle Infrastructure 58

Chapter 7. Conclusion 61
7.1 Research Question 1 61
7.2 Research Question 2 63
7.3 Research Question 3 63
7.4 Limitations and Further Research 65

References 67

Appendices I
A. Interview Guide, General Template I
B. Thematic Data Structure II

List of Figures

Figure 2.1: Circular Supply Chain as part of the Ecological system....5
Figure 2.2: Closed-loop supply chain setup....6
Figure 2.3: Circular Economy hierarchy....9
Figure 2.4: KPI cycle framework....12
Figure 2.5: Goal question metric framework hierarchy....13
Figure 3.1: Research process sequence....18
Figure 3.2: Knowledge Discovery in Databases process sequence....23
Figure 4.1: Map of identified key issue, major categories, and causes....35
Figure 4.2: The application of a circular economy framework to analyze the causes....36
Figure 6.1: Buyback pre-planning forecast accuracy (RS3)....49
Figure 6.2: Buyback value to total stock value, period-over-period (P1a)....50
Figure 6.3: Buyback value by type to total stock value, period-over-period (P1b)....52
Figure 6.4: Proportion of non-returned buybacks (RS2)....53
Figure 6.5: Buyback part quantity to total pushed part quantity (P2)....55
Figure 6.6: Buyback to backorder missed demand in value (RS1)....57
Figure 6.7: Scrap to total buyback value, period-over-period (RC1)....58

List of Tables

Table 3.1: Initial interviews conducted during the pilot phase 19
Table 3.2: Follow-up interviews conducted during the research phase 20
Table 3.3: Dealer sample selection for exploratory data analysis.. 22
Table 4.1: Buyback selection criteria.. 29
Table 4.2: Implementation of Goal, Question, Metric approach 37
Table 4.3: Set of circularity performance measurement metrics 37
Table 5.1: Buyback value to total stock value, with additional analytics (P1a) 42
Table 5.2: Buyback value by type to total stock value, with additional analytics (P1b) 43
Table 5.3: Buyback part to total pushed part quantity, with additional analytics (P2) 43
Table 5.4: Buyback to backorder missed demand in value, with additional analytics (RS1). 44
Table 5.5: Proportion of non-returned buybacks, with additional analytics (RS2) 44
Table 5.6: Buyback forecast accuracy, with additional analytics (RS3) 45
Table 5.7: Scrap to total buyback value, with additional analytics (RC1)............................. 45

List of Abbreviations

BA	Automatically purchased buybacks
BB	Buybacks
BM	Manually purchased buybacks
BO	Backorder
CDC	Central Distribution Centre
CE	Circular Economy
CSC	Circular Supply Chain
CSR	Corporate Social Responsibility
DIM	Dealer Inventory Management
DSP	Dealer Stock Control Package
EoL	End Of Life
EOQ	Economic Order Quantity
KDD	Knowledge Discovery In Databases
KPI	Key Performance Indicator
LCA	Life Cycle Analysis
LCC	Life Cycle Costing
LPA	Logistic Partnership Agreement
MDS	Material Data Sheet
OEM	Original Equipment Manufacturer
PM	Performance Measurement
PoP	Period-over-Period
RDC	Regional Distribution Center
RL	Reverse Logistics
RQ	Research Question
RSC	Reverse Supply Chain
SCA	Supply Chain Analytics
SCM	Supply Chain Management
SCR	Scrap
SDC	Support Distribution Center
SI	Service Index
SML	Service Market Logistics

Chapter 1. Introduction

This chapter introduces the topic of the master thesis, including a presentation of theoretical background regarding circular economy, reverse logistics, its performance measurement, and short introduction to buyback policy. The purpose of the research is then stated, along with the specific research questions and scope of the research. Finally, theoretical, and practical implications are considered.

1.1 Background and Context

Humanity has seen a persistent increase in the mean surface temperature, consumption of energy, waste generation and carbon dioxide (CO_2) emissions over the past few decades. Environmental protection is becoming increasingly vital as a result of problems with waste management, the depletion of natural resources, and the inability to sustainably manage all the produced goods (Turrisi et al., 2013; Valero et al., 2021).

As a result, many countries have endorsed strategies to advance environmentally responsible manufacturing. In accordance with the zero-carbon emissions initiative, Europe and many other developed countries have set goals to reduce transportation emissions by at least 55% by 2030 compared to 1990 levels. (European Council, 2023). This has forced manufacturers to implement circular economy (CE) principles in their operations, switching from a linear take-make-dispose model to a circular approach, which involves integrating processes such as reuse, remanufacturing, and recycling (Kirchherr et al., 2017). The surge in logistics demand, the need for sustainable cost-effectiveness, profit-cost considerations, and environmental constraints have all resulted in the adoption of Reverse Logistics (RL) programs to foster a CE-based value chain (Trivyza et al., 2022). RL embraces a range of activities involved in the recovery of a used or unused product from the time a customer decides to discard it (Guide & Wassenhove, 2002).

This research focuses on the analysis of RL activities within Renault Trucks, a French manufacturer of commercial vehicles that specializes in the creation, production, and distribution of transportation solutions. The company is a member of the Volvo Group and is committed to going along with various international environmental agreements as well as reaching global Volvo Group's sustainability targets, such as having a completely fossil-free fleet by 2040 (Renault Trucks, 2022).

1.2 Problem Statement

Today, the forward supply chains in the automotive industry are well-established, yet design strategies for RL have been relatively immature and unexplored. Although industries have realized that RL is essential for sustainable competitiveness, knowledge and agreement are absent on how to implement, develop and control RL systems effectively. According to Meade et al. (2007), while only a few companies have strategies in place for effectively managing RL, the majority tend to ignore this element of performance measurement and rely on traditional or forward supply chain approaches. Based on a survey of companies in different sectors (including automotive), nearly half of the respondents reported that they oversee their forward logistics, and only 20% declared they manage their RL (Deloitte, 2014).

Unlike forward supply chains, operations in RL are complex and inclined to a high degree of uncertainty due to the intrinsic differences between forward chains and reverse supply chains (RSCs). Experts outline several reasons for that. First, implementing RL requires making a strategic decision that involves considering a broad range of criteria, including strategic, operational, tangible, and intangible dimensions (Presley et al., 2007). Second, many companies have been using direct distribution systems for so long that they may not understand that RL is a unique concept, and that building the design of an RL system only on direct logistics may make it inefficient and costly (Dey et al., 2011). Third, it is difficult to predict the quality, quantity, location, and timing of returns, making performance metrics and evaluation techniques that are effective with traditional supply chains pointless (Butar et al., 2016). Fourth, a significant problem is that many companies are unaware of how large their RL costs are (Rubio et al., 2008).

Finally, assessing the CE performance of RL across numerous stakeholders, including suppliers, manufacturers, distributors, and consumers, presents a complex and challenging task for companies (Sloan, 2010). Despite a wide range of available CE metrics, companies find it difficult to select and integrate appropriate metrics that can support decision-making. Key reasons for these complexities include an absence of management understanding, ambiguous goals and objectives among supply chain partners, information systems that are unable to seize non-traditional data, and a lack of standardized performance measures (Qorri et al., 2018).

Even though RL performance measurement is fundamental to enhancing and achieving operational excellence, it is rarely discussed and there is limited analysis of the factors that affect its operation. Shaik and Abdul-Kader (2014) assert that the concept of reverse logistics is relatively new, and thus, limited structures and metrics have been established to quantify its effectiveness.

1.3 Additional Background

This thesis primarily focuses on a single type of RL flow – *buyback* policy. A buyback policy is a commonly used inventory management tool and, in some cases, can constitute a significant proportion of the whole RL system in a firm. A buyback policy is an arrangement where a supplier agrees to repurchase unsold inventory from a distributor. The supplier commits to minimizing unsold inventory by repurchasing stock at a pre-agreed percentage of the original cost. This approach offers an incentive for distributors to stock the supplier's products, as it mitigates the risk of demand uncertainty (Salami et al., 2022).

In the context of this thesis, the buyback policy being investigated is specifically linked to the Volvo Group's automatic stock refill system, which is elaborated on in Chapter 4 of this study. Buyback is an integral component of this system as it plays a key role in maintaining a balanced inventory for dealers by redistributing parts that are soon to be obsolete. The policy ensures that the dealer will be offered to sell back a certain selection of parts, thereby ensuring healthy stock levels. This safeguarding of the dealers' interests further strengthens the relationship with the company allowing to increase the end-customer satisfaction substantially.

The parts returned through the buyback policy are eventually reintroduced into secondary markets where demand for them may be higher. This not only generates additional revenue and reduces lead times, but also reduces waste by preventing parts from being scrapped.

1.4 Purpose and Research Questions

The growing stakeholder demands, and regulatory pressures related to sustainability have highlighted the significance of enhancing visibility in the reduction, reusing, and recycling capability of all RL streams. The RL flow of the company is strongly affected by a sophisticated stock management system. The research focuses specifically on investigating a critical aspect of it – the company's policy of buying back spare parts. Given the uniqueness of the stock management system and the Renault Truck case, this thesis aims to *explore the focal company's buybacks policy and develop a data-driven analytical solution for measuring its circular economy performance*, with the following three research questions in focus:

Research Question 1 – *What are the current areas of improvement of the circularity of the buyback policy in the focal company?*

The research question involves gathering feedback from the stakeholders on buyback-related challenges, as well as an understanding of the desired state. This approach allowed to obtain a comprehensive snapshot of the current system state, including both its limitations and competitive advantages. Next, this information provided a foundation for further research and the formulation of recommendations for measuring buyback circularity performance:

Research Question 2 – *What analytics should be implemented?*

In this research question, the emphasis was on exploring the implementation of analytics to improve the efficiency and visibility of buyback within CE approaches. This stage of the research involved integrating the insights obtained from interviews and the frameworks retrieved from the literature to develop an analytical solution. The solution included a set of metrics, backed by additional analytics. The solution addresses the improvement areas defined in the first research question. It empowers stakeholders to make informed decisions based on data, thereby improving the circularity efficiency of the current system. Lastly, the practical significance of the outcomes was validated through the application of the analytical solution on historical dealer data, providing insights to answer the final research question:

Research Question 3 – *What is the circularity performance of distinct dealers with varied profiles within a specific market when the proposed analytical solution is applied?*

1.5 Theoretical Implications

This thesis is designed to improve the theoretical understanding of performance measurement in RL, as this subject is of great interest to both industry and academia. Since there is a lack of applicable papers on this topic, the research sets up a basis for subsequent research. The study develops and describes a gradual methodology for circularity metrics development, based on the study of the global transportation company. This methodology could be adopted, further refined, and implemented based on the other case study. The thesis also provides a set of performance metrics for circularity, along with an exploratory analysis of historic data.

1.6 Practical Implications

Practical implications of this research assured to supply the focal firm with a data-driven buyback optimization analytical solution that will enable the minimization of costs, reduce resource consumption and lay grounds to achieve complete CE within part of the RL chain. This allows a deeper understanding of the focal company's stakeholders about the links between strategic objectives and performance measurement of buybacks.

Chapter 2. Theoretical Framework

This part of the thesis offers a review of the literature that has been utilized as a basis for theoretical framework for this thesis. The chapter commences with presenting relevant concepts related to circularity, including the circular economy and closed-loop supply chain. In addition, an in-depth analysis of reverse logistics concept, discussing its theoretical background, functions, and driving forces is provided. Finally, it considers literature related to establishing KPIs and performance indicators, followed by an overview of existing circularity metrics.

2.1 Circular Economy in Supply Chain

The *circular economy* (CE) is an economic paradigm in which resource acquisition, manufacturing, consumption, and reprocessing are optimized to elevate environmental sustainability and human well-being (Calzolari et al., 2021). CE is broadly deemed an important sustainability concept (MacArthur et al., 2013).

The notion of *Circular Supply Chains* (CSCs) is vital for achieving a CE and has started from the broader CE framework. CSCs aim to transform from a linear to a CE model by including return processes that add value and further integrate SC activities (Taddei et al., 2022). As shown in Figure 2.1, CSCs involve companies collaborating not only to deliver goods and services to end customers but also to settle feedback loops that enable self-sufficient production and the recurrent use of materials (Bocken et al., 2013). The products are designed in such a way, that prolongs their lifespan and allows them to flow through multiple use phases, while materials are recovered and recycled (Hollander et al., 2017; Bovea & Vergara, 2018).

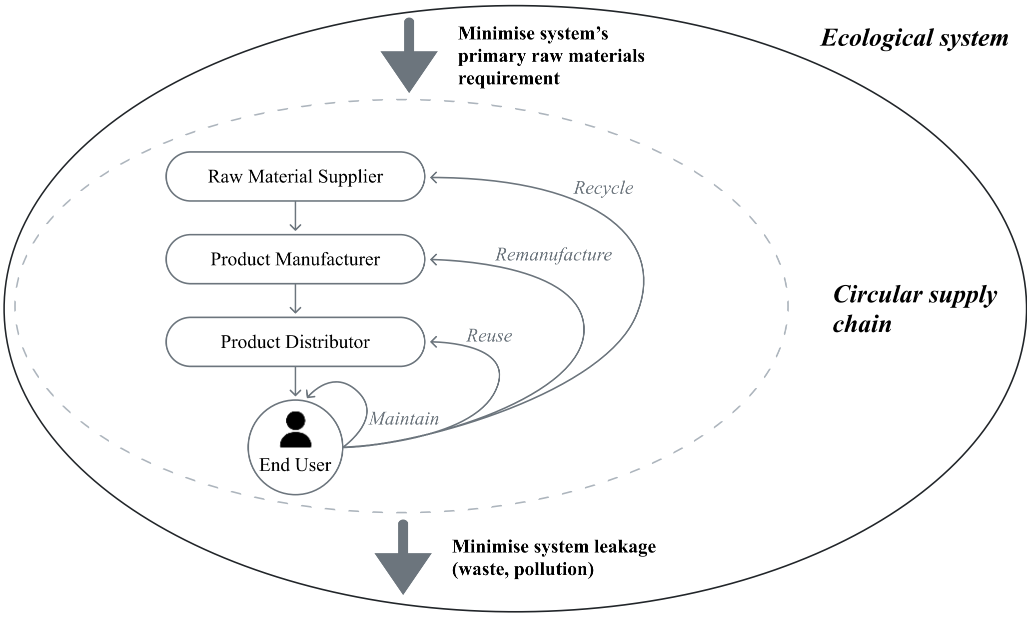

Figure 2.1: Circular Supply Chain as part of the Ecological system
Note: Figure recreated and adapted from Calzolari et al. (2021)

In the context of CE, products are considered an asset, and the objective is to maintain their value for as long as possible, reducing the demand for new products and raw materials, while maintaining consumption levels within global boundaries (Zink & Geyer, 2017). In this respect, the CSC should:

1. Coordinate forward and reverse logistics and endorse circular and product-as-a-service business models (Batista et al., 2018).
2. Reduce waste, restore materials, and regenerate biological materials (Farooque et al., 2019).
3. Limit the throughput flow of societal systems and respect the natural reproduction rates of ecosystem cycles (Korhonen et al., 2018).

2.1.1 Closed-Loop Supply Chain

A *closed-loop supply chain* (CLSC) is a more specific approach within the concept of CSCs, which focuses more on material recovery. The principles of closed-loop supply chains and RL form the foundation of CE (Murray et al., 2017). CLSC unifies reverse logistics with the traditional forward supply chain, forming a loop of material flows in which products, components, and materials are reused, recovered, or recycled (Sarkis & Dou, 2017). This integration is illustrated in Figure 2.2, which depicts the combination of forward and RL SC activities.

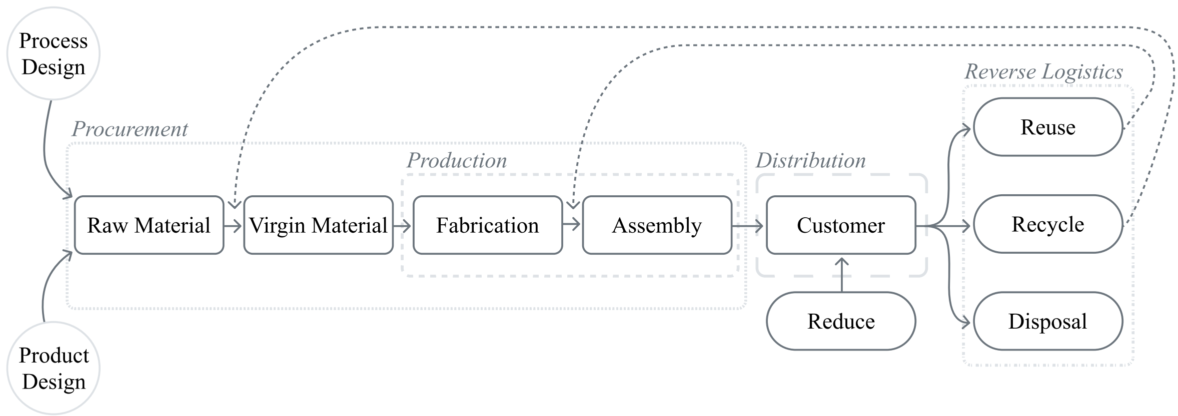

Figure 2.2: Closed-loop supply chain setup
Note: Figure recreated and adapted from Sarkis & Dou (2017)

The figure above represents both the forward and RSC functions. The forward supply chain includes all the traditional linear activities and begins with product and process design. It is then followed by procurement activities that focus on the upstream supply chain. Raw materials and virgin materials are acquired for production, which implies fabrication and/or assembly operations. Finally, distribution activities entail delivering the products to end customers. The return activities, managed by RL functions, flow back into different stages of the forward supply chain. These activities may also occur at various stages. The later the stage at which the flow of returned products occurs, the less energy is expended, consequently fewer operations occur, and less environmental burden results (Sarkis & Dou, 2017).

2.2 Reverse Logistics

Reverse logistics (RL) is a fundamental part of a CLSC and ultimately of the CE approach that deals with the management of returns from customers (Sarkis & Dou, 2017). These returned products create a reverse flow of goods that is distinct from the forward manufacturer-customer flow. In other words, RL addresses all the regular logistics activities, but they are carried out in the opposite direction (Maheswari et al., 2020). Literature also outlines the environmental benefits of RL, as expressed by Carter and Ellram (1998), RL is a process that allows companies to become more environmentally efficient through reducing, reusing, recycling, and remanufacturing.

During the initial literature review, the two most cited definitions of RL were discovered:

1. The Council of Logistics Management (Stock, 1992) – *"...the term often used to refer to the role of logistics in recycling, waste disposal, and management of hazardous materials; a broader perspective includes all relating to logistics activities carried out in source reduction, recycling, substitution, reuse of materials, and disposal."*

2. The European Working Group on Reverse Logistics, (De Brito & Dekker, 2002) – *"The process of planning, implementing and controlling flows of raw materials, in-process inventory, and finished goods, from a manufacturing, distribution or use point, to a point of recovery or point of proper disposal."*

2.2.1 Functions

A typical RL system involves three key steps: gatekeeping, collection, and sortation, as highlighted by Meade et al. (2007). Initially, used products, returned products, or waste is collected and further sorted, inspected, and stored. Subsequently, they are reused, recycled, remanufactured, or appropriately disposed. The stages and organizations involved may differ depending on the type of products and waste being managed (Sarkis & Dou, 2017).

2.2.2 Driving Forces

RL implementation is primarily driven by several factors. Organizations are influenced by regulatory issues, market and customer pressures, and ethical motivations to improve environmental performance. Additionally, product-related factors influence RL implementation in view of the product life cycle shortening and the need for flexible RL channels to take back products at the end of their life cycle (Sarkis & Dou, 2017).

Overall, the significance of RL continues to grow because of various reasons:

- **Legislative Pressures.** Governments across the globe are progressively legislating more demanding environmental regulations that hold manufacturers and producers responsible for the collection and management of their products at the end of their useful life. Under these policies, firms assume the financial burden and/or the logistics required to recover and recycle the goods they produce and are incentivized to integrate circular designs into their business models (Thierry et al., 1995; Carter & Ellram, 1998; Dowlatshahi, 2005; Kumar & Putnam, 2008).

- **Economic Gains.** RL brings not only environmental benefits but also economic advantages. The reuse or remanufacturing of products can result in direct and indirect cost savings. Direct benefits include the profits gained from decreased materials usage, reduced price volatility risks/supply disruption, and new revenue sources via remanufactured and recycled goods (Ferrer & Whybark, 2000; Larsen & Jacobsen, 2016). Indirect benefits emerge from improving the environmentally responsible image of the company, which results in a better reputation and possibly translates into higher sales (Jayaraman et al., 1999; De Brito & Dekker, 2002; Mazahir et al., 2011).
- **Environmental Consciousness.** Stakeholders are continuously putting more pressure on organizations to mitigate the environmental impact of their operations, as well as embrace aspects of Corporate Social Responsibility (CSR). One traditional way to accomplish the CSR targets is to shrink the consumption of natural resources by establishing reuse and recycling, where RL plays a vital role (Ferrer & Whybark, 2000; Mazahir et al., 2011).
- **Customer Services.** The increase in the returned goods volume resulted in an intensified focus on customer satisfaction. To this end, a liberal returns/repurchase policy has been recognized as a crucial strategy for retaining satisfied customers and gaining a market advantage. Indeed, competitive advantage no longer lies only in the manufacturing and sales of products but also in post-purchase services (Ellinger et al., 1997; Dowlatshahi, 2005; Turrisi et al., 2013).

2.2.3 Complexity and Constraints

Based on the literature reviewed, there is a popular opinion that the implementation of RL in the supply chain results in additional costs and complexity, regardless of possible revenue opportunities (Jović et al., 2020). Establishing return operations such as remanufacturing, adds a layer of complexity to operation management, requiring additional costs and resources (Linton et al., 2007).

Various constraints associated with the implementation of RL have been discussed in the literature, including insufficient information systems to handle returns and monitor the reverse flow of products, poor worker training in RL procedures, a deficit of identification on returned packages, the need for proper inspection of returns, and the potential placement of damaged returned products into secondary markets. A poorly designed RL system can have a substantial impact on the entire supply chain in terms of its financial performance and consumer perception of the product brand, possibly affecting future sales (Kuei, 2005). The success of RL implementation requires coordination between both forward and backward flows of materials and information, as claimed by Guide and Van Wassenhove (2002). The reverse flow of products entering the SC can impact the dynamics of inventory levels among supply chain members, affecting the performance of the whole system (Turrisi et al., 2013).

Finally, it is broadly acknowledged in the literature that a significant obstacle to successful RL implementation is the lack of attention and investment from top management.

Many firms view RL as a cost or a regulatory commitment, and as a result, these activities are often seen as non-strategic activities (Carbone & Moatti, 2008; Ravi & Shankar, 2005).

2.2.4 The 3Rs Strategy

CE, CLSC and RL are often discussed in relation to the "3Rs" strategy – reduce, reuse, and recycle – which are considered fundamental for reaching circularity (Potting et al., 2017). The strategy emphasizes waste prevention and reuse over recycling or other disposal methods (Mansilla-Obando et al., 2022). "3Rs" were derived from the waste hierarchy framework which was primarily introduced in European Commission Directive 2008/98/EC and eventually includes more steps (European Commission, 2008). In the "3Rs" strategy, the first step entails reducing waste generation, followed by reusing products or components for their original purpose, and finally, recycling materials that are no longer suitable for reuse (Demestichas & Daskalakis, 2020). Each step is discussed in more detail below:

- **Reducing** implies preventing waste generation as a priority (Rhein & Sträter, 2021). One approach is to implement changes in the production or distribution of products, which can result in reduced consumption of resources (Hultman & Corvellec, 2012). Another approach is to improve waste management practices to enable better material circulation and avoid landfills, which can help to minimize greenhouse gas emissions (Ghisellini et al., 2016).
- **Reusing** refers to the practice of using products that are still functional for their original purpose, therefore avoiding manufacturing (Demestichas & Daskalakis, 2020). If compared to the production of new products, this strategy helps to reduce the consumption of resources, energy, and labor (Castellani et al., 2015).
- **Recycling** involves the process of collecting and processing waste, transforming it into new products that can be used for the same or a different purpose (Rhein & Sträter, 2021). Recycling ensures that materials stay in a reuse cycle or are transformed into new products or substances. However, it is noted that recycling is the least efficient and cost-effective strategy compared to reducing and reusing (Mansilla-Obando et al., 2022).

Based on the information presented in Figure 2.3, it is evident that the "3Rs" of the CE are arranged in a hierarchical order, whereas the top sections are intended to have the highest priority for the organization.

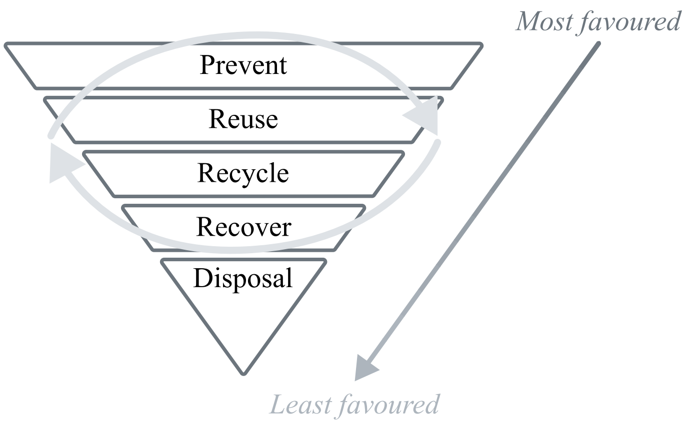

Figure 2.3: Circular Economy hierarchy
Note: Figure recreated and adapted from European Commission (2008)

2.3 Supply Chain Management and Analysis

Supply chain management (SCM) strategically integrates and coordinates multiple business functions and processes throughout the supply chain. It involves the management of both internal and external supply chain processes, buyer-supplier relationships, and network structures, and aligns supply chain strategies with general business objectives. The objective of SCM is to deliver superior customer service via synchronous management of the flow of goods, associated information, and finance from the point of origin to the point of consumption. By making the right products and services available to the right customers, at the right cost, quantity, quality, time, and place, effective SCM coordinates closely with a business strategy and improves its competitive advantage and profitability (Liu, 2022).

As more and more data sources in modern supply chains are starting to be available, supply chain analytics (SCA) allows applying various analytical techniques such as data mining, machine learning, statistical analysis, and optimization to performance measurements. SCA aims to produce insights and make data-driven decisions to enhance supply chain performance, by offering real-time insights for daily operations. Strong SCA capabilities can reduce uncertainties and complexities in the company's SCM, resulting in superior supply chain performance and sustained competitive advantage (ibid.).

2.4 The Performance Measurements

Performance measurements (PMs) have a primary role in SCA, implying a systematic evaluation and control of diverse aspects of the supply chain to assess its effectiveness. To achieve a profitable, efficient, and sustainable RL system, stakeholders demand effective tools to evaluate the adoption of CE practices (Calzolari et al., 2021). This idea is supported by Bai and Sarkis (2014), stating that to enhance the competitive advantages it is important to analyze PM approaches that can support stakeholders to focus on core supply chain sustainability-related decisions. As RL is a complex and multi-dimensional field, it requires constant improvement to meet the changing demands of customers and remain competitive. In this case, a powerful PM system will allow to define areas for improvement, develop sustainable reporting, and benchmarking standards, and measure the success of previous efforts. Moreover, the PM system adds visibility to an RL flow and communicates its importance across an organization (Wilson & Goffnett, 2021).

2.4.1 Strategic Objective

PM aims to offer valuable insights which allow organizations to improve the fulfilment of customers' requirements and to meet their strategic goals (Chan et al., 2003). By monitoring and assessing performance metrics, companies can adjust their strategies accordingly and ensure that the operations are efficient, profitable, and sustainable (Carter & Rogers, 2008).

Based on the literature review, the strategic goals for PM can be broadly categorized as follows:

- Improve organizational decision-making by recognizing deviations from planned results, providing root cause analysis and the application of appropriate measures.

- Facilitate communication across the organization and with external stakeholders.
- Deliver regular transparent reporting of actual versus planned results, allowing management to verify whether the targets have been accomplished.
- Motivate employees and encourage personal development through goal setting and achievement (Van Weele, 2018).

2.4.2 Terminology

As stated before, the implementation of a PM system assists organizations in establishing and evaluating their progress toward meeting their business goals. Business goals present a summary of the desired achievements of the enterprise, while business objectives establish *performance measures* and *metrics* to quantify these goals. Tracking the metrics related to these objectives to evaluate progress results in the creation of *performance indicators*. Those performance indicators that provide essential business information and require periodic reporting are considered *Key Performance Indicators* (KPIs). KPIs enable organizations to determine whether their business objectives are being met, leading to the accomplishment of their business goals (Ganesan & Paturi, 2009).

2.4.3 Classification

Parmenter (2019) divides PMs into three distinct classes: key result indicators, performance indicators, and key performance indicators. Key result indicators explain how well an organization has performed in a particular area while performance indicators propose actions to be taken to improve performance. KPIs can be categorized as either lagging indicators, which are typically financial metrics that reflect past actions, or leading indicators, which directly affect performance. Based on the reviewed literature, the classification of KPIs can be summarized as follows:

1. KPI can be broadly categorized into three groups: *Strategic*, *Tactical* and *Operational*, based on their association with management level and time frame, such as long-term/short-term (Sandhata Technologies, n.d.).
2. Mendes et al. (2001) classify goals into two categories. The first category includes *quantitative* and *qualitative* goals. The second category, based on the Balanced Scorecard framework, includes *strategic* and *operational* goals.
3. Gil and Sousa (2010) suggest a classification of metrics into three levels, specifically Levels 1, 2, and 3. Level 1, also known as *Accounting* or *Regulated* metrics, contains metrics that are dictated by external reporting requirements or the law. They are typically lagging indicators of performance that offer limited insights into the reasons for the outcomes. Level 2, known as *Performance* or *Non-regulated* Industry Standard metrics, consists of a well-justified set of mid-to-high-level metrics that ensure a comprehensive view of how well the business is performing across functional areas. These metrics are leading indicators. Lastly, Level 3, or *Analytical* or *Company-Specific* metrics, defines the performance metrics in detail and is employed for root-cause analysis. These metrics can be highly specific to a particular

business activity or task.

4. The Balanced Scorecard (BSC) is a framework that allows companies to translate their strategic goals into measurable objectives across four perspectives: *financial*, *customer*, *internal processes*, and *learning & growth*. Each perspective contains business goals, PMs, metrics, and targets (Kaplan & Norton, 1992).

2.4.4 The Method for Establishing Performance Measurements

The availability of a clear framework when developing a PM system is essential for several reasons. First, it guarantees that the system aligns with the organization's strategic objectives, thereby producing relevant measurements. Second, the framework provides a basis for evaluating and improving the metrics and indicators over time. As the organization evolves and its objectives change, the system can be revised to assure it remains relevant and useful (Ganesan & Paturi, 2009). Within this thesis, the development of metrics and indicators follows a four-phase approach known as the KPI cycle. Having defined the classification schema, the literature also defines the four-phase iterative approach which includes identifying, defining, associating, and tracking as Figure 2.4 depicts (ibid.).

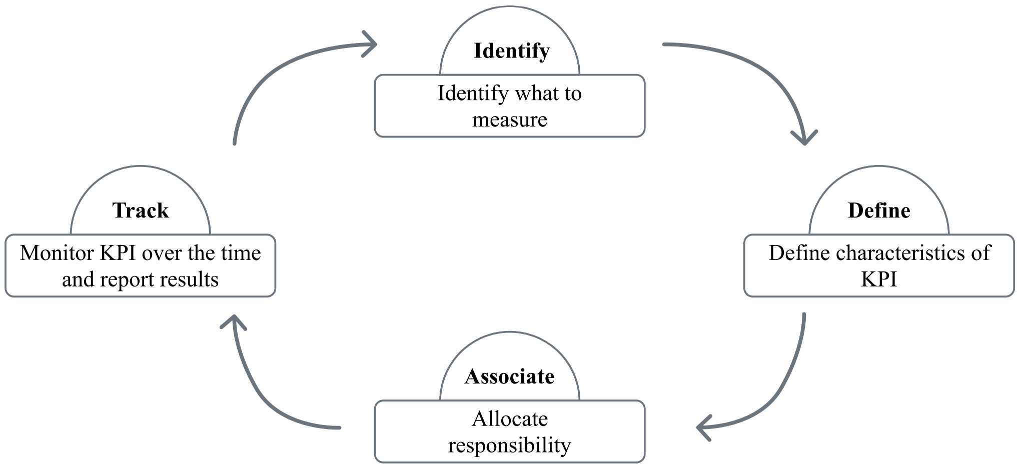

Figure 2.4: KPI cycle framework
Note: Figure recreated and adapted from Ganesan and Paturi (2009)

The first phase implies determining the goals to be measured using techniques such as the Balanced Scorecard (BSC) or Goal-Question-Metric (GQM) models. In the define phase, KPIs are defined according to the KPI Classification framework, including their metrics, target ranges, and benchmark levels. The associate phase involves connecting the KPIs to relevant processes and business participants that can affect the goals and objectives. Finally, the track phase involves collecting data, interpreting it, reporting the results, and performing trend analysis (Ganesan & Paturi, 2009; Sandhata Technologies, n.d.).

2.4.5 Question Metric Approach

The initial phase of a KPI framework is the *Identify* phase, where Goal Modelling techniques are employed to establish the organization's objectives. In this study, the Goal Question Metric (GQM) approach is used for the metrics identification. The GQM methodology assumes that an organization must first establish its goals for itself, then link those goals to the data intended to define those goals, and finally institute a framework for interpreting the data in relation to the stated goals, in order to measure deliberately (Basili et al., 1994; Van Solingen & Berghout, 1999).

As depicted in Figure 2.5, a GQM model is a hierarchical structure which begins with a goal. A goal specifies the purpose of the measurement, the object to be measured, and the issue to be measured. The goal is subsequently subdivided into a set of questions, which often break down the issue into its principal components. Each question is then further subdivided into metrics. The same metric can be utilized to answer different questions under the same goal.

The application of the GQM approach results in the creation of a measurement system that targets a specific set of issues and establishes a set of rules for interpreting measurement data (Basili et al., 1994).

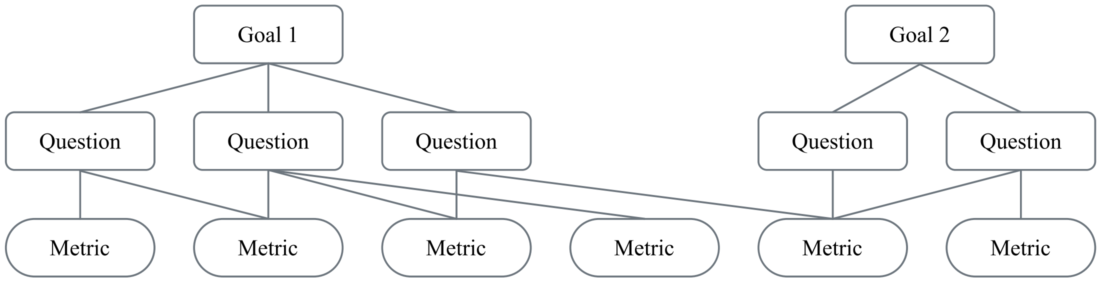

Figure 2.5: Goal question metric framework hierarchy
Note: Figure recreated and adapted from Basili et al. (1994)

2.4.6 Circular Economy Indicators for Supply Chains

Calzolari et al. (2021) distinguish existing performance metrics for CE with a systematic literature review of over 200 papers. The metrics are classified according to a Triple Bottom Line approach, which assesses an organization's sustainability performance by measuring its impact on three dimensions – *economic*, *social*, and *environmental*.

Economic indicators. The majority of studies (80%) use economic indicators, mainly based on cost-based measures such as production, transportation, and facility location costs. Some CE indicators are used throughout various categories of measures, such as the costs associated with RSC activities, profits from remanufacturing and recycling activities, and the quality of recovered products.

Environmental indicators. The environmental dimension is considered in 34% of papers and is predominantly measured using Global Warming Potential and Greenhouse Gas

Emissions indicators. Emission equivalent metrics are used three times more than any other environmental indicator category. Fewer studies utilize indicators related to residual waste and waste recovered through CSC feedback loops. Cumulative energy demand is another commonly used indicator. Traditional LCA frameworks are commonly used to assess impacts across the supply chain, but there is a gap in explicit metrics for measuring circularity. Few studies use specific indicators for measuring the proportion of waste and by-products reincorporated into the supply chain.

Social indicators. Only 18% of the papers considered in the sample include the social dimension in their objectives. The stakeholders involved in measurement approaches vary, with some only considering employees while others include customers, suppliers, organizations, or communities. The most common social indicator, found in 7% of papers, is the number of jobs created in the CSC, with a few papers including indicators for job quality. Less common indicators include customer environmental awareness (1%) and social cost of waste (1%) (Calzolari et al., 2021).

Chapter 3. Research Methodology

This chapter provides an extensive overview of the methodology used in this thesis. It encompasses the various steps involved in designing, executing, and analyzing the research, including the research philosophy, research strategy, literature review process, data collection methods, and analysis techniques employed. The chapter also presents an outline of the overall research process. Additionally, the reliability and validity of the collected data are discussed.

3.1 Research Philosophy & Approach

The research philosophy employed in this thesis has a considerable impact on the understanding of the research process and the development of knowledge. One resource that helped to understand the influence of philosophical beliefs on research methodology is the "four paradigms" model presented by Burrell and Morgan (2017). This model categorized and summarized the assumptions about the nature of organizations and how to study them. Given the objective and purpose of this research, the functionalist approach was utilized which incorporates studying organizations based on a rational problem-solving orientation which leads to a rational explanation of the problem (Saunders et al., 2012). This approach facilitated a logical understanding of the underlying causes of a specific problem (optimization of buyback policy efficiency in terms of CE concept) and enabled the formulation of recommendations (implementation of analytical solution) that align with the existing management framework of the focal company (ibid.).

Bell et al. (2019) maintain that the relationship between theory and empirical data is an important factor in choosing a research methodology. In the case of this research, the abductive approach was believed to be the most appropriate. Abduction combines the deductive and inductive approaches, where both theory and empirical data are used from the beginning, and theory is matched back and forth with the empirical findings continuously (Kovács & Spens, 2005). By employing abduction as a research approach, this study leveraged data to investigate a particular phenomenon, pinpoint recurring themes, explain observed patterns, and generate or refine theories for subsequent testing (Saunders et al., 2012.).

First, detailed and comprehensive data were collected to gain insights into the phenomenon, determine themes, and explain patterns related to buyback circularity. Then, these explanations were integrated into an overarching conceptual framework, forming a theory of buyback circularity performance within the focal organization. Finally, the theory was subsequently tested using existing and new data, with iterative revisions made to enhance its robustness and validity.

3.2 Research Strategy

This study adopted a mixed methods research strategy, combining multiple methods to address the research objectives. A more detailed discussion of the research methods will be presented in the subsequent section.

This research took a constructivist perspective, which views the transition to a CE as an intentional and active decision rather than a result of preexisting social norms (Saunders et al., 2012.). Finally, the pragmatism approach was embraced to develop relevant concepts that support action. This approach enabled the study to concentrate on detecting practical solutions that are supported by empirical evidence. Furthermore, the pragmatic research philosophy commonly advocates for the adoption of mixed methods research strategies, as it acknowledges that a comprehensive understanding of the research phenomenon cannot be achieved through a single perspective alone (ibid.). This aligns with the underlying principles of the thesis.

3.3 Research Design

The insights and findings presented in this thesis are based on data collected from a single actor within the transportation service market. A study conducted at a single company focusing on its specific settings and properties could, according to Eisenhardt (1989) and Gerring (2004), be called a single case study. This type of research design was particularly useful for understanding complex phenomena within real-world contexts, such as this research's main purpose. Case study research typically involves the collection of a wide range of data, including both primary and secondary sources, and the application of concepts to real-world situations, which is in line with the selected research strategy (Bell et al., 2019). Moreover, the case study allowed answering the research questions most efficiently, as according to Yin (2009), a case study has considerable ability to generate answers to the question "why?" as well as "what?" and "how?" questions. Finally, and again in line with this research, study designs frequently combine qualitative and quantitative methods for data collection and analysis.

To enable a systematic examination of phenomena, a case in research must be limited by temporal, spatial, and dimensional parameters (Gerring, 2016). In this study, the CE performance of reverse logistics is examined, with a focus on the buyback policy in particular, to ascertain the necessary metrics that support the focal company's data-driven decision-making. In order to do this, the reverse logistics flow agents, who are both actors and subjects affected by the system, serve as the unit of observation, and the CE PM system for buyback policy is taken into consideration as the unit of analysis.

3.4 Research Method

The initial stages of the research entailed a review of relevant literature and internal documents to gain a thorough understanding of the subject matter, specifically, reverse logistics and circular PM solutions. After this, a series of semi-structured interviews were conducted to acquire insights on current company-related issues and expectations regarding the subject. The qualitative data analysis stage included thematic analysis, which, in conjunction with the previously collected information, served as the foundation for further quantitative data analysis. The quantitative component of this study involved the computation of indicators and exploratory data analysis, aimed at addressing the previously specified challenges.

The utilization of both methods at different stages of the study reflects a partially integrated mixed-methods research approach (Saunders et al., 2012.). Moreover, this thesis is double-phased, as it involved more than one phase of data collection and analysis. It could be also identified as sequential exploratory research, as it commences with a qualitative, exploratory phase (e.g., stakeholders interview), followed by a quantitative, descriptive phase (e.g., exploratory data analysis) (ibid.).

The utilization of mixed methods in this study was motivated by various factors. Firstly, the incorporation of qualitative research, such as a literature review and interviews, at the outset enabled the establishment of a contextual background and a deeper comprehension of the research problem. Additionally, qualitative methods played a crucial role in facilitating the discovery of novel insights, which were later explored further using quantitative techniques. In particular, the employment of semi-structured interviews and literature review, allowed to detect challenges for the current system setup which were then tackled by employing metrics and analyzing authentic dealer data in the quantitative portion. The use of mixed methods also fostered a greater degree of complementarity, as the findings derived from qualitative methods were clarified, validated, exemplified, and linked to the following quantitative analysis. This entailed quantifying the insights gained during the interviews through exploratory data analysis. Finally, the application of mixed methods offered a higher level of triangulation by combining data from different sources to ascertain if the findings from the literature review and interviews mutually supported the conclusions drawn from the analysis of dealer data (ibid.).

3.5 Research Process

The research process of this thesis followed an iterative approach, characterized by three separate phases: pilot, research, and final. These phases were designed to build upon one another and purify the research methodology.

Given that this thesis was created in collaboration with a focal company, there was a general topic for the investigation predetermined. However, the specific scope of the study had not yet been established. Therefore, the first step implicated establishing an initial research scope. This entailed brainstorming sessions with company supervisors to specify relevant aspects to explore in relation to the research topic given the limitation and current company context.

The pilot phase of the research consisted of two main components: initial interviews and the first round of literature review. The purpose of the interviews was to gain insights into the current system setup and describe key areas for improvement in the buyback policy. On the other hand, the literature review pursued enhancing the understanding of the contextual background and existing concepts related to the circularity performance of RL. The pilot phase allowed to gather valuable preliminary information and knowledge, creating a foundation for the subsequent stages of the research.

The research phase started with the formulation of the problem definition and the study’s objective after a strong knowledge premise had been established. Three study issues were distinguished based on the scope and objective that were specified. Based on that, a thorough literature review was done to create a theoretical framework. A series of follow-up interviews were done to further clarify the problem statement and guarantee the alignment of the data analysis. The problem statement was improved through this iterative feedback loop, and the study methodology was evaluated to determine its effectiveness in achieving the goals.

Next, the research transitioned into the quantitative component, building upon the insights obtained from the qualitative one. In quantitative analysis, the primary focus was on generating practical outcomes, specifically the identification of relevant metrics and additional analytics to support these metrics. By implementing metrics and solutions to the historical data, further insights were gained. The iterative data analysis process allowed for the continuous strengthening of the quantitative outcomes, ensuring their accuracy and relevance.

The research eventually reached its concluding stage, which required integrating the quantitative and qualitative findings. In this stage, the emphasis was on combining the two techniques and developing the thesis's conclusions. An overview of the research project's methodology is shown in Figure 3.1.

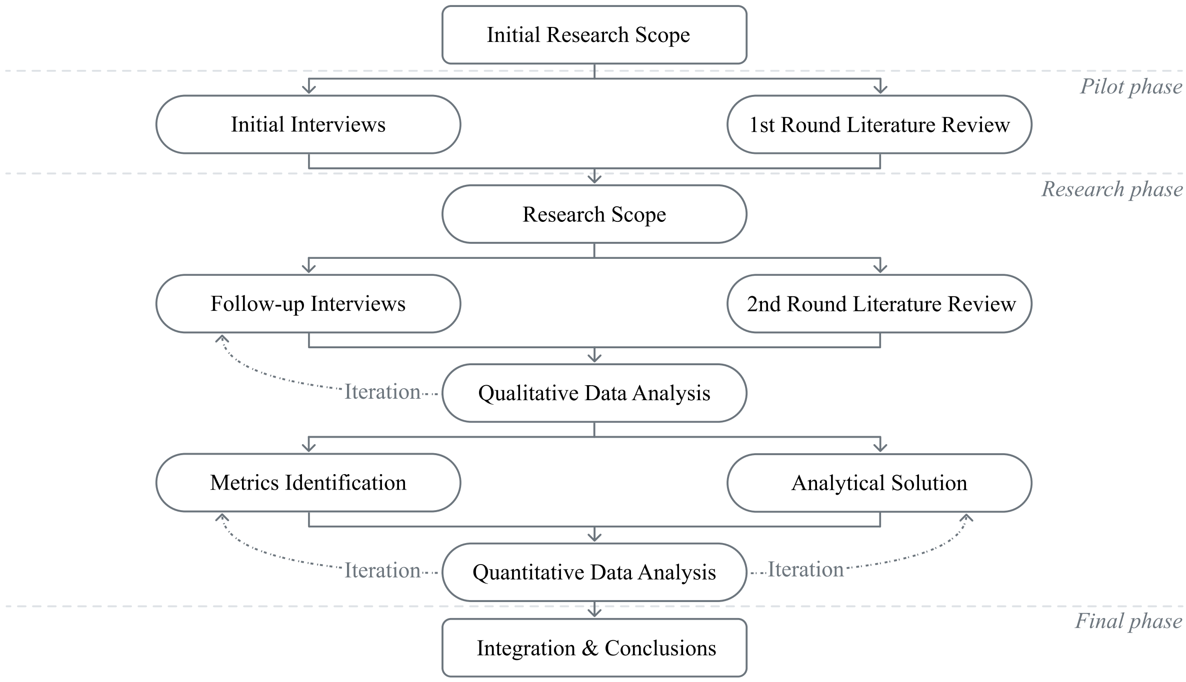

Figure 3.1: Research process sequence

3.6 Data Collection

3.6.1 Qualitative Data

The collection of qualitative data primarily involved conducting internal interviews. Moreover, the study also included other sources of information, such as internal documentation from Volvo Group and Renault Trucks, including directives, internal presentations, workshops, seminars, and training sessions. Additionally, publicly available sources such as annual reports were utilized as supplementary resources.

Throughout the planning phase, initial interviews and internal documentation analysis were conducted to gather general knowledge about Volvo Group's buyback operations and the work being done in the area of the research issue. To better comprehend the subject or to address any questions that had come up during the original interviews, follow-up interviews were undertaken after the initial interviews.

In the initial interviews, a semi-structured interview approach was employed to maintain flexibility in the process and facilitate the collection of comprehensive and detailed data. The use of semi-structured interviews prioritizes the interviewee's perspective and allows for an exploration of their interpretation and understanding of patterns, issues, and events. Instead of guiding the research with a predetermined set of investigation structures, the views of participants were compared and contrasted to find the most accurate solution to the research question. This method made it possible to identify the important elements that respondents said were important for understanding and describing events, patterns, and behaviors (Bell et al., 2019).

A broad interview guideline is provided in Appendix A. This guide was modified for each interview according to the position of the interviewee. The interview was based on the template, which was followed as closely as possible. The sequence of the questions had to be changed occasionally because most of them were open-ended.

3.6.2 Qualitative Data Sampling

As far as the interview participants were not sampled on a random basis, a non-probability form of sampling was utilized in this thesis. Specifically, a combination of convenience sampling and snowball sampling methods was employed. Convenience sampling involved the selection of participants that are readily available and easily accessible. While snowball sampling entailed selecting new participants referred by previous participants in the study (Bell et al., 2019).

In the initial phase, the convenience sampling method was utilized as it allowed a high level of accessibility. The individuals who were initially interviewed held primary stakeholder positions in the projects and had close working relationships with the thesis supervisors. This facilitated the interview process and ensured the involvement of key individuals from the beginning.

Subsequently, snowball sampling was employed to expand the sample by identifying and contacting other individuals who were relevant to the research topic, via the already selected group of relevant stakeholders. The selection of respondents with various positions ensured a diversity of views, responsibilities, and perspectives. See Table 3.1 for a detailed description of the participants.

Table 3.1: Initial interviews conducted during the pilot phase

Ref.	*Brand*	*Interview type*	*Interviewee role*	*Interview length, min*
I1	Renault	Virtual	Manager DIM and Refill	30
I2	Volvo	Virtual	Senior Excellence Manager	75
I3	Renault	Virtual	Dealer Logistic Coach	60
I4	Volvo	In-person	DIM Analyst	40
I5	Volvo	In-person	DIM Analyst	45

Follow-up interviews were conducted continuously during the research phase to gradually improve the understanding of areas where knowledge gaps were discovered or to validate the findings. Rather than following a specific template, a set of unique questions were prepared for each follow-up interview, which were sent beforehand or asked during the session. For more information concerning follow-up interviews refer to Table 3.2.

Table 3.2: Follow-up interviews conducted during the research phase

Ref.	*Brand*	*Interview type*	*Interviewee role*	*Interview length, min*
I2	Volvo	In-person	Senior Excellence Manager	50
I2	Volvo	Asynchronous Virtual	Senior Excellence Manager	-
I3	Renault	Virtual	Dealer Logistic Coach	≈300[1]
I6	Volvo	Virtual	MDS Specialist	35
I7	Renault	Virtual	DIM trainee	30
I8	Renault	Virtual	DIM trainee	35

3.6.3 Qualitative Data Analysis

After the interviews were finished, a logical method was used to analyze the audio recordings for themes. As a result, the data was evaluated using predetermined notions about the themes that would be discovered. The research question and prior knowledge played a significant role in shaping these themes. Six steps framework developed by Braun and Clarke (2006), was used to approach the thematic analysis:

1. *Familiarization with the data:* transcribe interviews.
2. *Initial coding:* mark first order codes (concepts) and categorize them into themes.
3. *Cleaning:* collect, sort, and merge codes.
4. *Themes generation:* discard vague or irrelevant codes, review codes for accuracy, name themes.
5. *Grouping dimensions:* highlight phrases in different colors to represent unique themes, which, in turn, correspondent to relevant dimension that generalized an idea or feeling expressed in the particular part of the text.
6. *Thematic analysis:* summarize research based on identified themes and dimensions.

Detailed thematic data structure that demonstrates links among concepts, themes, and dimensions is presented in Appendix B. The combination of data gathered during all of the interviews and internal documentation allowed to address both general themes related to the research question, as well as the individual experiences of each study participant. As a result, with the qualitative approach, the Research Question (RQ) 1 was covered, and the grounds for answering RQ 2 and RQ 3 were created.

[1] Multiple interview sessions were conducted over the course of the research period. The participant exhibited a keen interest in the research topic and possessed substantial relevant knowledge. This enabled the validation and refinement of the specified metrics, as the participant’s insights and expertise helped ascertain their relevance and accuracy.

3.6.4 Data Masking

Certain sensitive information is masked to protect confidentiality of the focal firm and its dealers according to the agreement. The masking technique used is limited to the anonymization of sensitive values with the symbol "x".

Larger values are represented by a greater number of symbols to render a visualization of the difference in numerical values. As an illustration, a value of 1 was replaced with a single "x" while a value of 10 was replaced with "xx" (note, the examples only serve as a masking logic explanation, not actual calculation). However, the omission of certain data does not compromise the quality of the work.

3.6.5 Quantitative Data

Three major steps were primarily engaged in gathering quantitative data. First, performance measures were calculated using the qualitative findings from earlier study stages. The second step involved developing an analytical solution by combining the measurements with the extra information required to support and complete the metrics. Finally, the circularity performance of a few selected dealers was examined using a combination of metrics and extra analytics.

The quantitative portion of the study includes but is not limited to historical operational data on buybacks (e.g., buyback line creation date, lead time, BB type, part quantity, part value, part number), dealers (e.g., location, sales, order quantities, picks, dead stock, refill parameters), order information (e.g., line value, back order) and part-level related information (e.g., bulk pack size, value per item). The historical time span of the data, in some cases, extends up to 36 months, allowing for period-over-period (PoP) comparisons. This helped to identify patterns and trends that may not be immediately apparent.

All of the quantitative data was collected from internal information systems of Volvo Group and Renault Trucks, which are hosted within business intelligence software platforms such as Microsoft Power BI and QlikView, as well as databases. This data was then processed using various tools for data analysis, including data manipulation and visualization packages for Python, such as Pandas, NumPy, Matplotlib, Seaborn, and others. Additionally, spreadsheet software like Microsoft Excel was utilized in the final stages of the research to collect and present the outcomes.

3.6.6 Quantitative Data Sampling

The quantitative data was sampled using a purposive sampling technique, which involved collaboration with one of the stakeholders. The primary goal of this sampling approach, as outlined by Blaxter et al. (1996), was to select specific cases that were deemed particularly interesting for the analysis. Consequently, purposive sampling allowed to strategically sample cases that would provide the most relevant answer to the RQ 3. In turn, the objective of the RQ 3 was to ensure the diversity of cases within the sample, where sample members differed from each other in terms of key characteristics, as described by Bell et al. (2019). This allows for to enhancement of the relevance and applicability of the analytic solution findings.

The rationale was to intentionally select three distinct groups of dealers within a single market, each showing various profiles. Therefore, the choice of the market for the study was influenced by several factors. Firstly, the importance (size) of the market was considered to maximize the impact of the analysis and enhance the relevance of the thesis. Secondly, the market was selected based on the availability of diverse dealer profiles. Thirdly, the market was chosen based on the accessibility of dealer operational information, ensuring a rich dataset for analysis. Lastly, the selection of the market was influenced by the stakeholder's close working relationship with the dealers in that specific market, which offered ample knowledge and additional information for the study. As a result, the analysis pivoted on one of the largest markets for the brand, situated within the European Union. The decision to focus only on one market was primarily fueled by motivations to exclude cultural biases, mitigate demand variability, differences in regulations, company inventory management strategy and other market-specific characteristics.

The selection of the dealers for the analysis was essentially based on specific profile characteristics, which included a main criterion – dealer size (determined by annual pick frequency[2]), additional criteria like obsolete stock ratio[3], a ratio of fast-moving parts[4], as well as dealers who are part of the anticipated obsolescence pilot project[5]. The main criteria were used to create clusters of dealers with comparable size attributes. Then, additional criteria were applied to further distinguish dealers within each cluster. Based on the aforementioned logic, a sample of seven dealers was created, comprising two large, three medium-sized, and two small dealers. While the exact values of some criteria cannot be disclosed due to confidentiality considerations, a comprehensive overview of the dealer selection can be found in Table 3.3.

Table 3.3: Dealer sample selection for exploratory data analysis

Dealer	*Size cluster*	*Annual picks*	*Obsolete stock ratio, %*	*Fast-moving parts ratio, %*
D1*	Large	xxxx	3.4	64.9
D2	Large	xxxx	5.9	57.1
D3	Medium	xxx	5.9	66.3
D4*	Medium	xxx	17.7	69.4
D5*	Medium	xx	11.8	31.3
D6	Small	x	34.1	25.7
D7*	Small	x	21.9	22

*Dealers that are part of the anticipated obsolescence pilot project

The selection of lookalike dealers enabled the benchmarking of their performance against one another. By choosing multiple groups with different characteristics, it was possible to validate the identified metrics and analytics across various dealer profiles, including those with specific characteristics of particular interest to both the study and stakeholders.

[2] One pick is defined as one order occurrence of an arbitrary number of units (I3).
[3] A proportion of inventory that is considered as no longer sellable (I2, I3, I4).
[4] Fast-moving part is a type of inventory that has a high rate of turnover compared to other parts in the same product line (I5). Ex: Oil filter requires regular replacement after a certain number of kilometers. Filters have a consistently high demand due to their frequent usage, making them classified as fast-moving parts (I2).
[5] The anticipated obsolescence project is a part of the company's ongoing efforts to improve its circular performance. The project will be examined in detail in Chapter 4 and 5 of the thesis.

3.6.7 Quantitative Data Analysis

To provide a complete solution for RQ2 and RQ3, it was necessary to employ exploratory data analysis to address the research problem, which involved exploring large datasets to uncover patterns and relationships. As such, a data mining technique was selected. Overall, data mining is the automated extraction of implicit, potentially valuable information from data that was previously unknown. It involves several tasks that can be combined based on the specific application context (Lara et al., 2014).

According to Fayyad (1997), data-mining tasks are typically divided into two categories: predictive and descriptive. Predictive tasks involve creating a model that can be used to forecast. In contrast, descriptive tasks aim to build a model that can effectively describe the data in a comprehensible form (ibid.). In this thesis, the data-mining task will be descriptive, as the objective is to summarize the general characteristics or features of a specific class of data.

The literature presents several established approaches to data analysis, however, in this study, the Knowledge Discovery in Databases (KDD) methodology was employed to develop a generic data analytics framework for modelling buyback PM. KDD aims at discovering patterns that:

1. Do not result in straightforwardly computing predefined quantities (i.e., non-trivial),
2. Can apply to new data with some degree of certainty (i.e., valid),
3. Have been unknown so far (i.e., novel),
4. Contribute benefit to the user or to further tasks (i.e., potentially useful),
5. Lead to useful insights, immediately or after some post-processing (i.e., understandable) (ibid.).

The KDD process consists of five key phases that follow an iterative and interactive sequence, as illustrated in the Figure 3.2.

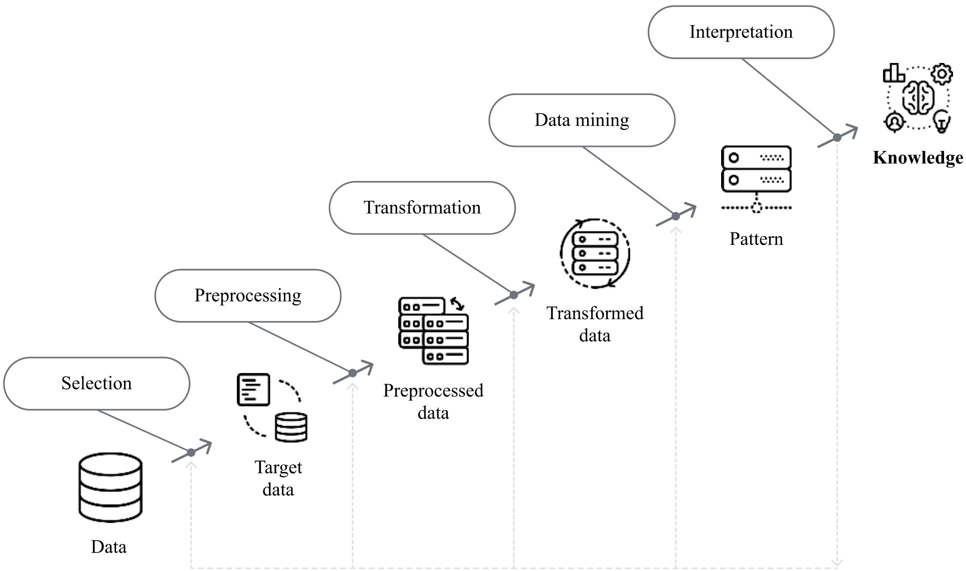

Figure 3.2: Knowledge Discovery in Databases process sequence
Note: Figure recreated and adapted from Gullo (2015). Icons sourced from Flaticon.com.

Within this thesis the following steps were completed:

- ***Selection.*** The target dataset for each metric was developed based on the raw data. This was done by identifying, extracting, and collecting groups of variables which will be used for discovery process.
- ***Preprocessing.*** This step included "data cleaning" procedures. During this step all incorrect, corrupted, duplicate data were removed and incorrect formatting or structural errors were fixed within a target dataset.
- ***Transformation.*** The data was then reduced and projected to obtain an appropriate representation for the specific task of the metric.
- ***Data mining.*** The metrics were applied to the target dataset in a form of a data-mining methods, allowing to extract desired patterns.
- ***Interpretation/evaluation.*** Finally, the knowledge was interpreted from the mined patterns by visualizing them. In some cases, some iterations took place by reverting back to previous steps in the process for improving final results (Lara et al., 2014; Gullo, 2015).

In the quantitative portion of this thesis, metrics were developed and calculated, supported by an analytical approach, to address the challenges specified in the qualitative component. These metrics were then applied to a selected group of dealers, allowing for the quantification, validation, and generalization of the qualitative findings. As a result, this process tackled RQ 2 and RQ 3 while fulfilling the main objective of the thesis.

3.6.8 Literature Review

The purpose of literature review was primarily to collect and expend upon existing knowledge on RL, circularity within RL, RL PM, and data-driven analytics within RL. To get an understanding of previous methods for measuring sustainability performance in an RL a narrative literature review was applied, taking an in-depth but no systematic approach. There were two rounds of literature reviews, as part of pilot and research phases.

During the pilot phase a more general and exploratory topics were considered, like supply chain, CLSC, green logistics, CE, RL, buybacks, KPIs. The primary aim of the pilot literature review was to assess and embrace a bigger theoretical picture of reverse flows characteristics in the supply chain. In combination with the initial interview session, the pilot literature review allowed to establish the research scope and select the preliminary theoretical framework that the research phase will be based on.

The second round of the literature review was shaped by the previously identified scope and theory, which facilitated a better understanding of the nature of RL circularity and its performance. Consequently, the second round was more specific and focused on existing solutions for supply chain sustainability KPIs, supply chain circular performance, and RL PM. Finally, it is critical to state that no existing literature were found concerning circular performance metrics, KPIs, or analytics specifically focused on buyback policy. This fact recognizes a major gap in this area, further emphasizing the theoretical significance of this thesis.

The keywords that were used in search engines for literature collection included following: *Circular Economy; Circular Performance; Closed Loop Supply Chain Management; End-Of-Life Product Management; Green Logistics; Return To Supplier; Reverse Logistics Performance; Reverse Logistics Sustainability; Reverse Logistics; Reverse Supply Chain; Supply Chain Analytics; Supply Chain KPIs; Sustainable Performance Assessment.*

3.7 Reliability and Validity

The concept of reliability relates to the extent to which the results of a study can be replicated (Bell et al., 2019). Therefore, the research methodology of this thesis has been presented with utmost clarity and transparency, aiming to allow others to replicate the study and reach similar conclusions.

While Bell et al. (2019) admit that subjective opinions and conclusions can add depth to research and are sometimes inevitable, it is still critical to conserving to address and minimize subjectivity. In the case of this study, the qualitative data collected during the semi-structured interviews were processed and coded by the author of this thesis. On top of that, informal conversations (that will not be explicitly described in this research) took place. These facts suggest interpretations will be subjective to some extent. Thus, it will be impossible to reproduce a similar analysis in this case. Yet, objectivity, neutrality, and impartiality were a priority throughout the thesis.

In turn, the concept of validity pertains to the accuracy and soundness of the conclusions drawn from a research study (ibid.). Authors highlight several types of research validity: *measurement* (if a study measures what it is intended to measure); *internal* (if a design allows for a causal inference between the independent and dependent variables); as well as *external* (if a study can be generalized to other populations, settings, times).

In the case of this thesis, measurement validity was reached by ensuring data collection from several sources as well as continuous validation of documentation and calculations. Internal validity was established during post-sessions with company supervisors for systematizing a summary of the most important findings from the interview sessions and data analytics. As the thesis focused on a single-case study, the external validity of the conclusion could be limited, as the outcomes are tailored to the specific case of Volvo Group Service Market Logistics. Despite this limitation, it is believed that the conclusions could also apply to other cases, as the theory and empirical findings will be thoroughly compared and contrasted.

Chapter 4. Qualitative Findings & Analysis

This chapter presents an empirical findings of the qualitative data collection. It opens with an overview of the focal company's distribution structure. The relevant department involved in the research is then described. Additionally, a description of the automatic refill system is provided to establish the context. Next, the focus shifts to a thorough examination of the returns system, with a specific focus on the buyback policy. It offers an extensive exploration of the insights derived from the interview sessions, encapsulating the most important aspects relevant to the research objectives. The chapter concludes by describing the performance metrics and explaining the process used to identify them.

4.1 Distribution Structure

The focal company has three types of distribution centers: the Central Distribution Center (CDC), Support Distribution Centers (SDCs), and Regional Distribution Centers (RDCs). The CDC is the largest and handles all forward flows. The inventory replenishment process for dealers typically involves CDC as the primary source. RDCs are used to increase the coverage and supply those dealers, that are located far away from the CDC. Urgent needs may require priority orders to be sent to SDC. To better serve dealers and end customers, SDCs and RDCs are strategically placed throughout the markets based on lead time requirements (I4, I5).

4.2 Dealer Inventory Management

Inventory management policy has a significant impact on how effectively an organization deploys its assets to produce goods and services (I1, I3). Excessive inventory, which is an indication of poor inventory management, leads to wasteful use of resources and negatively impacts financial performance (I6). In contrast, the optimal amount of inventory can support manufacturing, logistics, and other organizational functions (I5). The ultimate responsibility for fulfilling the demands of end customers rests with the dealers (I1, I2, I3, I4, I5). A dealer is an entity that buys and sells goods to customers for profit (I5). In the context of the focal company, the dealers play a role of a middleman between the original equipment manufacturer (OEM) and the end customer (I4, I5).

The focal organization has established a Dealer Inventory Management (DIM) department under Supply Chain Optimization to tackle the challenge of effective inventory control. The DIM department aims to optimize inventory levels at both DCs and dealers (I1). As part of its service offering to dealers, Volvo Group assumes full responsibility for the replenishment process of parts and currently manages the replenishment process for over 2500 dealers globally (I5). This is intended to guarantee that dealers maintain appropriate stock levels, allowing them to ensure a high service level (I2, I4, I5).

The core elements of the DIM concept include managing customer demand through point-of-sales forecasting, planning dealer stock via stock holding policies, and replenishing dealer stock through auto ordering, rebalancing, and buyback (I4, I5).

4.3 Introduction to LPA

The DIM department is closely linked to the Logistics Partnership Agreement (LPA), which is a system for automatic stock replenishment based on dealer performance that was developed by the Volvo Group. The LPA concept covers the material flow between the distribution centers (CDC, RDC, and SDC) and the dealers. It involves the signing of a contract with the dealer, which allows the company to control the supply of parts to the dealer's inventory (I4, I5).

The Dealer Stock Control Package (DSP) is an information system that supports the LPA process by providing quantitative PMs through KPIs. It facilitates control and administration of stock replenishments at the dealer level by storing information such as sales history, forecasts, and current stock situations for each dealer (I4, I5). The system generates purchase proposals based on this data and the conditions set by the DIM team (I5). The DSP offers various parameters and control functions that can be customized to fit the sales and marketing strategies of each dealer. As stated by several interviewees (I2, I3, I4), implementing the LPA concept allows dealers to achieve cost efficiency, maintain healthy stock levels, improved turnover, ensure the availability of stock, and achieve operational excellence (I5).

4.3.1 LPA Refill

The inventory management system is a combination of automatic and manual processes that evaluate a dealer's stock needs based on their consumption patterns. The decision of whether to order a product is determined by using the table of a pick that considers the parameters of price and frequency of picks for a specific part. Meanwhile, the determination of when and how many parts should be ordered is controlled by the parameters reorder point (when) and order quantity (how much). These parameters are set based on the picks and forecasts of the part. These tables are customized based on the brand, and region. To ensure the system works effectively, dealers must commit to purchasing genuine parts and providing current stock levels and sales data to Volvo Group. This enables the replenishment of correct parts in the right quantity and at the appropriate time (I2, I5).

4.4 Return Types

Volvo has a well-developed RL system that includes return flows of spare parts and packaging (I1, I2, I3). Consequently, there are several reasons why products can be returned within the company:

- **Initial buyback.** Refers to the clearance of the dealer's stock of passive parts that have accumulated over several years, usually taking place when the dealer signs an LPA for the first time (I1). Out of scope for this thesis.
- **LPA-initiated periodical buybacks.** Involves the periodic repurchase of dealer inventory by Volvo Group, intending to maintain a healthy stock following the initial buyback efforts (I2, I3, I4). This type of return is the primary focus of the research.
- **Discrepancy returns.** Refers to a claim for a part that has either been

supplied incorrectly, damaged or ordered by mistake and is returned to a shipping DC. Out of scope for this thesis (I1, I2).

- **Core returns.** Replacement parts are shipped mainly to a firm core hub, where they are processed and remanufactured for reuse (I2). Out of scope for this thesis.
- **Battery.** Out of scope for this thesis.
- **Quality campaign returns.** Parts subjected to warranty claims (I1, I2). Out of scope for this thesis.
- **Packaging.** Out of scope for this thesis.

4.5 The LPA-Initiated Buybacks

Under the LPA policy, Volvo Group has an obligation to continuously maintain a satisfactory inventory turnover rate at the dealers' warehouses. This policy involves a periodic "cleaning" of stock, which creates a regular need for buybacks (I4). Several interviewees (I1, I2, I3, I4) noted that buybacks play a significant role in the overall process and strategic goal of LPA and enable dealers to ensure proper parts availability to end customers.

Overall, the buyback process could be divided into 4 phases: request, preparation, validation, and execution. Volvo Group initiates the buyback process by preparing a buyback proposal based on the current stock of dealers. The proposal includes a list of eligible parts, the terms for accrual, and specific return actions for the buyback line. Buyback can be managed with or without accrual, where dealers accumulate a "return right" based on their purchase history within a certain period. The buyback pricing is determined automatically, but internal users can adjust it in case of manual buyback approval. This process is performed twice within a buyback period to ensure efficiency (I4, I5).

The validation process, which includes a review, adjustment, and confirmation with the dealer (I4), is carried out after the buyback proposal is prepared. The dealer has the right to reject or partially complete the buyback proposal based on the actual demand of their end customers (I2, I3). However, if the dealer refuses to return parts that are eligible for buyback, they risk losing their "return right" in the next buyback proposal period (I3). According to the rules, the dealers will not be refunded in the next periods for previously declined parts if they fail to sell them to the end customer (I3, I4, I5).

In the final stage, the execution phase commences, where the dealer completes a return authorization form, detailing the final list of parts included in the buyback. The dealer then proceeds to select, package, and dispatch all the parts to the DC. Upon receiving the returned goods, Volvo conducts a reception validation process and initiates subsequent collection activities. After the parts were approved by Volvo quality control, the dealer is refunded via a credit note (I1, I3, I4, I5).

4.5.1 Selection Criteria and Compensation Rules

The decision to buy back parts from dealers is a multifaceted process governed by the DSP system, specific DIM criteria, and return rules. This is where the term "dead stock" is applied, to select parts that have not been sold for a certain number of months (I4). The primary suggestion for the selection criteria is based on the logic provided in Table 4.1.

Table 4.1: Buyback selection criteria

Line Value, €	*Last Sale Date, months*	*Last Receipt Date, months*	*Action*
< x	≥ xxx	≥ xxx	Scrap
≥ x	≥ xx	≥ x	Return

For example, the decision to scrap the part will be made if the line value is below a specific threshold. If the value falls below this threshold, it means that the part is no longer feasible to keep in stock. Then, the last sale and receipt date are considered. If the part has not been sold or received within a significant period of time, it means that there is limited demand for the part and it is less likely to be needed in the future (I2, I3, I4). Based on these criteria, the part gets scrapped, freeing up inventory space for more relevant parts (I4).

In general, the responsibility for selecting genuine parts that should be returned or scrapped to achieve the target level of the healthy stock lies with Volvo Group (I2, I3, I5). The buybacks could be also categorized based on whether the order line purchase was initiated by Volvo or by the dealer. In this thesis, both types were explored:

- **Automatically purchased parts.** Implies parts that were automatically replenished and approved by the dealer through the refill system (I2, I3, I4). Designated as Buyback Auto (BA) hereafter.
- **Manually purchased parts.** Implies parts that were manually ordered by the dealer. In other words, the dealer initiated the purchase order for these parts instead of them being automatically pushed by the refill system (I2, I3, I4). Designated as Buyback Manual (BM) hereafter.

The compensation amount for a returned or scrapped part is determined by the part type and the return action. BA result in higher compensation amounts compared to manually purchased parts (I4). It should be noted that the analysis conducted in this thesis does not cover the portion of scrap resulting from manually purchased parts due to a lack of available data.

4.6 Current state of buyback policy

4.6.1 Strategic Role

The majority of the interviewees emphasized that the buyback policy has significant strategic implications for the overall LPA system, making it a key element. For instance, I5 stated that a buyback policy serves as a strategic tool to help the company mitigate the effects of demand uncertainty and encourage retailers to place larger orders. Additionally, the same interviewee also mentions another important factor – “buyback allows the dealer to have exactly the inventory needed, thus minimizing inventory that sits on the shelf and immobilizes cash, preventing them from investing money into inventory they truly need”.

The Volvo Group’s risk of buybacks is mitigated to some extent by the availability of an extra market to dispose of the unsold goods (I4). In turn, the dealer is assured that the automatic refill system’s stock can be sold back if they do not require it, thus increasing trust in the partnership (I5). Overall, the buyback policy implemented by Volvo Group has several benefits, as outlined by the stakeholders interviewed. These benefits can be summarized as follows:

1. **Cost savings and improved cash flow for dealers.** The buyback policy reduces the cost of holding excess inventory, which frees up warehouse space and allows dealers to use financial assets more efficiently (I1, I2, I3).
2. **Increased end-customer and dealer satisfaction.** By providing dealers with a way to return unsold or excess orders, Volvo Group improves dealer loyalty. Dealers can stock more parts, increasing availability and then enhancing end-customer satisfaction (I1, I2).
3. **Improved forecast accuracy.** By tracking return parts through a buyback policy, Volvo Group gains a better understanding and visibility of end customers demand. This understanding can help improve forecast accuracy, reducing the risk of stockouts or overstocking (I7).
4. **Reduced waste.** The buyback policy helps reduce waste by closing the supply chain loop and allowing the reuse of inventory on secondary markets. This practice is intended to enable Volvo Group to meet sustainability goals and improve its public reputation (I2).

4.6.2 Factors That Are Driving Buybacks

To gain a better understanding of the overall process and to establish grounds for investigating the improvement areas, it was crucial to identify the factors that impact buyback volumes first. As stated earlier, Volvo Group offers services to a multitude of dealers worldwide, each of which possesses a unique profile with distinct attributes, which affects the buyback return volumes.

Parts variety. The nature of the parts stocked by dealers varies depending on their market environment, with some dealers handling more homogeneous vehicle parts while others stock more diverse types of parts for different truck models, ages, and customizations. These factors have a direct impact on the variety of parts ordered and their frequency, which can result in excessive stock and an increased risk of buybacks in the following period's proposal (I1, I2, I3, I5).

During the interviews, one of the participants shared an example of a dealer whose inventory consists of approximately 70% of parts for newer vehicle models and 30% for older ones (I2). Another example included a dealer whose inventory consisted mostly of older parts, with a significantly smaller proportion allotted for newer models. In such instances, the parts that are at the greatest risk of being subject to buybacks are typically those that are categorized as slow-moving parts, as there is a heightened risk that they may become obsolete over time (I3). Volvo Group therefore seeks to buyback these components before they reach the point of obsolescence (I1, I2, I3, I4).

Dealer size. According to the information provided by I2 and I3, the size and volume of business of a dealer play a significant role in determining the stock refill parameters. Typically, dealers with more significant inventory and a history of higher demand for parts, or those located in densely populated and industrial areas with higher demand, tend to have more aggressive refill parameters. In contrast, dealers with lower demand tend to have more defensive parameters. This variance in parameters also affects the cost and size of the order lines, which ultimately affects the buyback volumes (I2, I4, I5).

Dealer steering. The primary objective of the LPA system is to guide dealers in selecting a particular combination of parts to enhance the *Service Index*[6] (SI). As such, dealers must strive to increase the availability of parts to maintain or exceed the target level of SI. As a rule of thumb, the higher the availability of parts goes, the higher will be the buyback increase risk (I1, I2, I3, I5).

However, it is important to balance the level of SI with an acceptable volume of buybacks, as the associated indirect financial and environmental costs, such as collection, transportation, and DC handling, may surpass the immediate benefits of a high SI (I1, I2).

It should be noted that there is an exception to the trade-off between the SI level and buyback quantity. If a strategic decision is made to increase the company's presence in a specific market, the SI level may be intentionally increased as well. In this case, the long-term benefits may outweigh the immediate costs, and an increase in buybacks can be perceived as an investment rather than a burden (I1).

Dealer behavior. Upon agreeing with Volvo Group, dealers are expected to comply with the rules of the LPA process, which entails regularly and accurately reporting stock levels and sales, as well as adhering to physical stock management. While dealers have the right to determine the extent to which they rely on the LPA process, their commitment to the process is critical to the success of the program (I2, I3). The confidence level of dealers in the system may vary due to the human factor, which can affect their adherence to the return process and the quality of data they report to the focal company (I3). This, in turn, can impact the level of obsolete stock dealers hold and perhaps result in negative outcomes for buyback returns (I1, I2, I3). To address this issue, Dealer Coaches from the DIM department are assigned to work closely with dealers, ensuring that the system functions as efficiently as possible for every dealer (I1, I3, I4, I5).

4.7 Current Areas of Improvement

4.7.1 General Perception

Several interviewees identified a key shortcoming related to the overall perception of buybacks within the organization. Specifically, the buyback policy is viewed as a cost burden and a necessary measure to keep the push strategy to dealers running without any opportunities for profitability (I2, I3). Consequently, a misleading strategic mindset has developed that fails to recognize the unique characteristics of buybacks and their potential to capture new efficiencies in terms of better inventory redistribution, creating additional revenue sources and elevating sustainability opportunities (I2, I3, I5). In this way, the organization is missing out on a critical opportunity to support buyback policy development (I5).

The difference in approaches. The buyback flow activities stretch across several departments, with some more closely related to the process than others (I2). This has created a

[6] Service Index is a dealer-level KPI which implies readiness of dealers to meet the future demands of the end customers (I5).

certain imbalance in the perception of buybacks across the organization (I2, I5). Some departments that work with dealers and buybacks on a daily basis could prospectively see development opportunities (I2, I3). However, other, partly engaged departments are measuring buybacks in silos, seeing only one side of the process (I2).

System setup. The current criteria, rules, and ways of working for the buyback process were established approximately two decades ago (I2, I3, I4, I5). Since that time, there have been significant changes in technology, products, customer preferences, and the overall supply chain landscape. As a result, the efficiency of the current system setup has become increasingly limited (I2, I3, I4).

Dealer segmentation. The selection criteria and compensation rules for buybacks have become too rigid to effectively align with the varying profiles of dealers (I4, I5). This highlights the need for an improvement in the existing rules, incorporating specialized dealer segmentation criteria that consider factors such as location, weather, demand, vehicle park, and product availability (I1, I2, I4).

Line value. The interviewees also identified another system setup shortcoming related to the buyback line value (ceiling) in the selection criteria (I2, I4), as described in the previous subsection. The current ceiling has been in place for a long period of time, and the organization has become somewhat resistant to adjust it due to the high risk of incorrectly setting it, which could negatively impact the overall reverse chain and LPA system (I1, I2, I3).

The incentive to stimulate change. Given the prevailing perception of buybacks as a source of expenditure, there is currently insufficient incentive to invest in research and analysis to determine an appropriate setup that could result in fundamental changes (I2, I3). Additionally, as environmental regulations become increasingly strict, and Volvo Group is committed to pursuing environmental goals and CE practices, the current buyback system is unable to fully integrate circularity principles (I2).

4.7.2 Reuse Efficiency

The existing dealer inventory is not viewed as an asset, according to the feedback of multiple respondents, as a result of the current false impression and system configuration (I2, I3, I4). The existing flows adhere to a rigid structure that ignores chances to add value by maximizing the network inventory and determining the best use for returned goods in the most effective manner (I2).

Backorders alignment. Several participants observed that certain limitations in the buyback system can result in lost revenue and longer lead times (I1, I2, I3). For instance, when parts are classified as scrap, they become blocked and are no longer available for redistribution. This can create a situation where a dealer has an active backorder[7] (BO) for the same part that is being scrapped at another dealer within the same location, but fulfilling this need becomes impossible due to system limitations (I2). In such cases, transporting the parts between neighboring dealers is often a more cost-effective and environmentally sustainable solution compared to producing and delivering new parts (I1, I4, I7). Another interviewee noted that an analysis conducted in a major market revealed that a significant portion of scrapped parts had

[7] An order for a part that cannot be filled at the current time due to a lack of available supply (I2, I3, I4, I5).

positive forecasts for other dealers, indicating a high probability of successful redistribution (I2, I3, I7).

Broken package. The current system limitations also include other reasons for blocking parts that negatively affect the optimization of returns. One such reason is the broken package, which results in the scrapping of all parts in the package if the package was opened, regardless of the state of the part (I2). For instance, if a pack of seven filters was opened, and three filters were taken out, the remaining four filters in perfect condition will be scrapped according to the established rules. This leads to situations where almost complete packages of parts are scrapped despite their high value and outstanding demand in the same region (I2, I3).

Reconfigurable parts. Another reason is the misinterpretation of the status of reconfigurable parts. Some parts require additional information to be ordered, such as a key, while others, such as the engine control unit, can be reconfigured by any dealer and reused (I2). However, these statuses are often misunderstood, leading to the scrapping of some of the most expensive parts (I2, I3). One interviewee has highlighted the issue of supersession parts being scrapped, despite their potential to still be used (I2).

Supersession parts. These parts are replaced with newer versions due to changes in design or quality or safety issues with the old part (I3). According to the current rules, all supersession parts must be scrapped, regardless of their possible usefulness (I2, I3). The parts that could still be used have a superseded use-up status, meaning that they can still be sold. Although there is a system in place to mark these parts, many of them are still being disposed of. This represents a loss of revenue and a missed opportunity for sustainability (I2).

Transportation cost. Some interviewees have raised concerns about the lack of established monitoring for the impact of buyback transportation on both financial and environmental terms (I1, I2, I3). Currently, the measurement of buyback flow costs is limited to global transportation costs, which hinders visibility and makes it difficult to accurately delimitate and assess the actual cost of returning flows to the Volvo Group (I1).

Final handling. Currently, the company handles buyback volume forecasting twice during a buyback period. The goal is to anticipate the expected volumes coming back to return centers, thus pre-planning workload allocation (I3, I4). One of the interviews highlighted that there is no existing solution to assess the accuracy of the forecast and, therefore, the effectiveness of the returns station's readiness to handle the incoming buyback flows (I3). Additionally, there is an overall lack of transparency regarding the fate of returned buyback parts after they have been collected and processed by the DC (I1, I4, I5).

4.7.3 Scrap Efficiency

According to some interviewees, buyback return flows can still yield added value to the company through recycling or remanufacturing, even if they cannot be reused directly (I2). However, there is currently no established process for this due to the complexity of collecting, transporting, handling, and processing the waste, as well as the range of parts and components involved (I1, I2, I6).

Life Cycle Costing. The most commonly scrapped parts tend to have a relatively low line value, meaning they are relatively simple in terms of manufacturing and materials. This is due to procurement rules designed to minimize return costs. There is an opinion that the current procurement rule that only considers the line value of the parts is misleading (I2, I3, I6). When scrapping, none of the parts are considered at their life cycle costing (LCC) (I2, I3, I6, I8).

Current scrap monitoring system. One of the most significant issues related to scrapping buybacks raised by most participants is the lack of control over how waste is processed with the existing scrap monitoring system which entails photo validation for scrapping parts on-site from dealers (I1, I2, I3, I4, I5, I6). Participants identify it as non-effective in terms of responsible handling of waste and compliance with environmental regulations or Volvo Group circularity goals (I2, I3, I4, I6).

Environmental impact estimation. In addition to establishing proper tracking and verification of waste disposal, there is a need for a system to measure the environmental impact of scrap (I2, I8). Some parts may have a higher environmental impact when scrapped due to their hazardous components or source of the material (I2). Therefore, it is necessary to assign a weight to the environmental impact of each part, to determine which parts should be prioritized for avoidance of scrapping (I2, I6, I8).

4.7.4 Overview of Existing Analytics

Currently, the focal company lacks dedicated analytics explicitly designed for monitoring the efficiency of buybacks within the CE context (I1, I2, I3, I4, I5). Nevertheless, there are several analytical systems that allow stakeholders to manage operational and financial information related to buybacks (I1, I3).

One such system is the buyback monitoring tool, which operates as a business intelligence dashboard. The tool offers a detailed follow-up on fundamental operational data across various levels, ranging from the market level to the individual parts level. It combines all information regarding buyback part numbers, quantities, order values, line statuses, line creation dates, and more in a single place. This tool supplies valuable insights for stakeholders, providing real-time data to support monthly buyback operations and generate reports. Furthermore, the tool encompasses historical data for retrospective analysis (I3).

Another solution discussed during one of the interview sessions is the financial flow report per market. Given that buybacks constitute a big part of the financial flows within the whole RL system, it is important to continuously monitor the corresponding financial indicators. The report consists of a spreadsheet that is updated every month and provides an overview of the repaid buybacks, as recorded in the credit notes issued to dealers in each market. This tool is primarily used to follow budget considerations, benchmarking markets, retrospective analysis, pattern recognition, etc. (I1).

Finally, there are three other solutions currently under development that explicitly tackle the environmental context (I3). Although these solutions are beyond the scope of this thesis, they will be briefly discussed as part of the identification process for the analytical solution outlined in this thesis with the main objective to avoid duplicating features or developing a solution which already exists.

The first solution anticipates part obsolescence by utilizing a complex machine learning algorithm. This system allows to preplan obsolescence and facilitates corresponding adjustments in a stock refill for specific dealers, thereby improving stock health management (I1, I2, I3). At present, the preliminary solution has been developed and is already being implemented in the pilot phase with several dealers, including specific ones from the sample. A second solution is a dashboard tool for monitoring scrap. This tool is aimed to enhance visibility into the overall scrap process, reasons, parts, and values allowing stakeholders to track and manage the disposal of parts more effectively (I3, I8). Finally, another tool is being developed to automate the alignment of backorders and buybacks within a region. The main objective of this tool is to optimize part reuse efficiency and minimize the lead time for backorder fulfillment (I3, I7).

4.8 Process of Performance Metrics Identification

Some of the buyback drivers and challenges that were recognized earlier in the thesis have laid the groundwork for further analysis and are addressed in the performance metrics that have been developed. While this research has addressed many issues relating to the buyback operational processes, it is crucial to note, that there are more strategic challenges, such as the optimization of criteria and rules, that fall outside the scope of this thesis. These challenges are discussed in depth in Chapter 5 but are addressed by the metrics or the data analysis.

In general, the drivers, challenges, and existing solutions outlined in the previous sections served as a guide for the process of specifying metrics. All factors were gathered, sorted, and filtered to start the process of developing performance metrics. Figure 4.1 displays all of the elements that were discussed in this thesis.

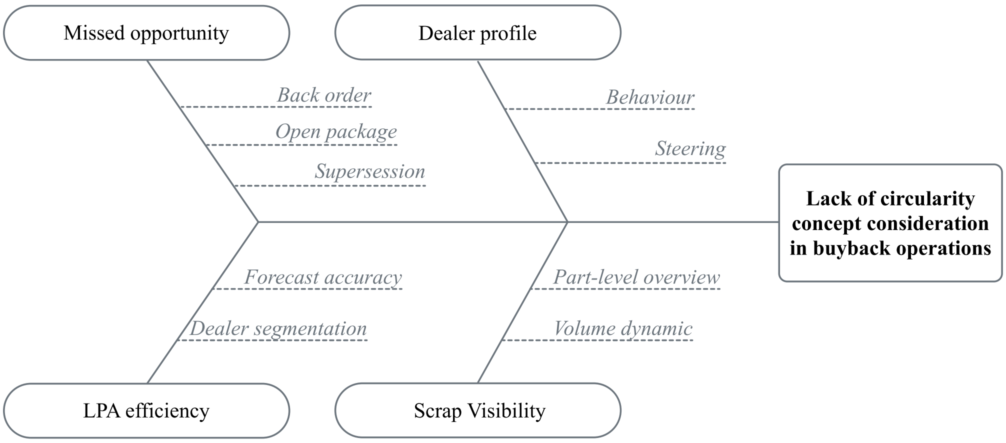

Figure 4.1: Map of identified key issue, major categories, and causes

The figure above determines a key issue targeted by the thesis, which is the lack of circularity in the buyback operation activity, in line with the research purpose. Therefore, the metrics are designed to offer insights into the circularity of buyback operations and detect inefficiencies, empowering stakeholders with an additional data layer for decision-making.

The major categories that contribute to the identified problem were determined and organized into groups. These categories include missed opportunities for redistribution, dealer profile characteristics, LPA push system efficiency, and scrap visibility. Each category has several causes, which further define the focus for each metric that is developed. The causes were refined by several stakeholders during the follow-up interviews (I2, I3).

After pinpointing the causes that needed to be addressed, they were aligned with a CE concept. This was achieved by using the CE hierarchy framework to categorize the causes based on their environmental priority. The "3Rs" of the CE concept, which prevent (reduce), reuse, and recycle, were utilized to categorize the causes, as illustrated in Figure 4.2.

The framework was important in ensuring that each factor was classified accurately according to the anticipated priority. Therefore, it is recommended that causes related to improving the prevention capability of the system be given priority and placed at the top of the hierarchy, as these are the most desirable solutions. Conversely, causes related to scrap, which represent the worst-case scenario from a CE perspective, should be located at the bottom of the hierarchy and given less priority.

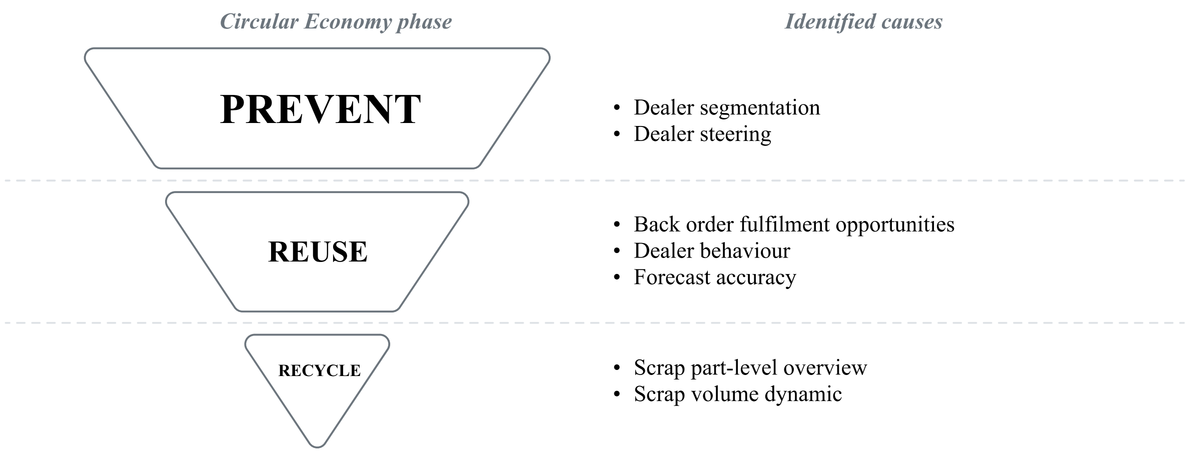

Figure 4.2: The application of a circular economy framework to analyze the causes

The identification of causes and their mapping to the CE concept phases enabled the final set of metrics to be established. For this, the GQM approach was utilized to finalize the metrics development. The metric hierarchy was constructed by starting with the conceptual level and progressing to a quantitative response to those concepts.

To align the causes with the CE concept phases, corresponding goals were established that are addressing major CE phases of preventing, reusing, and recycling buyback flows. These goals were further refined using operational-level questions to characterize them as measurement points. To ensure the validity of the determined metrics, the dataset was linked to each question. The process was iterative, as certain metrics were found to be non-relevant or difficult to maintain daily.

4.9 Final Set of Performance Metrics

After identifying and prioritizing areas for analysis and determining the relevant metrics, it was important to define and associate these metrics. The define phase involved creating a detailed methodology for each metric that described its calculation method and measurement purpose. In the associate phase, an aggregated table of metrics was created to supply a comprehensive overview of the objectives, measurement characteristics, and circularity phases associated with each metric, presented in the next subsection.

The aim was to ensure that the metrics were easily understandable even for stakeholders without deep specific knowledge in the buybacks area. The implementation of the GQM approach to the causes is illustrated in Table 4.2.

Table 4.2: Implementation of Goal, Question, Metric approach

		Description
Goal	G1	Prevent the risk of buybacks
Question	Q1	What is the buyback operational performance on period basis?
Metric	M1	Buyback value to total stock value, period-over-period
Question	Q2	What is the level of accuracy of LPA in pushing parts?
Metrics	M2	Buyback part quantity to total LPA pushed part quantity
Goal	G2	Optimize the redistribution of returned flows
Question	Q3	What is the proportion of parts that have the unused redistribution capacity?
Metrics	M3	Buyback to backorder missed demand in value
Question	Q4	To what degree are dealers adhering to the buyback process?
Metric	M4	Proportion of non-returned buybacks
Question	Q5	How to ensure that return station will have enough capacity?
Metric	M5	Buyback pre-planning forecast accuracy
Goal	G3	Ensure that scrap is disposed of in the most appropriate way
Question	Q6	What portion of the buybacks is being scrapped on period basis?
Metric	M6	Scrap value to total buyback value, period-over-period

A total of six metrics were developed, with two metrics related to the Prevent phase, three to the Reuse phase, and one to the Recycle phase. The metrics cover diverse categories such as buyback costs, system shortcomings, redistribution opportunities, dealer training, and waste management. The finalized list of metrics is illustrated in the Table 4.3.

Table 4.3: Set of circularity performance measurement metrics

Code	*Name*	*Main objective*	*Circularity phase*	*Sustainability dimension*	*Category*	*Preferrable action*
P1	BB to total stock in value, PoP	To illustrate buyback dynamics overtime.	Prevent	Economic	Cost	Minimize
P2	BB to LPA push in part quantity	To monitor the efficiency of the LPA push system.	Prevent	Economic	Cost	Minimize
RS1	BB to BO demand in value	To quantify opportunities for fulfilling BO with BB flows.	Reuse	Economic & environmental	Redistribution	Maximize
RS2	Proportion of non-returned BB	To follow up on dealer compliance with procedures.	Reuse	Informational	Training	Minimize
RS3	BB pre-planning forecast accuracy	To control the accuracy of BB return flow pre-planning.	Reuse	Informational	System	Maximize
RC1	Scrap to total BB in value, PoP	To illustrate scrap proportion within total BB dynamics overtime.	Recycle	Economic & environmental	Waste	Minimize

Chapter 5. Quantitative Findings & Analysis

This chapter centers on the empirical finding obtained from quantitative data collection. It commences by presenting an overview of the methodology employed for calculating the performance metrics, followed by a detailed explanation of each metric along with their corresponding formulas. Next, the additional analytics to support the metrics is presented. Lastly, the chapter presents the outcomes derived by applying a combination of metrics and the analytics to the dealer selection.

5.1 Performance Metrics Calculation Methodology

Each metric will be thoroughly described, along with its calculation method, in the sections that follow. Due to the fact that the formulas are created for each dealer separately, it is necessary to repeat these calculations for every single dealer separately. The metrics are presented in a way that answers four fundamental questions:

1. What is being measured?
2. Why it is being measured?
3. How to interpret the results?
4. How to calculate the metric?

5.2 Prevent

5.2.1 Buyback Value to Total Stock Value, Period-Over-Period *(P1)*

This metric assesses the ratio between the value of buybacks and the total stock of the dealer, comparing the current period to the previous one. The ratio is used to assess the relative value of buyback, as using raw financial values in retrospective PoP comparisons could be misleading. This is because ratios produce normalized financial values, allowing to account for inflation, as well as currency and price fluctuations.

The total stock was selected as the denominator for this ratio because of the observed relationship between the two values. As previously discussed, higher service levels for end customers lead to increased parts availability and subsequently cause higher inventory stock value and an increased risk of buybacks.

The results of this metric bring insights into the proportion of buybacks within the dealer's total stock, enabling historical trend exploration and benchmarking with similar dealers. This allows for a fundamental buyback performance analysis on a period basis. An increase in the ratio without a corresponding increase in sales and stock value suggests an abnormal buyback proportion. Therefore, it is necessary to conduct a closer investigation to outline the underlying cause of the increase, which could be influenced by a range of factors such as market conditions, and thus a more comprehensive analysis is required.

The P1 is obtained using Equation (5.1).

$$\text{P1}=\left(\frac{(\sum \text{BAv}\ (\textit{prev. period}) \times \alpha + \sum \text{BMv}\ (\textit{prev. period}) \times \beta)}{\sum \text{Sv}\ (\textit{prev. period})}\right) - \left(\frac{(\sum \text{BAv}\ (\textit{cur. period}) \times \alpha + \sum \text{BMv}\ (\textit{cur. period}) \times \beta)}{\sum \text{Sv}\ (\textit{cur. period})}\right) \times 100\% \quad (5.1)$$

Where *BAv* is a financial value of automatically purchased buyback parts; *BMv* denotes financial value of manually purchased buyback parts; *Sv* indicates an annual mean value of weekly total stock value. Currently, the calculation of final compensation value that Volvo Group has to return for each buyback type is a manual process that involves applying the accrual proportions α and β to the respective buyback types.

5.2.2 Buyback Part Quantity to Total LPA Pushed Part Quantity *(P2)*

This metric calculates the proportion of parts that ended up under a buyback proposal in the current period, which were pushed by the LPA system in the previous period. Simply put, it compares what the company pushes to what it buys back. It serves as a measure of the parts that dealers failed to sell, signaling that system has overestimated the demand.

The results of this metric enable valuable insights into the effectiveness of the LPA system in pushing parts to dealers. For example, the mean values across different markets or regions can be used for a higher-level analysis. An increase in the ratio indicates that the LPA system may have overstocked the dealer with a certain selection of parts, resulting in a higher buyback amount.

The ideal state for this metric is 0%, which means that all parts pushed by the system were sold, suggesting that the system is perfectly balanced. However, this is unlikely in the real world, so the metric serves as a robust monitoring system for any variations in LPA performance, which can directly impact buyback amounts and return costs. The P2 is calculated using Equation (5.2).

$$\text{P2} = \frac{\sum \text{Part}\ \gamma \text{ in BB porposal } (cur.period)}{\sum \text{Part}\ \gamma \text{ in LPA pushed list } (prev.period)} \times 100\% \quad (5.2)$$

Where *Part* γ denotes a quantity of parts with unique number that were matched in both BB return proposal and LPA pushed parts list.

5.3 Reuse

5.3.1 Buyback to Backorder Missed Demand in Value *(RS1)*

This metric quantifies the total value of existing buyback inventory that can possibly fulfill outstanding backorders within the same region. Fundamentally, it aims to capture missed opportunities for part redistribution. As previously discussed, this metric highlights the capacity to prevent new parts production by promoting reuse and simultaneously reducing lead times for dealers.

In an ideal scenario, the value of this metric would approach 100%, indicating that all backorder demand could be covered by the buyback flow. However, achieving 100% is highly unlikely in practice. Therefore, the objective should be to maximize the value of this metric, as higher values indicate greater utilization of buybacks to fulfill the BO demand. The RS1 is calculated using Equation (5.3).

$$\text{RS1} = \frac{\text{Actual BB value}}{\sum(\text{Part }\delta \times \text{Part }\delta\text{ line value} \times \alpha/\beta)} \tag{5.3}$$

Where *Actual BB value* represents the sum of compensation values of automatically and manually purchased buybacks, as well as scrap parts. *Part δ* represents a quantity of parts with unique number that is present in both the buyback return parts proposal and the backorder request list. The accrual proportion (α or β) is then applied aligning with the respective buyback type. The *Part δ* is calculated using Equation (5.4).

$$\text{Part }\delta = \text{Part }\delta\text{ qty }(BB\ proposal) - \sum \text{Part }\delta\, qty\ (BO\ list) \tag{5.4}$$

Where:

$$\text{Part }\delta = \{0, \text{if Part }\delta < 0, \\ \text{Part }\delta, \text{if Part }\delta > 0\} \tag{5.5}$$

First, *Part δ* must satisfy the condition that the buyback arose earlier than the backorder demand for it, indicating a chronological alignment between the two. Second, the parts should be matched only within the same region. Third, the output of (5.4) should be zero if the BO quantity prevails the existing buyback inventory for specific part, as illustrated in Equation 5.5.

5.3.2 Proportion of Non-Returned Buybacks *(RS2)*

This metric shows the proportion of parts that were initially proposed as a buybacks but were ultimately not returned by the dealer. This allows to understand how closely the dealers are following the procedures of the buyback process and helps to identify the portion of inventory that remains unavailable for reuse due to dealer intentions. This information is particularly relevant for Dealer Coaches, as it enables them to monitor and benchmark dealers' adherence to the rules, thereby facilitating effective communication and training for the dealers.

In ideal scenario, the metric should be close to zero, indicating that all of the proposed parts are being processed and returned by dealers, allowing the company to reutilize this inventory more effectively. Accordingly, the objective should be to minimize the value of this metric, as lower values indicate a better dealer coherence with the rules and higher availability of parts for reuse.

However, it is important to consider that dealers may intentionally hold proposed parts in the stock due to potentially having knowledge of specific demands from certain end customers. That is why supplementary information is needed to reason the value of the metric, which will be provided by the additional analytics in the following section.

The RS2 is calculated using Equation (5.6).

$$\text{RS2} = \frac{\sum \text{BB line } (\textit{not packed})}{\sum \text{BB line}} \times 100\% \quad (5.6)$$

Where *BB line (not packed)* indicates a part line which was proposed for return under the buyback policy but was eventually not returned by the dealer.

5.3.3 Buyback Pre-Planning Forecast Accuracy *(RS3)*

This metric calculates the mean absolute percentage error for the buyback forecast that is done within the buyback pre-planning system for each dealer. The metric is being measured because it allows insights into the effectiveness of the pre-planning system by assessing its capacity of accurately forecasting demand. Accurate forecasting is critical for keeping proper buyback handling, and weak forecast accuracy can lead to capacity shortage at the return centers.

In an ideal scenario, the value of this metric would be close to zero, indicating that the pre-planning system has a perfect accuracy. Yet, achieving a value of zero may be unrealistic in real-world conditions. Therefore, the goal should be to minimize the value of this metric, as lower values suggest better accuracy and a reduced inconsistency between forecasted and actual demand. The RS3 is obtained using Equation (5.7).

$$\text{RS3} = \frac{\text{Actual BB value } - \text{Forecasted BB value } (H1 + H2)}{\text{Actual BB value}} \times 100\% \quad (5.7)$$

Where *Forecasted BB value* represents a sum of the estimation for both halves of the period.

5.4 Recycle

5.4.1 Scrap Value to Total Buyback Value, Period-Over-Period *(RC1)*

This metric is similar to P1, but only considers scrap as a point of analysis. As a denominator, the total buyback value is used. Hence, the purpose of the metric is to illustrate percentage of scrap in relation to the overall buyback flow PoP. The metric also enables historical trend exploration and benchmarking with similar dealers. The results of this metric deliver insight into the relative proportion of scrap within the total buyback flow.

An elevated ratio indicates an abnormal scrap proportion. In such cases, additional information is needed to further support the interpretation of the metric, which will be presented in the forthcoming analytical solution. The RC1 is obtained using Equation (5.8).

$$\text{RC1}=\left(\frac{\sum \text{SCv } (\textit{prev. period})}{\sum \text{BAv } (\textit{prev. period}) \times \alpha + \sum \text{BMv } (\textit{prev. period}) \times \beta}\right) - \left(\frac{\sum \text{SCv } (\textit{cur. period})}{\sum \text{BAv } (\textit{cur. period}) \times \alpha + \sum \text{BMv } (\textit{cur. period}) \times \beta}\right) \times 100\% \quad (5.8)$$

Where *SCv* is a financial value of buyback parts specified as scrap.

5.5 Description & Application of Proposed Solution

The identified metrics were later complemented with additional analytics, where each metric being accompanied by a unique set of information. The main goal of the additional analytics is to give context for the results obtained from the metrics. The combination of metrics and analytics is forming an analytical solution that covers a significant part of the current buyback policy challenges, as well as provides deep insights into several aspects of buybacks from circular perspective. The following subsections will grant the description of additional analytics, as well as connect them to the key metric and present its application on the data pertaining to the dealer selection. The results will be further discussed in the following chapter.

5.5.1 P1 Analytical Solution

The P1 metric is accompanied by data points utilized in its calculation, namely the total buyback value and the stock value. It is further supported by sales difference between the current period and the previous period, as well as obsolete stock ratio and proportion of fast-moving parts in the dealer's inventory. The outcomes of applying the P1 metric together with related analytics can be observed in Table 5.1.

Table 5.1: Buyback value to total stock value, with additional analytics (P1a)

Dealer	***P1, %***	*BB* value total, €*	*Stock value total, €*	*Sales delta, %*	*SI**, %*	*Obsolete stock, %*	*Fast-moving parts ratio, %*
D1	**-1.3**	xxx	xxx	-2	90.6	3.4	64.9
D2	**-1**	xxxx	xxxx	+21	91.1	5.9	57.1
D3	**-4.5**	x	xxx	-12	93.8	5.9	66.3
D4	**+2.4**	xx	xxx	+11	93.4	17.7	69.4
D5	**-6.2**	xx	xx	-16	81.2	11.8	31.3
D6	**+17.8**	xx	xx	-6	86.4	34.1	25.7
D7	**+12.6**	x	x	+18	80.8	21.9	22

*BB – buybacks; **SI (Service Index) – part availability rate.

The findings unveiled that a majority of dealers experienced a decline in buyback value during the current period. Generally, larger and medium-sized dealers experienced a reduction in buyback value. On contrary, smaller-sized dealers showed a significant increase. The outcomes are further elaborated with the second part of the solution. It allows a detailed analysis of the buyback type as of the total buyback value, stock value, and obsolete stock.

Part B of the P1 solution is presented in Table 5.2.

Table 5.2: Buyback value by type to total stock value, with additional analytics (P1b)

Dealer	*BA**				*BM***			
	P1, %	*Of total, %*	*Stock Value, %*	*Obsolete stock, %*	***P1, %***	*Of total, %*	*Stock Value, %*	*Obsolete stock, %*
D1	**-1.3**	95	84	2.5	**-0.1**	5	16	0.9
D2	**-0.8**	91	74	3.7	**-0.2**	9	26	2.2
D3	**-6.1**	77	53	2.9	**+1.5**	23	47	3
D4	**-1.6**	63	61	3	**+4**	37	39	14.7
D5	**-6.6**	93	75	7.1	**+0.5**	7	25	4.8
D6	**+19.2**	84	35	4.1	**-1.4**	16	65	30
D7	**+3**	53	41	3.1	**+9.6**	47	59	18.8

*BA – buyback parts pushed by the system; **BM – buyback parts purchased by the dealer manually.

The second part of the analysis disclosed out of the seven dealers studied, five observed a decrease in buyback value for BA parts. However, D6 stands out with a sharp rise of 19.2%, contrasting with lookalike D7 which only saw 3% increase. The situation is reversed with the value for BM parts, where a larger portion of dealers observed an influx. Notably, D7 exhibited the strongest growth of 9.6% among the entire sample.

5.5.2 P2 Analytical Solution

The P2 metric is complemented by information used in its calculation, such as the quantity of parts that were pushed in the previous period. Additionally, a value of the overstocked parts is provided, which is measured separately by considering data from the period before the previous period. To further support the metric, the total buyback value in the current period is presented, along with the ratio between the two values. The findings obtained from the application of the P2 metric and associated analytics are presented in Table 5.3.

Table 5.3: Buyback part to total pushed part quantity, with additional analytics (P2)

Dealer	***P2, %***	*Qty of parts pushed*	*BB* value of overstocked parts*	*P2/total BB value, %*
D1	**1.04**	xxxx	xxx	38
D2	**1.46**	xxxx	xxxx	42
D3	**1.33**	xx	xxx	25
D4	**1.31**	xxx	xxx	25
D5	**1.40**	xxx	xx	41
D6	**8.3**	x	xx	66
D7	**7.97**	x	x	33

*BB – buybacks

The results of the P2 analytical solution demonstrate that large and middle-sized dealers experienced a relatively consistent proportion of the buyback part quantity to pushed part quantity. The proportion ranged from a minimum value of 1.04% to a maximum value of 1.46% represented by D1 and D2 respectively. Smaller-sized dealers D6 and D7 exhibited considerably higher values of 8.3% and 7.97%, respectively.

5.5.3 RS1 Analytical Solution

The RS1 metric is enhanced with information that is utilized in its calculation – total buyback value and total value of parts matched with backorders. Table 5.4 demonstrates the results of implementing the RS1 metric, along with the corresponding analytics.

Table 5.4: Buyback to backorder missed demand in value, with additional analytics (RS1)

Dealer	***RS1, %***	*Buyback total value, €*	*Matched parts value, €*
D1	**19.3**	xxx	xxx
D2	**18.4**	xxxx	xxxx
D3	**25.6**	x	x
D4	**44.7**	xx	xxxx
D5	**29.5**	xx	xx
D6	**20**	xx	x
D7	**35**	x	xx

The application of RS1 revealed a high variability in values between the dealers, without any patterns appearing. Interestingly, almost half (44.7%) of the buyback value for D4 could be potentially reduced by fulfilling the backorder demand with the existing inventory. While in contrast, D2 represents the lowest, yet still significant, redistribution capacity of 18.4%.

5.5.4 RS2 Analytical Solution

The RS2 metric embodies several additions, including the total quantity of BB lines, which is further detailed to outline the portion of automatically and manually purchased parts. Furthermore, the total value of parts not returned is included, to show the magnitude of parts that dealers choose not to return. In addition, the proportion of parts that were returned in the current period is provided to shed light on the dynamics of the return behavior. Solution also highlights the proportion of parts that eventually became scrap. The results derived from applying the RS2 metric and additional analytics are presented in Table 5.5.

Table 5.5: Proportion of non-returned buybacks, with additional analytics (RS2)

Dealer	***RS2***			*Qty of lines not returned (prev. period)*	*Total value of parts not returned, €*	*From which returned (cur. period), %*	*From which became scrap, %*
	BA, %*	*BM**, %*	***Total, %***				
D1	0	0.4	**0.4**	xxx	x	66.67	33.33
D2	0.4	0.2	**0.6**	xxxx	x	75	0
D3	0.3	10	**10.3**	xx	xx	5.88	0
D4	1.3	27.7	**29.1**	xx	xxxx	11.54	0
D5	1.1	3.5	**4.6**	xx	x	52.38	0
D6	0	0.4	**0.4**	x	x	0	0
D7	0	53.3	**53.3**	x	xxx	2.05	0

*BA – buyback parts pushed by the system; **BM – buyback parts purchased by the dealer manually.

The analysis of RS2 indicates that a majority of the sample have a considerably low rate of non-return for the proposed parts. Nevertheless, certain dealers, such as D3, D4 and D7, have a substantially larger proportion of intentionally held parts. As an example, D7 holds more than a half of the proposed parts. However, it is important to note that the vast majority of non-return primarily consist of BM parts.

5.5.5 RS3 Analytical Solution

The RS3 metric includes information that is utilized in its calculation, namely the actual and forecasted BB values. Moreover, the mean absolute error is also included, further supporting the RS3 results.

The findings of RS3 emphasize variations in forecast accuracy among the sample. It could be observed that the forecast was exceptionally accurate for D4 with only 7.6% error. On the other hand, D3 showed the highest absolute percentage error of almost 70%.

The outcomes of applying the RS3 metric together with related analytics are depicted in Table 5.6.

Table 5.6: Buyback forecast accuracy, with additional analytics (RS3)

Dealer	***RS3, %***	*Actual value, €*	*Forecast estimation, €*	*Deviation, €*
D1	**52.4**	xxx	xx	xxxx
D2	**19.7**	xxxx	xxxx	xxx
D3	**69.7**	x	xx	xxx
D4	**7.6**	xx	xxx	xx
D5	**52.9**	xx	xxx	xxx
D6	**20.5**	xx	xx	x
D7	**39.8**	x	x	x

5.5.6 RC1 Analytical Solution

Finally, the RC1 is strengthened by inclusion of total scrap value, which facilitates cross-dealer comparison. Besides that, the maximum and mean values of scrapped parts are provided. The maximum value identifies outlier cases where abnormally high-value parts have been scrapped. Conversely, the mean value renders a measure of the normality of values for scrapped items. Table 5.7 shows the results achieved by applying the RC1 metric and the related analytics.

Table 5.7: Scrap to total buyback value, with additional analytics (RC1)

Dealer	***RC1, %***	*Total scrap ratio, %*	*Total scrap value, €*	*Maximum part value scrapped, €*	*Mean part value scrapped, €*
D1	**+2.8**	8.8	xxx	xxxx	xx
D2	**+2**	8.1	xxxx	xxxx	xx
D3	**-3.1**	13.6	x	xx	xx
D4	**0**	7.1	x	xxx	x
D5	**-1**	13.3	xx	xx	xx
D6	**+6.7**	9.7	x	xx	xx
D7	**-12.8**	9.6	x	x	xx

The RC1 analysis exhibited that half of the sample experienced an increase in the value of parts scrapped, while the other half displayed a decrease. In addition, one sample had no changes compared to the previous period. Remarkably, smaller-sized dealers represented the most significant changes in scrap value. D6 increased scrap value by nearly 7% and D7 mitigated about 13% of its scrap value.

Chapter 6. Discussion

In this chapter, a thorough analysis and interpretation of the empirical findings in light of the research questions and existing literature will be presented. The chapter will begin with an examination of the specified challenges and their possible solutions, along with the author's reflection on the subject. The discussion will then interpret the results obtained from applying the analytical solution to the dealer selection data. The discussion aims to give a complete understanding of the research findings by analyzing the results, synthesizing the findings, and assessing their significance and implications.

6.1 Addressing Current Areas for Buyback System Improvement

The challenges identified in the study are consistent with those found in the literature, indicating that they are not unique to the industry being analyzed. Previous research on RL has distinguished various factors and considerations at different levels of the process. The current study has also detected specific areas for improvement in the topic-related sections, which will be discussed further in the following sections.

6.1.1 Changing the Strategic-Level Approach to Buybacks

One of the major challenges is related to the corporate mindset, where returned inventory is viewed as a cost rather than an asset. This mindset is in line with several studies in the literature on RL, where authors have highlighted the lack of top management awareness of the importance of return flows (Carbone & Moatti, 2008; Jović et al., 2020). In the case of the Volvo Group, the buyback system is perceived as a burden to be managed for the efficient operation of the push strategy under the LPA system. This highlights the need for a shift in the corporate mindset towards capturing the maximum value of returned products and the prospective opportunities for improving the circularity performance of the buyback system.

Profit-planet trade-off. Buyback policy, despite its benefits in terms of economic and environmental sustainability, as well as dealer relationships, is not typically viewed as a strategic activity. During the interview sessions, it was noted that sustainability investments must not only avoid additional costs but also create savings opportunities to be deemed worthwhile. This lack of strategic attention may be due to what is known as the profit-planet trade-off, whereas substantial benefits can take a long time to emerge, and pressures from shareholders may favor other investments that can bring added value in a shorter timeframe.

As a result, implementing sustainable practices can be extremely hard, especially given the company's legacy systems and the fact that its current systems are financially sound. The advantages of being environmentally conscious are typically outweighed by the potential for sustainable practices to increase costs, decrease efficiency, and reduce short-term profits.

The answer to this particular question is not within the scope of this thesis. However, it is evident that to support the ongoing environmental-related projects discussed earlier, the necessary culture must be settled. In established organizations, radical ideas may face opposition, thereby organizational design is crucial to ensure openness to novel ideas. Additionally, management should establish appropriate organizational structures, provide adequate resources, allow sufficient time for experimentation, and personally engage to ensure the successful implementation of such projects (Goffin & Mitchell, 2016).

Ongoing actions. It is important to note that the difficulties have been specifically named by the company representatives, and several initiatives to improve the buyback system are currently in motion. Since the issues are complicated and necessitate a thorough comprehension of the cause-and-effect relationships within the system, it is clear that they are not being understated. Multiple departments and teams are involved in addressing these challenges, and effective collaboration is essential for success. Strategic level support is also crucial, in the form of circularity goals, environmental programs, and return optimization projects (cross-functional collaborations, workshops, etc.), as well as the development of CO_2 and environmental impact estimation systems. The ultimate objective should be to develop a supply chain that is more effective, sustainable, and maximizes value for all parties involved.

6.2 Strategically Concentrating on Preventing Buybacks

The primary objective of buyback activities should be to proactively avoid returns by establishing a strategic focus on preventing them from occurring in the first place. This approach aligns with the Prevent phase of the CE concept and has the most capacity to enhance the environmental perspective. This phase highlights the importance of preventing waste and maximizing resource efficiency through sustainable production and consumption practices. As established through both the literature review (Butzer et al., 2017) and qualitative research, preventing returns is a crucial area of improvement for buyback policies.

While the Prevent phase of the CE concept is the most desirable approach, it is also the most difficult to execute due to the demand uncertainty and volatility of RL flows. Implementing this approach necessitates significant changes to the current system setup, which in turn would require strong initiative from the top corporate level. This creates a top-down cause-and-effect chain, where a strategic decision is needed to develop tactical and operational solutions to address the challenge.

For example, the current buyback policy and selection criteria were created a decade ago, and since then, there have been significant changes in the global supply chain environment, regulations, technologies, products, services, customer demands, and competitive landscape. This indicates that the existing rules and settings of the buyback system have reached their effective limit and need to be revised. This will help in developing a better understanding of the underlying logic, motivations, and overall effectiveness of the system.

6.2.1 Revising the Policy Rules

One such change relates to the line value. Line value is a crucial factor in determining whether a part is eligible for buyback, and this criterion has remained unchanged for several years. While the logic behind the acceptable line value variable is straightforward, its impact on the entire system can be significant. If the acceptable line value is set too high, it can result in a considerable increase in scrap parts with a higher value. As more parts are deemed scrap, the potential for redistribution decreases significantly, impeding the possibility of generating additional revenue streams and increasing the amount of waste produced. On top of that, there is no reliable infrastructure for converting this waste into value-added products as of now.

Conversely, if the line value is set too low, it could result in a significant increase in the volume of cheaper parts eligible for buyback, impacting transportation and handling, as well as general buyback costs for the company. As a result, even small changes in the buyback system setup may have a significant impact on operations, given the importance of the LPA system as a competitive advantage for the focal company. It is also important to consider whether there are sufficient capacities at distribution centers to handle the increased return flows.

At this point, the RS3 metric could be employed to control the accuracy of the buyback inflow estimation. This metric could play a critical role in enhancing the pre-planning activities for the return centers. By strategically utilizing the RS3 metric, the return handling procedures can be facilitated, particularly in cases where changes in line value may lead to an increase in buyback flows.

Based on the current analysis presented in Figure 6.1, it is prominent that the spread of RS3 values for the samples is currently too wide, making it challenging to recognize any reasonable patterns. For instance, the absolute error for sample D4 is relatively low at 7.6%, denoting that both the forecast value and actual value are closely aligned. In parallel, sample D3 reveals a considerably higher error, reaching almost 70%, suggesting a strong discrepancy between the estimation and reality.

In general, the absolute error in RS3 values for most dealers is quite significant, making accurate pre-planning unachievable. These factors indicate that the forecasting model needs revision and improvement. For instance, the RS3 values can be used to adjust and train the forecasting model based on time series data, allowing for better accuracy in future estimations.

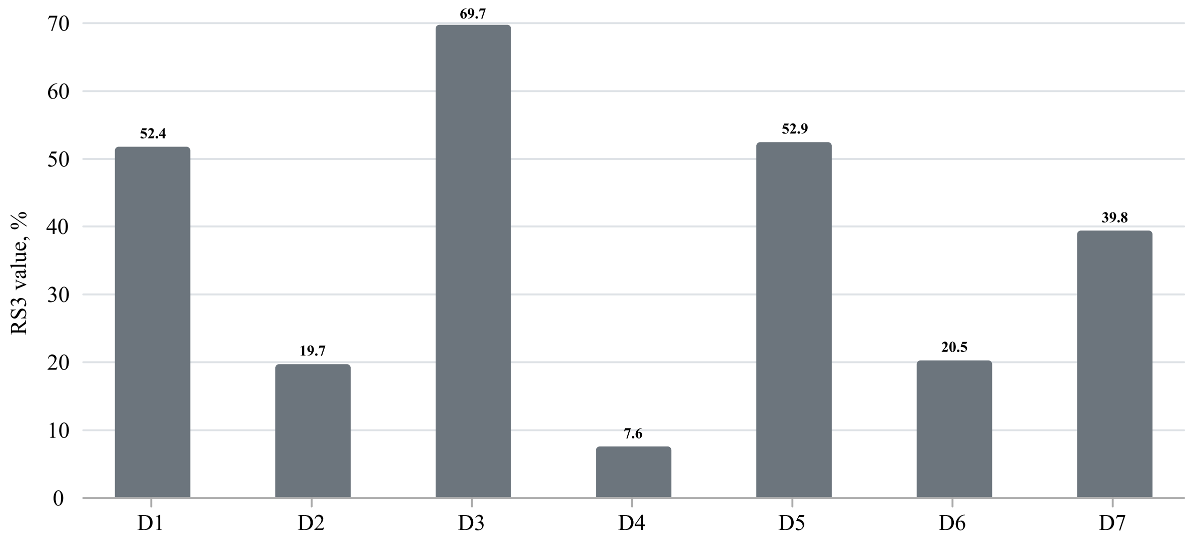

Figure 6.1: Buyback pre-planning forecast accuracy (RS3)

6.2.2 Adjusting the Buyback Selection Criteria

Furthermore, the current buyback selection criteria lack specifications that consider regional or brand factors. For instance, the company could benefit from a flexible line value that is tailored to the dealer location, market, or vehicle park, as these factors can significantly affect the buyback return flows. Implementing such customized criteria would enable the company to better address dealer characteristics and ensure alignment with the market environment. However, it would require a considerable investment in exploration, development and validation of multiple system setups that operate simultaneously.

The implementation results of the adjustable system setup could be controlled effectively using the P1(a) solution. By comparing the differences in the relative buyback value period-by-period, it becomes possible to assess the current effectiveness of the new criteria and make necessary corrections based on live data. This allows for real-time adjustments and observation of how dealers respond to the changes.

Moreover, the P1(a) analytics could also serve as a benchmarking tool to compare the buyback values of similar dealers over the pilot phases of the implementation. It enables the comparison between control samples and samples with adjusted settings, thereby accurately monitoring the efficiency of the system upgrades. The fundamental information produced by P1(a) can also be used for interpreting other metrics to gain a better understanding of the overall performance, which will be done continuously throughout this chapter. Figure 6.2 visually represents the P1(a) values of the selected dealers. It will be interpreted with a help of the Table 5.1.

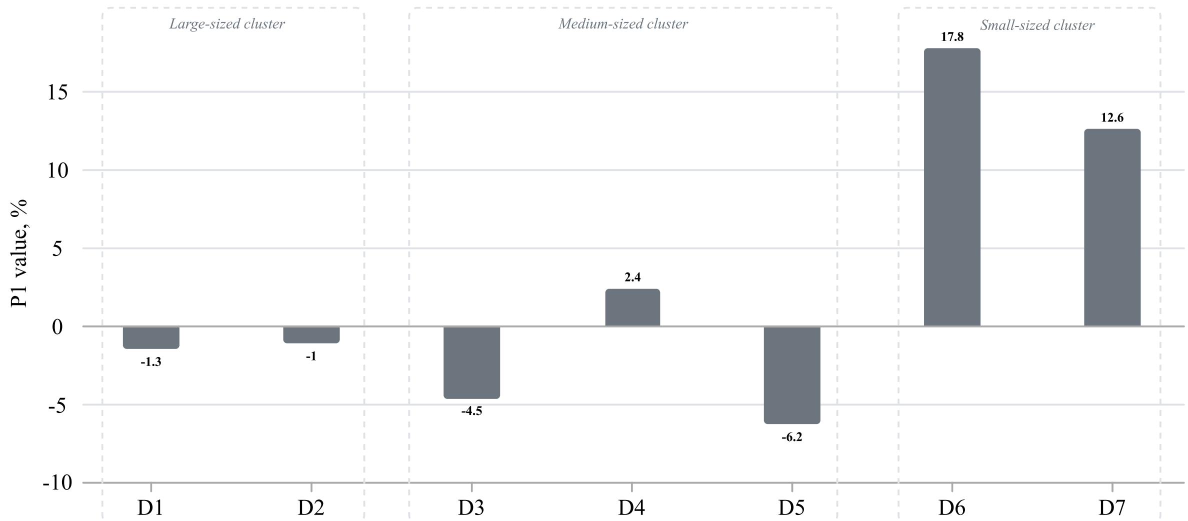

Figure 6.2: Buyback value to total stock value, period-over-period (P1a)

According to the information provided in the figure above, both large-sized dealers (D1 and D2) were successful in reducing their buyback value in the current period. One point which is worth considering when interpreting the metric is to analyze the changes in sales, as they directly impact both buyback volumes and stock value.

D1 experienced a slight decrease in sales, which could have resulted in lower buyback volumes, as fewer parts were pushed to the dealer. At the same time, D2 underwent a massive increase in sales (+21%) while still managing to minimize the buyback value in the current period. Given that both dealers exhibit a high SI rate, suggesting a sufficient availability of parts and consequently increasing the risk of buybacks, it could be implied that the system worked efficiently for these dealers. Finally, it could be also observed that D1 has a lower proportion of obsolete stock and a higher proportion of fast-moving parts compared to D2. This difference in inventory may explain the slightly stronger decrease in buyback value for D1.

Further analysis discovered that for medium-sized samples the changes in the P1 value were even more sound, compared to the larger samples. D3 and D5 showed a decrease in relative buyback value by -4.55% and -6.2% respectively. However, it is crucial to note that both dealers experienced a sharp decrease in sales volumes. This decrease in sales could explain the comparable trend in buyback values. Conversely, D4 is the only dealer in the medium-sized group that observed an increase in P1 value by 2.4%. This dynamics could also be explained by the development in sales during the current period.

Accounting for the part availability rate and stock composition characteristic allows to draw interesting conclusions. D3, which has the highest SI rate among the group, faces an increased risk of buybacks. This factor explains the relatively smaller rate of decrease in the P1 value for D3 compared to D5. However, D5 has a higher ratio of obsolete stock and a lower proportion of fast-moving parts compared to D3. As previously identified, slow-moving parts are one of the key factors driving buybacks, as it is hard for the system to accurately assess the demand for these parts. Regardless of that fact, D5 still managed to deliver a more substantial decrease in buyback value, suggesting effective management of the buyback flow. Lastly, D4 also exhibits high availability of parts and the highest obsolete stock ratio out of the group. This combination could also leverage an influx in the P1 value for D4.

In general, it could be concluded that the buyback flow volumes for the middle-sized group did not represent any strong inconstancies. The changes in the P1 value were to a large extent due to sales trends, parts availability disproportions, and obsolete stock levels.

The analysis of the smaller-sized group underlined the highest surplus in buyback volumes among the selection. D6 experienced a surge in relative buybacks value of 17.8%, while D7 observed a 12.6% increase. Interestingly, D7 achieved a lower P1 value in spite of the sales growth. Several factors can contribute to this result. Primarily, D7 has a lower part availability compared to D6, as well as a lower proportion of obsolete stock. Yet, D6 circulates a higher proportion of fast-moving parts, which should have decreased the buyback risk to some extent.

These results support the fact that smaller dealers are more prone to buyback risk due to their business environment. Clearly, it is challenging to push the correct set of slow-moving parts, given the volatility of demand. Proportionally higher values of P1 for the smaller dealers highlight the need for an effective dealer segmentation system strategy, which will account for such characteristics. It is worth mentioning that a detailed analysis of buyback types is needed which is conducted with the P1(b) solution in the next subsection. This analysis will allow to outline the dynamics for each specific buyback type. Finally, a combination of both P1(a) and P1(b) enables stakeholders to develop targeted strategies for specific dealers or groups of dealers, further improving the buyback circularity management.

6.2.3 An In-Depth Look at the Buyback Type

As noted previously, the current buyback policy covers both manually ordered parts (BM) and those automatically pushed through the LPA system (BA). Even though the compensation rules are lower for BM parts, they can still account for a significant portion of the return flows within the buyback policy. This is supported by the results of the P1(b) solution, which generates a detailed breakdown of the relative buyback value dynamics by type. The results are presented in Figure 6.3, and their interpretation will be facilitated by referring to Table 5.2.

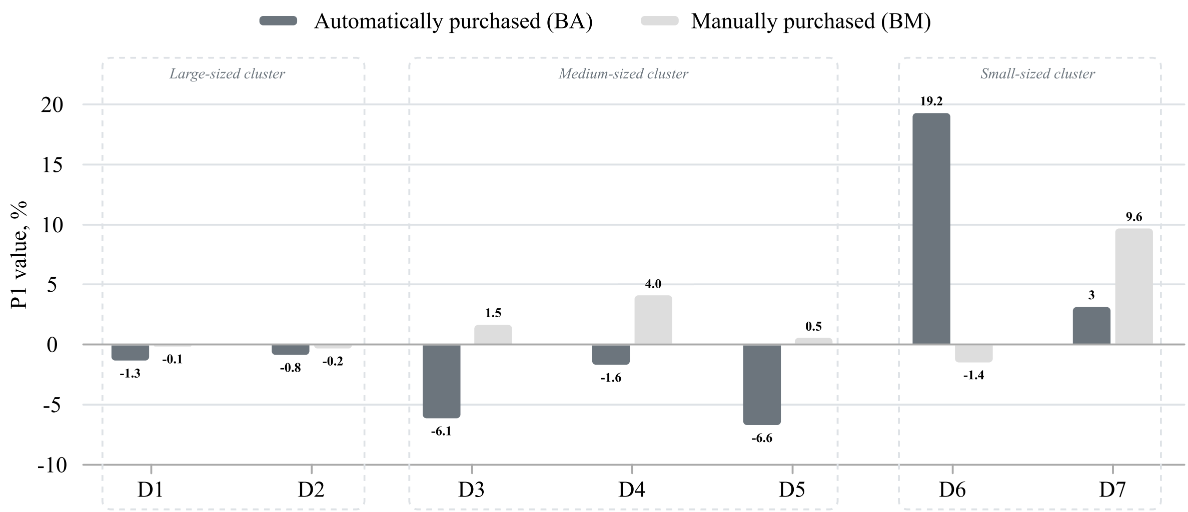

Figure 6.3: Buyback value by type to total stock value, period-over-period (P1b)

The data presented in the figure suggests that among the samples in the large and medium-sized groups, there was a decrease in BA value. The decrease was partially eminent for D1 and D2, where BA parts present a majority. Therefore, the decline in BA resulted in a higher general decrease in buyback volumes for these dealers. Yet, when assessing the cost-related parameters (which are not disclosed in this thesis), the BA will have a more significant impact due to their higher volume. This is expected, as for these dealers significant portion of stock is refilled automatically, so it will naturally have a higher value of BA.

Upon analyzing the middle-sized group, it becomes noticeable that the division between BA and BM is more pronounced. Specifically, only the BM parts experienced an increase in value. This indicates that these dealers may have overestimated the demand for a portion of the parts ordered, resulting in an expansion of the total buyback cost. As mentioned previously, D4 experienced a rise in sales, which contributed to the lowest decrease in BA and the highest increase in BM among lookalikes.

Nonetheless, it should be noted that some middle-sized dealers rely less on the LPA system compared to their larger counterparts. For instance, D5 has 75% of its stock automatically ordered, whereas D3 has only 53% of its automatic stock. This is explained by the fact that the proportion of manually ordered LPA-ordered parts varies significantly among dealers and depends solely on their behavior and purchasing strategies (e.g., the total LPA coverage for a dealer). In conclusion, the results of the P1(b) analysis for the middle-sized group shows the impact of BM parts on the total cost and the difference in reliance on the LPA system.

Among the smaller-sized dealers, the D6 represented an abnormal increase in BA buybacks, recording a rise of 19.2%. Despite relying more on manual stock, the proportion of BA increase is abnormally high, especially considering that the dealer's sales volumes have decreased. This indicates that the LPA system has overstocked the dealer, highlighting the need for adjustments for avoiding such discrepancies in the following period.

On the contrary, D7 demonstrates the highest increase in BM among all the samples in the selection. Moreover, D7 is the only dealer in which the split between BA and BM buybacks approaches a 50/50 ratio. This implies that the company had to reimburse the dealer for a majority of BM parts. This increase raises the question of why the dealer overstocked these parts, creating a necessity for further investigation. Summarizing, these findings stress the importance of optimizing the buyback system setup for smaller-sized dealers.

The reuse efficiency is highly dependent on the dealer's behavior as well. As was mentioned in previous chapters, dealers have a right to decline the return of the part that Volvo Group deems as a buyback. The main reason that affects the decision of the dealers not to return the part to Volvo is their specific knowledge. Some dealers, particularly those working with a limited number of end customers, have a more precise understanding of the actual demand for certain parts compared to the company's forecasts. As such, the BA parts that were proposed for return but were refused by the dealer will become BM parts in the next period, thereby reducing the refund amount. This rule is in place to incentivize dealers to accurately assess their demand and avoid accumulating excess inventory.

The RS2 solution was developed to offer an efficient way to monitor the volumes of non-returned products and produce valuable insights into the results of such actions from the dealer side. The results obtained from applying the RS2 solution are presented in Figure 6.4, and their interpretation will be supported by the data presented in Table 5.4.

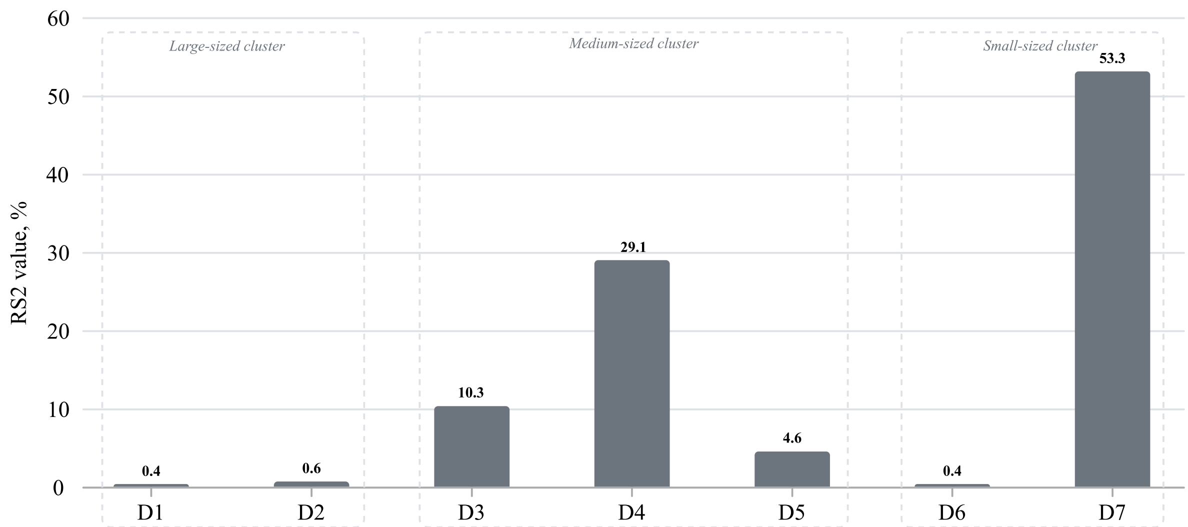

Figure 6.4: Proportion of non-returned buybacks (RS2)

The figure above demonstrates that three samples (D1, D2, D6) from the selection follow the buyback procedure extremely carefully. The larger dealers, for example, have a comparatively low ratio of non-returned buyback lines to total buyback lines when compared to other dealers in the selection. However, their absolute quantities are still higher due to the total volume of buyback flows they generate.

In the previous period, D1 returned all of the BA parts and kept only the BM lines. D2 retained both BA and BM lines, albeit in insignificant proportions. In the current period, D1 and D2 returned 66.67% and 75% of the previously declined portion of parts, respectively. It should be noted that for D1, 33.33% of the parts in this portion were identified as scrap, meaning that it became not possible to reuse those parts anymore.

Medium-sized dealers, specifically D3 and D4, demonstrated higher proportions of non-returned buyback parts. For example, D3 kept over 10% of the proposed parts, with the majority being BM type parts. D3 ultimately returned only 5.88% out of the previously non-returned parts. D4 shows an interesting pattern, as almost 30% of the proposed parts were not returned, primarily consisting of BM type parts. Nonetheless, the total value of non-returned parts held by D4 was relatively high compared to other samples, implying that the dealer may have had a specific demand for these more expensive BM parts in the current period. Out of this portion, 11.54% were eventually returned, and no parts were eligible for scrap. D5 stands out with the lowest RS2 value among the group, at 4.6%. Out of this proportion, more than half were eventually returned during the current period.

Among the smaller-sized dealers, D6 excels by returning almost all of the proposed buyback lines. Conversely, D7 has not returned nearly half of the parts, all of which belong to the BM category. Yet, D7 succeeded in selling the majority of these parts, requiring them to return only 2.05% of the portion from the previous period. This further supports the notion that smaller-sized dealers operate in a specific environment, characterized by having well-established relationships with a limited number of end customers. This factor enables smaller dealers to have a more concise understanding of potential demand and adjust to it accordingly.

To sum up, RS2 reveals a trend of dealers predominantly retaining BM parts. This phenomenon may be explained by two key factors. First, unlike the BA parts, holding BM parts does not create a risk for dealers to lose the higher compensation rate. Therefore, dealers may choose to keep this type of part to maintain control over them. Second, dealers usually manually stock specific parts that they deem relevant, based on their requirements or the demands of the end customers. A combination of these two factors may contribute to the pattern observed with the RS2 solution, where BM parts are more common as non-returns compared to BA parts.

6.2.4. Anticipating the Obsolescence

The literature review indicates that spare parts are prone to obsolescence due to their unique features. As a response to this challenge, the company has developed the aforementioned anticipated obsolescence project. By predicting which parts are likely to become obsolete, the company can prevent the refill of future obsolete parts and reuse planned obsolete parts in stock. By blocking parts that the algorithm will deem as inefficient for a refill, the company expects to mitigate the risk of having an influx of buyback volumes. This approach increases the efficiency of both the prevent and reuse phases by providing an understanding of how much time the company has to reuse a specific part before it becomes obsolete.

At this stage, the implementation of the P2 analytics solution can be utilized not only to monitor the overall efficiency of the refill system but also to assess the results of the anticipated obsolescence pilot. By comparing the variations in volumes between pushed parts and buyback parts, it is possible to see if the system was able to effectively block parts for refill. P2 analytics could serve as a benchmarking tool to compare the performance of lookalike dealers, those undergoing the pilot phase of the project and those that are not. Even though the specific impact exploration of the project may not fall within the exact scope of the thesis, it is worthwhile investigating and comparing sample performance as a part of the general analysis.

As mentioned previously, four dealers in the sample selection, namely D1, D4, D5, and D7, are currently undergoing the pilot phase of the anticipated obsolescence project. The remaining dealers (D2, D3, D6) are considered as control samples. Figure 6.5 delivers a visual representation of the P2 values. It is important to note that the data presented in the P1 solution (Table 5.1) is often used to give context for the observed P2 values.

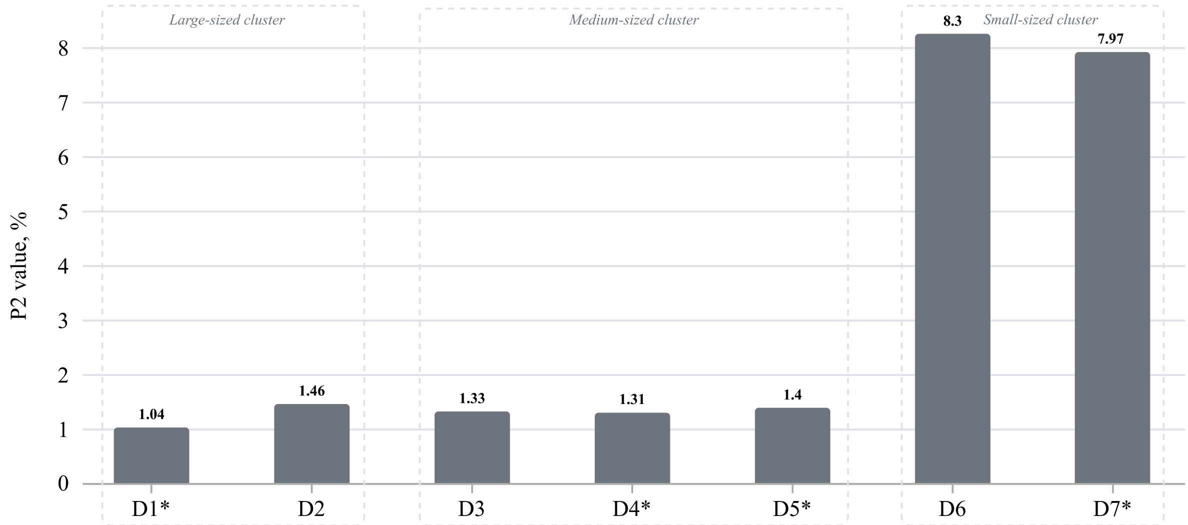

Figure 6.5: Buyback part quantity to total pushed part quantity (P2)
*Dealers that are part of the anticipated obsolescence pilot project

By analyzing samples within their size groups, it becomes apparent that dealers participating in a pilot generally perform better compared to those that are not involved. For example, there is a remarkable difference of 0.42% between the large-size pilot sample D1 and the control sample D2. The difference could represent a substantial portion of the buyback flows, considering the volume of pushed parts to these dealers. This implies that the refill system may have performed better for D1 compared to D2, as fewer parts pushed in the previous period were to become obsolete in the current period. However, the extreme increase in sales for D2 should be considered in this case. As discussed previously, it raises the risk of additional buyback inflow and could potentially affect the difference in the values discovered.

The control sample D3 and the pilot sample D4 represent a smaller variation of only 0.02% in their P2 values. Again, D4 experienced an increase in sales during the current year, resulting in a higher volume of pushed parts overall. This may contribute to the reduced difference in P2 values between the two samples.

In contrast, D5 has a larger proportion of slow-moving parts compared to lookalike dealers. For this reason, the P2 value could be inflated for D5, even accounting for the possible mitigating effect of the pilot. Yet, when compared to a smaller-sized group, the difference in values for D5 becomes significant, especially when considering that D6 and D7 also deal with a majority of slow-moving parts and elevated buyback risk. This indicates that the system worked efficiently for D5, considering the huge level of buyback risk it confronted.

The small-sized dealers, such as D6 and D7, are exposed to the highest buyback risk due to their prevailing inventory of slow-moving parts. Accordingly, the P2 value for these samples is significantly higher compared to the selection. However, when comparing D6 and D7 in isolation, a positive pattern appears. For instance, pilot sample D7 exhibits a lower P2 value by 0.33% compared to control sample D6. This phenomenon could be explained by the proportion of BA parts, as D6 has a higher proportion (84%) which influences the P2 value. In contrast, D7 has a lower proportion (53%), providing the observed difference in values between the two samples.

6.2.5 Ensuring the Maximum Potential for Reusing Existing Inventory

The second phase of the CE hierarchy entails maximizing the reuse rate of existing inventory through its further redistribution. In general, the redistribution of parts plays a significant role in generating additional revenue and ensuring environmental responsibility, as it helps to avoid the least preferred option for buybacks – scrapping. By effectively reusing inventory, Volvo Group reduces manufacturing requirements, leading to a decrease in the use of raw materials and energy consumption. This combination enables the company to minimize its carbon footprint and promote sustainable operations.

Success story mentioned during the interview. During one of the interview sessions, an example was offered that underlined the successful application of the reuse approach. As part of the benchmark study, a non-automotive company based in the United States was analyzed. The case company established a return flow setup that allowed it to cover up a significant portion, specifically 40%, of outstanding backorders from dealers. This was made possible by effectively reusing the existing inventory. According to the interviewee, this real-life case illustrates how inventory could effectively fulfill any unexpected demand that cannot be met by production alone. By implementing this system, the company increased overall SC resilience and customer satisfaction. Moreover, returns to DC were decreased by up to 50%.

One of the major success points in this case, according to a participant, is a decreased dealer involvement in return activities. This increases the efficiency of both RL and dealer operations, as dealers perceive these activities as non-core and additional work they have to do. This mainly includes administrative functions such as transportation, packaging, reporting, invoicing, and payment. Indeed, such activities could be managed within the Volvo SML department or by a third party, as a part of the service deal. Possibly, this will allow dealers to focus on their core activity such as selling and improving the customer experience with the brand.

Success story from the literature. In the reviewed literature, another instance of effective management of a strategic RL program was discussed, along with a case study of the global technology company Cisco Systems Inc. The study claims that Cisco approached RL as a cost center and treated almost all of its returned equipment as scrap, which repeats the case of the focal company. However, Cisco was able to turn its RL function into a $100,000,000 profit center in just a few years. Discovery, planning, a pilot program, and transformation were the four stages of the transformation process (Wilson & Goffnett, 2021).

To better understand the opportunities in its product returns operations, Cisco commissioned a study during the discovery phase. This study revealed that many of Cisco's product labs were ordering new versions of the same units as returns. This indicated a chance to close the loop on these product flows and reuse what Cisco had previously viewed as scrap. By creating a value recovery team to maximize the value of returned products and an asset recovery team to manage customers and streamline the return authorization process, Cisco sought to increase both product recovery and utilization rates during the planning phase (Chandrasekaran, 2009a). At this point, the study presents several similarities that can be drawn with the focal company regarding which issues to prioritize and the methods to resolve them.

In transitioning RL from a cost center to a business unit, Cisco collaborated with its internal finance group to clarify the actual costs and revenues generated from the pilot program. The company developed a proprietary allocation algorithm to maximize gains and deliver the most benefit to customers. The success of the program was driven by the company's foresight and support from senior management. The profit-oriented approach and internal rethinking of product labs as internal customers for used products made the value of the program more appealing to senior management (Chandrasekaran, 2009b). These four phases serve as a prime illustration for the focal organization on how to effectively reutilize its current inventory.

Currently unused potential. The analysis results provided by the RS1 solution confirm and support the presence of unused capability for redistributing buybacks to fulfill backorder demands. Figure 6.6 illustrates that a considerable portion of the existing buyback inventory can be effectively reused for all of the dealers in the selection.

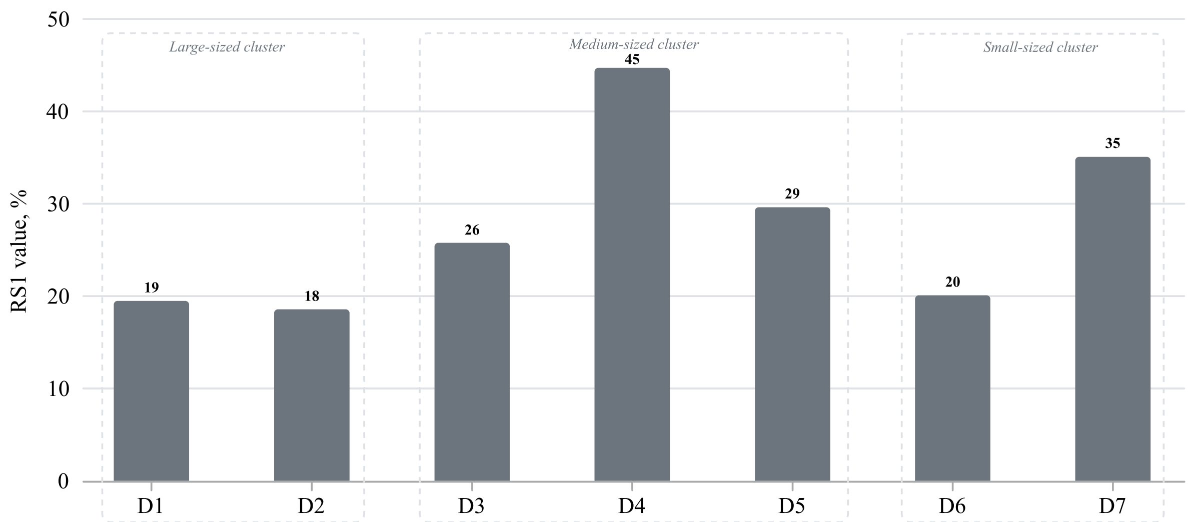

Figure 6.6: Buyback to backorder missed demand in value (RS1)

Large dealers D1 and D2 have a capacity to decrease around 20% of total buyback flows by addressing the backorder demand in the region with the available inventory. Likewise, D3, D5, and D6 were able to match 26%, 29%, and 20% of their buybacks parts with backorders demands, respectively. Notably, D4 and D7 exhibited the highest opportunity for reuse efficiency in addressing backorders, with 45% and 35% respectively. The analysis outcomes align with the findings discovered during the interview sessions and the literature review, indicating that the focal company can significantly reduce lead times for backorders, reduce the returns to the DCs and enhance buyback circularity efforts.

6.3 Building the Efficient Recycle Infrastructure

In the context of CE, recycling is considered as the least desirable option, but it remains a critical aspect for every company. The ability to effectively recycle products allows companies to reclaim value from returns by reusing the materials for remanufacturing, which is a key success factor for RL (Butzer et al., 2017). Furthermore, disposing of scrap in an environmentally friendly manner can significantly enhance the sustainability of the entire system and facilitate a truly CLSC. The insights on scrap value could be obtained by analyzing RC1 solution. The Figure 6.7 illustrates the RC1 values among the selection of the dealers. The interpretation of the results will be referring to Table 5.7.

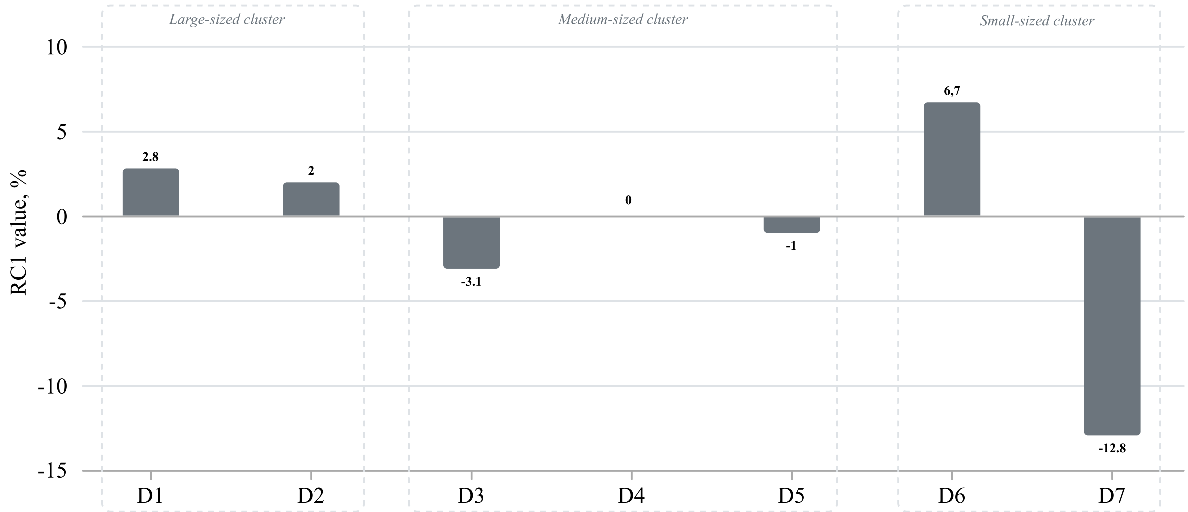

Figure 6.7: Scrap to total buyback value, period-over-period (RC1)

Although D1 and D2 represented a general trend of decreasing the total buybacks value in current period, there has been an increase in the proportion of parts scrapped compared to the previous period. D1 experienced a 2.8% increase, while D2 a 2% increase. Yet, when considering the scrap value ratio in relation to the total buyback volumes, both D1 and D2 have relatively low scrap ratios compared to other samples in the selection.

In contrast, the total value of scrap is significantly higher for D1 and D2, primarily because of the larger part volumes that these dealers operate with. Interestingly, the D1 and D2 also scrapped some of the most expensive parts of the entire selection. This observation requires further analysis to detect the underlying reasons for the increased scrap. Furthermore, the results imply that additional analysis is needed to identify the cause of increased scrap value, as both samples showed a decrease in total buyback value. It indicates that the system may have overstocked these dealers with low-cost parts.

The pattern is more positive for the medium-sized group, where D3 and D5 managed to decrease their proportion of scrap value by 3.1% and 1% respectively. At the same time, D4 maintained the value on the same level. In general, this trend aligns with the dynamics observed in the P1 value, where D3 and D5 saw a reduction in relative total buyback value, while D4 experienced growth. Given that D5 displayed a relatively weaker decrease in RC1 compared to D3, its total scrap value ended up being higher, even though D3 observed a stronger decline in P1. Same as larger dealers, D4 scrapped relatively expensive parts, which again requires detailed analysis.

The analysis of the small-sized dealers discloses an interesting trend. Even though both D6 and D7 experienced an increase in total buyback value, the proportion of scrap value is not consistent between the two. Specifically, the D6 shows a strong development in RC1, suggesting an increased scrap value. Whereas, D7 presents an even stronger decrease, suggesting that the system overstocked D6 with cheaper parts, compared to D7.

To summarize, the RC1 solution outcomes reveal a division among the samples, with nearly half undergoing an increase in scrap value ratio and the other half experiencing a decrease. Meanwhile, the smaller-sized dealers demonstrated more significant variation compared to the other groups. Another influential insight is the occurrence of dealers scrapping extremely expensive parts. This underscores once more the need for a comprehensive inspection and adjustment of the system to mitigate such incidents in future periods. The mean scrap value of the parts remains consistent throughout the selection, with only a slight deviation for D4, suggesting the general stability of the scrap identification system.

Scrap on the dealer. Several interview participants criticized the current dealer scrap reporting system. Concerns about assurances that the waste from buyback parts would not just end up in a landfill or that all necessary parts were scrapped are raised by this issue. This is especially problematic for smaller dealers in remote areas who may lack the financial resources to establish recycling stations or coordinate with third-party services for recycling. To tackle this issue, it is necessary to develop a set of recycling standards or policies for the dealers that will clearly outline the best recycling procedures to adhere to.

Returning all scrap. In light of the limitations of the current scrap reporting process, returning all scrap to the DC for proper handling may be a viable alternative. By doing so, Volvo Group can extract materials for remanufacturing or ensure environmentally responsible disposal under its direct control. This approach would require significant engagement from suppliers to refurbish scrap materials and could establish a strategic partnership with upstream chain players (Butzer et al., 2017). However, it remains uncertain whether transporting these parts to the CDC in Lyon for recycling or remanufacturing is financially and environmentally feasible, particularly given the distance of some dealers from the CDC. Consideration of LCC will also be necessary in assessing the viability of this approach.

Life cycle costing. LCC considers the total cost of producing, operating, maintaining, and disposing of a spare part over its entire life cycle (European Commission, 2002). By evaluating all these costs, LCC will allow a more explicit estimation of the total cost of the part, which can help to better understand the real value of scrap and make more informed choices regarding scrap management. By considering the LCC, the scrap real value can increase substantially, providing stakeholders with greater profit-related incentives to pay closer attention to the scrap management process.

Environmental impact estimation. While Volvo Group has responsible purchasing and environmental impact assessment systems in place, creating a comprehensive system to fully assess all factors such as CO_2 emissions from scrapping every single part would be extremely resource-intensive, given the level of supplier confidentiality and the number of suppliers and parts involved. Such a project would require significant investments of time, money, and human resources, and given that recycling provides the least benefit for all actors involved, it may have not enough organizational capacity to be executed successfully.

Chapter 7. Conclusion

This final chapter presents analytical solution, as well as analysis of its outcomes, developed based on the identified driving factors, organizational characteristics, ongoing projects, and potential areas of improvements through an analysis of the "as is" state of the buyback system within the RL of the focal company. The structure of this chapter is based on addressing the research questions, highlighting the contributions made in this thesis, and discussing future research possibilities.

The objective of this study was to form an analytical solution to evaluate the untapped opportunities for enhancing the circularity performance of the buyback policy of the focal company. Using qualitative research methods, significant areas of improvement were distinguished, and participants from different departments and corporate positions provided valuable insights. This diverse range of perspectives ensured an in-depth understanding of the challenges faced at all levels of the system, from strategy to operation. The study's quantitative analysis allowed to quantify the untapped capacity of buyback circularity performance, by applying the identified analytical solution to the selection of distinct dealers. The findings are intended to grant stakeholders valuable insights to align the current system's capabilities with a desired financial and environmental performance by exploiting the available data to its maximum.

7.1 Research Question 1

The selection of the appropriate performance metrics and analytical solutions was informed by the findings of the initial investigation into the current state of the buyback policy. The first research question: **"*What are the current areas of improvement of circularity of the buyback policy in the focal company?*"** describe the structure of the buyback process and finds areas for potential improvement and optimization.

The research revealed that the buyback policy is an integral part of the LPA automatic refill system and plays a significant role in the strategic operations of the Volvo Group SML department, which is responsible for spare parts distribution. The interviews and analysis showed that the buyback policy contributes to the achievement of several strategic goals of the LPA system. These include improving dealer cash flow by minimizing excess inventory and increasing customer and dealer satisfaction by improving part availability and reducing lead times.

The study outlines three main drivers that influence the buyback return flows: the diversity of parts managed by dealers, and their profile characteristics such as size, steering, and behavior. These factors directly impact the volumes and value of the buyback returns, which can vary significantly among dealers. These drivers are fixed and cannot be changed through system optimization but must be addressed to ensure inventory balancing. The DIM department is responsible for managing the risk between parts pushed by the LPA system and the buyback returns.

The primary outcome of the first research question was the identification of prospective improvement areas, which could be categorized into several factors and sub-factors:

- **General corporate perception of the buyback policy**
    - *The difference in approach across the organization* – the departments that work closely with the dealers possess a more positive perception compared to other partly-engaged departments that could sometimes perceive buyback performance in silos.
    - *System setup shortcomings* – legacy system rules reached its efficiency limit given the current business environment.
    - *Dealer segmentation is not considered* – the various dealer profiles are treated by the single system setup without considering important dealer features.
    - *Line value of buybacks* – parts selection criteria that are eligible for buyback has to be revised.
    - *An insufficient incentive to stimulate change* – there is currently not enough organizational capacity diverted to ensure effective balancing of the system setup.
- **Redistribution efficiency**
    - *Alignment of buybacks with outstanding backorders* – there is currently no established informational system to track and match buybacks with outstanding backorders in the same region, which limits the redistribution efficiency.
    - *Broken package limitation* – system constraints prevent almost complete packs from redistribution, identifying them as scrap, regardless of the line value.
    - *Reconfigurable parts limitation* – some parts that could be redistributed and reconfigured by another dealer are identified as scrap due to misinterpretation of statuses.
    - *Supersession parts limitation* – system limitation prevents complete parts from being redistributed, identifying them as scrap.
    - *Transportation cost* – currently the buyback transportation cost is limited to global expenses, thus misrepresenting its real value.
    - *Ambiguous final handling* – Pre-planning efficiency for the buyback handling is currently not assessed. Additionally, there is a lack of visibility in subsequent redistribution after the parts have undergone final processing at the distribution center.
- **Scrap efficiency**
    - *Life cycle costing considerations* – current procurement rules prioritize minimizing handling costs, which results in a limited evaluation of the complete cost related to scrapping a part throughout its entire life cycle, including production, distribution, and disposal.
    - *Current scrap monitoring* – the dealers are allowed to scrap parts on-site by providing photo-proof to Volvo Group. However, this approach fails to ensure complete control over the disposal procedure.
    - *Environmental impact estimation* – at present, there is no established system to take into consideration the composition of the scrapped parts, resulting in a lack of visibility of their potential environmental impact.

The challenges that were determined in the first research question formed the basis for discovering performance metrics and developing an analytical solution in the second research question.

7.2 Research Question 2

As has been repeatedly emphasized in the literature and by several participants, the importance of metrics in operational success cannot be underestimated. An established performance measurement system allows a company to find applications for the data generated and collected. Without a robust analytical solution, the unstructured data is not suitable to afford additional value. Yet, if the organization will succeed in capturing the value, it will be able to reduce uncertainties and complexities related to the buyback flow. This, if effectively combined with the CE concepts, allows for securing a superior buyback circularity performance and sustained competitive advantage. The outcome of the second research question: ***"What analytics should be implemented to measure the efficiency of circularity in buyback flows?"*** aims to provide a specific measurement system to satisfy those needs.

The buyback drivers, areas for improvement and existing solutions in combination with a stakeholder's desired state vision allowed to creation of a solid base for establishing performance metrics. The identified set of metrics was supplemented with additional data points that together form an analytical solution that allows achieving a full data layer for the completeness of the information. The analytical solution consists of the following metrics:

1. *Buyback value to total stock value, period-over-period (P1)* – generates insight into the dynamics of the proportion of buyback value within the dealer's total stock value, enabling general normality monitoring, historical trend exploration and benchmarking with similar dealers. The solution also includes additional analytics, that provides a breakdown of the relative buyback value dynamics by type.
2. *Buyback part quantity to total LPA pushed part quantity (P2)* – monitors the effectiveness of the LPA system, by calculating the ratio of buyback parts in the current period to pushed parts from a previous period.
3. *Buyback to backorder missed demand in value (RS1)* – quantifies the unused opportunities for fulfilling outstanding backorders with existing buyback flows.
4. *The proportion of non-returned buybacks (RS2)* – allows to monitor to what extent dealers comply with a buyback procedure in terms of returning the proposed parts.
5. *Buyback forecast accuracy (RS3)* – aims to control the accuracy of buyback pre-planning by measuring the mean absolute difference between forecast and actual results.
6. *Scrap value to total buyback value, period-over-period (RC1)* – aims to illustrate the dynamics in a proportion of scrap within the total buyback flow, enabling general normality monitoring, historical trend exploration and benchmarking with similar dealers.

7.3 Research Question 3

In the final step of this study, the practical relevance of the analytical solution was validated and integrated into the primary empirical findings. The analytical solution was applied to analyze three distinct groups of dealers with varied profiles, securing the relevance and applicability of the analytic solution findings.

The answer to the final research question: ***"What is the circularity performance of distinct dealers with varied profiles within a specific market when the proposed analytical solution is applied?"*** aims to reveal a detailed overview of the current circularity performance of various dealers, as well as develop valuable insights into the efficiencies or inefficiencies of their operational activities. This not only validates the proposed analytical solution based on historical data but also quantifies the output of the first two research questions. The outline of the main outcomes provided by each metrics analysis is presented below:

- **Outcomes of P1(a) and P1(b)**

The P1(a) analysis revealed successful prevention of buybacks by large-sized dealers, suggesting adequate functioning of the refill system within the group. The middle-sized group represented consistent volumes of buyback flow, influenced by sales trends, parts availability rate, and disproportions in obsolete stock levels. In contrast, the smaller-sized group experienced the greatest excess in buyback volumes, indicating their exposure to buyback risks. These findings outline the significance of establishing dealer segmentation strategies that will address demand volatility and complexities in slow-moving parts management.

The P1(b) analysis disclosed a drop in buybacks that were pushed by the system for both the large and medium-sized dealer groups, supporting the earlier finding in P1(a) related to an effective operation of the refill system for these dealers. Both smaller dealers, one relying on the refill system and the other making manual purchases, ended up overstocked. This emphasizes the need of optimizing the refill procedures specifically for smaller dealers.

- **Outcomes of P2**

The analysis of P2 allowed to address two aims at once: assess the efficiency of the refill system, as well as benchmark dealers participating in the pilot aimed at preventing buybacks with those not included in the project. In general, pilot dealers observed improved performance in preventing buybacks across various size groups. The effect of the pilot varied depending on several factors, including but not limited to deviation in sales volume, ratios of slow-moving parts, and the proportion of pushed parts. Notably, smaller dealers that a prone to a higher buyback risk, benefited from the pilot, suggesting its effectiveness in preventing buyback flows through optimization of the refill system.

- **Outcomes of RS1**

The findings from RS1 are in line with the information obtained during the interview sessions and literature review, suggesting that addressing the backorder demand using the existing buyback inventory creates a significant opportunity to reduce backorder lead times, decrease buyback returns to distribution centers, as well as improve overall buyback circularity.

- **Outcomes of RS2**

The outcomes of RS 2 imply that dealers tend to hold manually purchased parts more often than ones pushed by the system. The underlying logic is based on the lower risk of losing the higher compensation right for manual parts, as well as specific stocking strategies that are individual for each dealer. The adherence to the buyback procedure is not consistent among dealers of different sizes, whereas smaller dealers were prone to hold more precise control over the returns given their relationships with end customers and understanding of demand.

- **Outcomes of RS3**

The RS3 disclosed a significant absolute error in the buyback forecasting estimation, which results in difficulties in generating adequate return centers preplanning. The observations yielded suggest that there is a need for reviewing and improving the forecasting model. One of the suggested approaches is to involve the outcomes generated by the metric to model training, allowing for improved accuracy in future estimations.

- **Outcomes of RC1**

The RC1 revealed a 50/50 split among the samples, with about half showing a rise in scrap value and the other half observing a decline. The dealers experiencing a positive trend in scrap value may be subject to a potential overstocking with cheaper parts. The occurrences of scrapping expensive parts emphasize the lack of a comprehensive system to minimize such incidents. Finally, the mean scrap value rests stably across the selection, denoting that the system is capable of holding the line value balance.

7.4 Limitations and Further Research

The thesis has demonstrated that the buyback system is complex and involves multiple departments and stages within the supply chain. This system presents challenges at various levels of the organization, from operational to tactical. Due to the complexity of the system, it is not possible to address all aspects of circularity performance within the context of this research. Therefore, there are numerous possible directions for future research in this area.

First and foremost, the research for this thesis only focused on the current problems, producing a snapshot of the current state. However, the Volvo Group is a dynamic company that is constantly evolving, and new projects may render some of the metrics and solutions irrelevant. Therefore, a second study should be conducted to assess the future efficiency of the system and benchmark it against the results presented in this thesis. The goal of this second study would be to make sure that the metrics and solutions continue to be applicable over time and to track the effectiveness of efforts made to optimize the system.

The thesis is limited in its scope to only one of the seven types of returns that Volvo Group SML handles. A similar study could be conducted, which will concentrate on the other kinds of returns. In particular, an intriguing and significant topic of investigation would be the circularity of battery returns. These parts demand more attention compared to other parts eligible for buybacks, as they contain highly toxic materials with a substantial environmental impact when improperly disposed of. Another interesting aspect to consider is the scarce minerals that the batteries contain. This outlines the elevated significance of circularity aspects, as these minerals could be depleted. In that way, an analysis of battery returns' circularity would prove to be highly beneficial for the organization's environmental and financial performance.

Further research is warranted due to the scope limitation of the current study, which focused solely on one market. Conducting a study that includes dealers from multiple markets could shed light on the cultural, market environment, and regulatory factors that impact the buyback system's circularity performance. An international study would offer new perspectives and valuable insights into the system's optimization, allowing for a more comprehensive understanding of the challenges and opportunities for improvement.

The thesis focused primarily on operational-level challenges within the buyback system, and further research could delve into the tactical and strategic aspects of the system. For example, a study could explore strategies for balancing profitability and sustainability and overcoming corporate inertia towards sustainability initiatives. Alternatively, the research could examine additional revenue streams that could be generated by implementing circular economy and sustainability concepts within the RL process, such as green taxation.

Avenues for further research include replicating this study in a different automotive company or even in a different industry, as the relevant literature indicates a significant gap in this area. Such a study could be used for benchmarking purposes in comparison with the findings of this thesis.

References

Bai, C., & Sarkis, J. (2014). Determining and applying sustainable supplier key performance indicators. Supply Chain Management, 19(3), 275–291. https://doi.org/10.1108/scm-12-2013-0441

Basili, V. R., Caldiera, G. & Rombach, D. H. (1994). The Goal Question Metric Approach. John Wiley & Sons.

Batista, L., Bourlakis, M., Smart, P., & Maull, R. (2018). In search of a circular supply chain archetype – a content-analysis-based literature review. Production Planning & Control, 29(6), 438–451. https://doi.org/10.1080/09537287.2017.1343502

Bell, E., Bryman, A., & Harley, B. (2019). Business Research Methods (5th ed.). Oxford University Press.

Blaxter, L., Hughes, C., & Tight, M. (1996). How to Research. http://ndl.ethernet.edu.et/bitstream/123456789/41461/1/20.pdf.pdf

Bocken, N., Short, S. W., Rana, P., & Evans, S. D. (2013). A value mapping tool for sustainable business modelling. Corporate Governance, 13(5), 482–497. https://doi.org/10.1108/cg-06-2013-0078

Bovea, M. D., & Vergara, M. (2018). Identifying design guidelines to meet the circular economy principles: A case study on electric and electronic equipment. Journal of Environmental Management, 228, 483–494. https://doi.org/10.1016/j.jenvman.2018.08.014

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Burrell, G., & Morgan, G. J. (2017). Sociological Paradigms and Organisational Analysis. In Routledge eBooks. https://doi.org/10.4324/9781315242804

Butar, M. B., Sanders, D. S., & Frei, R. (2016). Measuring Performance of Reverse Supply Chains in a Carpet Manufacturer. Journal of Advanced Management Science, 152–158. https://doi.org/10.12720/joams.4.2.152-158

Butzer, S., Schötz, S., Petroschke, M., & Steinhilper, R. (2017). Development of a Performance Measurement System for International Reverse Supply Chains. Procedia CIRP, 61, 251–256. https://doi.org/10.1016/j.procir.2016.11.264

Calzolari, T., Genovese, A., & Brint, A. (2021). Circular Economy indicators for supply chains: A systematic literature review. Environmental and Sustainability Indicators, 13, 100160. https://doi.org/10.1016/j.indic.2021.100160

Carbone, V., & Moatti, V. (2008). Greening the Supply Chain: Preliminary Results of a Global Survey. Supply Chain Forum, 9(2), 66–76. https://doi.org/10.1080/16258312.2008.11517200

Carter C.R. & L.M. Ellram (1998), Reverse logistics: a review of the literature and

Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: moving toward new theory. International Journal of Physical Distribution & Logistics Management, 38(5), 360–387. https://doi.org/10.1108/09600030810882816

Castellani, V., Sala, S., & Mirabella, N. (2015). Beyond the throwaway society: A life cycle-based assessment of the environmental benefit of reuse. Integrated Environmental Assessment and Management, 11(3), 373–382. https://doi.org/10.1002/ieam.1614

Chan, F. T., Qi, H. R., Chan, H., Lau, H. C. W., & Ip, R. W. (2003). A conceptual model of performance measurement for supply chains. Management Decision, 41(7), 635–642. https://doi.org/10.1108/00251740310495568

Chandrasekaran, S. (2009a). Turning end of life product reprocessing into a profit center at Cisco Systems - Part A. Stanford School of Engineering, [Case Study MS&E-001-2009].

Chandrasekaran, S. (2009b). Turning end of life product reprocessing into a profit center at Cisco Systems - Part B. Stanford School of Engineering, [Study MS&E-002-2009].

De Brito, M. P., & Dekker, R. (2002). A Framework for Reverse Logistics. ERIM Report Series Reference No. ERS-2003-045-LIS. https://ssrn.com/abstract=423654

Deloitte. (2014). Why reverse logistics needs a dedicated channel. Retrieved May 21, 2023, from https://www2.deloitte.com/content/dam/Deloitte/us/Documents/process-and-operations/us-cons-moving-forward-inreverse-091714.pdf

Demestichas, K., & Daskalakis, E. (2020). Information and Communication Technology Solutions for the Circular Economy. Sustainability, 12(18), 7272. https://doi.org/10.3390/su12187272

Dey, A., LaGuardia, P., & Srinivasan, M. (2011). Building sustainability in logistics operations: a research agenda. Management Research Review, 34(11), 1237–1259. https://doi.org/10.1108/01409171111178774

Dowlatshahi, S. (2005). A strategic framework for the design and implementation of remanufacturing operations in reverse logistics. International Journal of Production Research, 43(16), 3455–3480. https://doi.org/10.1080/00207540500118118

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. Academy of Management Review, 14(4), 532. https://doi.org/10.2307/258557

Ellinger, A. E., Daugherty, J., & Gustin, C. M. (1997). The relationship between integrated logistics and customer service. Transportation Research Part E: Logistics and Transportation Review, 33(2), 129–138.

European Commission. (2002). Life-cycle costing (LCC) - Fact sheet. In European Commission. Retrieved May 28, 2023, from https://ec.europa.eu/environment/gpp/pdf/toolkit/module1_factsheet_lcc.pdf

European Commission. (2008). Waste prevention and management. Retrieved May 28, 2023, from https://ec.europa.eu/environment/green-growth/waste-prevention-and-management/index_en.htm

European Council. (2023, February 7). Climate change: What the EU is doing. Retrieved May 21, 2023, from https://www.consilium.europa.eu/en/policies/climate-change/

Farooque, M., Zhang, A., Thürer, M., Qu, T., & Huisingh, D. (2019). Circular supply chain management: A definition and structured literature review. Journal of Cleaner Production, 228, 882–900. https://doi.org/10.1016/j.jclepro.2019.04.303

Fayyad, U. M. (1997). Knowledge discovery in databases: An overview. In Lecture Notes in Computer Science (pp. 1–16). Springer Science+Business Media. https://doi.org/10.1007/3540635149_30

Ferrer, G., & Whybark, D. C. (2000). From garbage to goods: Successful remanufacturing systems and skills. Business Horizons, 43(6), 55–64. https://doi.org/10.1016/s0007-6813(00)80023-3

framework for future investigation, Journal of Business Logistics, 19(1):85-102.

Ganesan, E., & Paturi, R. (2009). Key Performance Indicators Framework - A Method to Track Business Objectives, Link Business Strategy to Processes and Detail Importance of Key Performance Indicators in Enterprise Business Architecture. Americas' Conference on Information Systems, AMCIS 2009 Proceedings (736). https://core.ac.uk/download/pdf/301348541.pdf

Gerring, J. (2004). What Is a Case Study and What Is It Good for? American Political Science Review, 98(2), 341–354. https://doi.org/10.1017/s0003055404001182

Gerring, J. (2016). Case Study Research. Cambridge University Press. https://doi.org/10.1017/9781316848593

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. Journal of Cleaner Production, 114, 11–32. https://doi.org/10.1016/j.jclepro.2015.09.007

Gil, M., & Sousa, D. C. (2010). Using Key Performance Indicators To Facilitate The Strategy Implementation And Business Process Improvement in SME's. https://doi.org/10.5220/0002886501930197

Goffin, K., & Mitchell, R. (2016). Innovation Management: Effective Strategy and Implementation. Bloomsbury Publishing.

Guide, V. D. R., & Wassenhove, L. N. V., Jr. (2002). The Reverse Supply Chain. Harvard Business Review, Sustainable Business Practices. http://hbr.org/2002/02/the-reverse-supply-chain

Gullo, F. (2015). From Patterns in Data to Knowledge Discovery: What Data Mining Can Do. Physics Procedia, 62, 18–22. https://doi.org/10.1016/j.phpro.2015.02.005

Hollander, M. D., Bakker, C., & Hultink, E. J. (2017). Product Design in a Circular Economy: Development of a Typology of Key Concepts and Terms. Journal of Industrial Ecology, 21(3), 517–525. https://doi.org/10.1111/jiec.12610

Hultman, J., & Corvellec, H. (2012). The European Waste Hierarchy: From the Sociomateriality of Waste to a Politics of Consumption. Environment and Planning A, 44(10), 2413–2427. https://doi.org/10.1068/a44668

Jayaraman, V., Guide, V. D. R., & Srivastava, R. (1999). A closed-loop logistics model for remanufacturing. Journal of the Operational Research Society, 50(5), 497–508. https://doi.org/10.1057/palgrave.jors.2600716

Jović, M., Schlierf, J. F., Heinen, B., & Tijan, E. (2020). Information management in Reverse logistics. Pomorski Zbornik, 58(1), 155–167. https://doi.org/10.18048/2020.58.10

Kaplan, R. S., & Norton, D. P. (1992). The Balanced Scorecard - Measures that Drive Performance. Harvard Business Review Magazine. https://hbr.org/1992/01/the-balanced-scorecard-measures-that-drive-performance-2

Kirchherr, J., Reike, D., & Hekkert, M. P. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. Resources Conservation and Recycling, 127, 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005

Korhonen, J., Honkasalo, A., & Seppälä, J. (2018). Circular Economy: The Concept and its Limitations. Ecological Economics, 143, 37–46. https://doi.org/10.1016/j.ecolecon.2017.06.041

Kovács, G., & Spens, K. (2005). Abductive reasoning in logistics research. International Journal of Physical Distribution & Logistics Management, 35(2), 132–144. https://doi.org/10.1108/09600030510590318

Kuei, C. (2005). Principles of Supply Chain Management – A Balanced Approach. International Journal of Quality & Reliability Management, 22(3), 329–330. https://doi.org/10.1108/02656710510582525

Kumar, S., & Putnam, V. (2008). Cradle to cradle: Reverse logistics strategies and opportunities across three industry sectors. International Journal of Production Economics, 115(2), 305–315. https://doi.org/10.1016/j.ijpe.2007.11.015

Lara, J. M. G., Lizcano, D., Martínez, M., & Pazos, J. B. (2014). Data preparation for KDD through automatic reasoning based on description logic. Information Systems, 44, 54–72. https://doi.org/10.1016/j.is.2014.03.002

Larsen, S. B., & Jacobsen, P. (2016). Revenue in reverse? An examination of reverse supply chain enabled revenue streams. International Journal of Physical Distribution & Logistics Management, 46(8), 783–804. https://doi.org/10.1108/ijpdlm-03-2015-0054

Linton, J. D., Klassen, R. D., & Jayaraman, V. (2007). Sustainable supply chains: An introduction. Journal of Operations Management, 25(6), 1075–1082. https://doi.org/10.1016/j.jom.2007.01.012

Liu, K. Y. (2022). Supply Chain Analytics: Concepts, Techniques and Applications. Palgrave Macmillan.

MacArthur, Ellen et al. (2013). "Towards the circular economy". In: Journal of Industrial Ecology 2, pp. 23–44.

Maheswari, H., Yudoko, G., Adhiutama, A., & Agustina, H. (2020). Sustainable reverse logistics scorecards for the performance measurement of informal e-waste businesses. Heliyon, 6(9), e04834. https://doi.org/10.1016/j.heliyon.2020.e04834

Mansilla-Obando, K., Jeldes-Delgado, F., & Guiñez-Cabrera, N. (2022). Circular Economy Strategies with Social Implications: Findings from a Case Study. Sustainability, 14(20), 13658. https://doi.org/10.3390/su142013658

Mazahir, S., Lassagne, M., & Kerbache, L. (2011). Reverse Logistics and Push-Pull Manufacturing Systems: The Case of Electronic Products. Supply Chain Forum, 12(2), 92–103. https://doi.org/10.1080/16258312.2011.11517263

Meade, L., Sarkis, J., & Presley, A. (2007). The theory and practice of Reverse Logistics. International Journal of Logistics Systems and Management, 3(1), 56. https://doi.org/10.1504/ijlsm.2007.012070

Mendes, R., Vasconcelos, A., Caetano, A., Neves, J., Sinogas, P., & Tribolet, J.M. (2001). Representing Business Strategy through Goal Modeling. International Conference on Enterprise Information Systems.

Murray, A., Skene, K. R., & Haynes, K. (2017). The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context. Journal of Business Ethics, 140(3), 369–380. https://doi.org/10.1007/s10551-015-2693-2

Parmenter, D. (2019). Key Performance Indicators: Developing, Implementing, and Using Winning KPIs. John Wiley & Sons.

Potting, J., Hekkert, M.P., Worrell, E., & Hanemaaijer, A. (2017). Circular Economy: Measuring Innovation in the Product Chain.

Presley, A., Meade, L., & Sarkis, J. (2007). A strategic sustainability justification methodology for organizational decisions: a reverse logistics illustration. International Journal of Production Research, 45(18–19), 4595–4620. https://doi.org/10.1080/00207540701440220

Principles of Supply Chain Management – A Balanced Approach. (2005). International Journal of Quality & Reliability Management, 22(3), 329–330. https://doi.org/10.1108/02656710510582525

Qorri, A., Mujkić, Z., & Kraslawski, A. (2018). A conceptual framework for measuring sustainability performance of supply chains. Journal of Cleaner Production, 189, 570–584. https://doi.org/10.1016/j.jclepro.2018.04.073

Ravi, V., & Shankar, R. (2005). Analysis of interactions among the barriers of reverse logistics. Technological Forecasting and Social Change, 72(8), 1011–1029. https://doi.org/10.1016/j.techfore.2004.07.002

Renault Trucks. (2022). Sustainability. Renault Trucks Corporate. Retrieved May 21, 2023, from https://www.renault-trucks.com/en/about-renault-trucks/sustainability

Rhein, S., & Sträter, K. F. (2021). Corporate self-commitments to mitigate the global plastic crisis: Recycling rather than reduction and reuse. Journal of Cleaner Production, 296, 126571. https://doi.org/10.1016/j.jclepro.2021.126571

Rubio, S., Chamorro, A. C., & Miranda, F. J. (2008). Characteristics of the research on reverse logistics (1995–2005). International Journal of Production Research, 46(4), 1099–1120. https://doi.org/10.1080/00207540600943977

Salami, M. S., Eslamipirharati, M., Bakhshi, A., Aghsami, A., Jolai, F., & Yazdani, M. (2022). Does a Buyback Contract Coordinate a Reverse Supply Chain Facing Remanufacturing Capacity Disruption and Returned Product Quality Uncertainty? Sustainability, 14(23), 15939. https://doi.org/10.3390/su142315939

Sandhata Technologies. (n.d.). Building an outcomes-driven KPI framework. In Sandhata White Paper. Retrieved May 28, 2023, from https://www.sandhata.com/wp-content/uploads/2022/05/Sandhata-Building-Outcome-driven-KPI-framework.pdf

Sarkis, J., & Dou, Y. (2017). Green Supply Chain Management. In Routledge eBooks. https://doi.org/10.4324/9781315233000

Saunders, M. N. K., Thornhill, A., & Lewis, P. (2012). Research Methods for Business Students (6th ed.). Pearson Education.

Shaik, M. R., & Abdul-Kader, W. (2014). Comprehensive performance measurement and causal-effect decision making model for reverse logistics enterprise. Computers & Industrial Engineering, 68, 87–103. https://doi.org/10.1016/j.cie.2013.12.008

Sloan, V. (2010). Measuring the Sustainability of Global Supply Chains: Current Practices and Future Directions. University of Massachusetts Lowell. http://faculty.uml.edu/tsloan/papers/sloan-jgbm-v6n1-2010.pdf

Stock J. R. (1992). Reverse logistics : white paper. Council of Logistics Management.

Taddei, E., Sassanelli, C., Rosa, P., & Terzi, S. (2022). Circular supply chains in the era of industry 4.0: A systematic literature review. Computers & Industrial Engineering, 170, 108268. https://doi.org/10.1016/j.cie.2022.108268

Thierry, M. C., Salomon, M., Van Nunen, J., & Van Wassenhove, L. N. (1995). Strategic Issues in Product Recovery Management. California Management Review, 37(2), 114–136. https://doi.org/10.2307/41165792

Trivyza, N. L., Rentizelas, A., Oswald, S., & Siegl, S. (2022). Designing reverse supply networks for carbon fibres: Enabling cross-sectoral circular economy pathways. Journal of Cleaner Production, 372, 133599. https://doi.org/10.1016/j.jclepro.2022.133599

Turrisi, M., Bruccoleri, M., & Cannella, S. (2013). Impact of reverse logistics on supply chain performance. International Journal of Physical Distribution & Logistics Management, 43(7), 564–585. https://doi.org/10.1108/ijpdlm-04-2012-0132

Valero, F. A., Pellicer, P. C., Pérez-Perales, D., & Recuerda, A. M. (2021). A Reference Model of Reverse Logistics Process for Improving Sustainability in the Supply Chain. Sustainability, 13(18), 10383. https://doi.org/10.3390/su131810383

Van Solingen, R., & Berghout, E. (1999). The Goal/Question/Metric Method: A Practical Guide for Quality Improvement of Software Development.

Van Weele, A. (2018). Purchasing and Supply Chain Management (7th ed.). Cengage Learning.

Wilson, M. W., & Goffnett, S. P. (2021). Reverse logistics: Understanding end-of-life product management. Business Horizons, 65(5), 643–655. https://doi.org/10.1016/j.bushor.2021.10.005

Yin, R. K. (2009). Case study research: Design and methods. The Canadian Journal of Action Research, 14(1). https://doi.org/10.33524/cjar.v14i1.73

Zink, T., & Geyer, R. (2017). Circular Economy Rebound. Journal of Industrial Ecology, 21(3), 593–602. https://doi.org/10.1111/jiec.12545

Appendices

A. Interview Guide, General Template

General inquiries related to buyback policy

- What is the main goal of buybacks for Volvo? Sharing the risks of demand uncertainty, with dealers? Or is it solely environmental? If yes, how about scrap?
- What drives the buyback volumes? What are the ways to decrease them?
- What are the main challenges for the buyback efficiency?
- The logic is that parts are considered for the buyback only if the company needs them, what is this need then? Active backorders from other dealers?
- What happens if parts are eligible for buyback (no sales for a long period of time & low line value) but the company does not need them? Do they stay as a deadstock at dealers' warehouses?
- What is the main revenue stream for the buybacks, especially considering the whole reverse flow?

Buyback metrics and data

- Are there any financial or sustainability metrics established for the buybacks?
- Was there any work done on that so far?
- What kind of data is currently available on the buybacks? Quantities, parts, costs, locations?
- How good is current reverse flow visibility?
- Is there any analysis of the financial feasibility of redistribution rather than scrapping?
- Is part obsolescence being considered for the buybacks?
- What is the desired state for the buyback analytics?

Scrap and sustainability

- Is there any way to measure CO_2 emissions from the reverse flows?
- What happens with the scrap? Is it just dumped, or the waste is sent somewhere for remanufacturing? How the company controls waste management?
- In the scenario where simply scrapping the part is easier and more financially feasible than returning it to DC, which one is of a bigger interest for the company?
- What happens when parts are delivered back to the sorting center? Are they redistributed or could be scrapped also?

B. Thematic Data Structure