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Packaging solution evaluation at Aurobay

A case study of the packaging solutions at an engine supplier in the automotive industry

Master's thesis in Supply Chain Management

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Abstract

Material flows and logistics systems have gained increasing attention over the last decades, where development towards a more holistic view of the supply chain and capacity utilization is in focus. Businesses today strive to preserve the environment while maintaining economic growth and gaining competitive advantage. The environmental aspect comes with pressure to reduce packaging waste and reuse materials, which have major impacts on the logistics infrastructure. In recent years it has shown that making changes in the materials handling systems can bring both economic and environmental benefits. In today's industries, packaging has an important role as it ensures the quality of the product throughout the transport and enables safe and efficient handlings in the transportation system. In this master's thesis the current packaging and associated systems at a Swedish automotive supplier, Aurobay, are investigated and evaluated, with the purpose to present improvements and alternative packaging solutions with increased performance in costs, sustainability and supply chain efficiency. The thesis is a case study based on a theoretical framework developed through literature studies and empirical findings at Aurobay. The thesis results in the presentation of two alternative packaging systems that increase performance within either transport costs and CO2-emissions, or parts presentation and quality of products, and a third solution where the current system is developed in-plant to improve production performance.

Keywords: *packaging systems, packaging logistics, returnable packaging, disposable packaging, automotive industry.*

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Elina Grape & Ali Salih
Gothenburg, May 2022

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Abbreviations

MCA	– The Multi-Criteria Analysis
PoU	– Point of Use
KPIs	– Key Performance Indicators
TPS	– Toyota Production System
JiT	– Just-in-Time
RTIs	– Returnable Transport Items
B2B	– Business to Business
B2C	– Business to Consumer
VCC	– Volvo Cars Corporation
VLC	– Volvo Logistics Corporation
RoRo	– Roll on Roll Off
V-EMB	– Volvo Standard Packaging (Volvo Emballage)
OIS	– Operator Instruction Sheet

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1. Introduction

In this chapter the area of study and the background of the issue to be investigated is described. The case company is introduced and a problem description is presented along with purpose and aim of the study, research questions and the delimitations of the work.

1.1 Background

Businesses today operate in an increasingly challenging environment as the business environment has become more and more turbulent (Melnyk et al., 2014). With the increasing competition in the markets and more demanding customers, companies need to focus on reducing costs in order to maintain their place in the market (Azevado et al., 2019). This is reflected in the manufacturing industry, where increased product complexity along with high pressures on costs has been a challenge for several years and puts pressure on efficient manufacturing and logistics processes in order to maintain a competitive advantage (Dörnhöfer et al., 2016). The development within global trade during recent years is a trend that has brought attention to the efficiency of the global supply chain (Hood & Young, 2000), and packaging is an important enabler when looking into these challenges. The packaging makes it possible to move goods and products from one part of the world to the other, keeping the products safe and intact throughout the journey, while ensuring a high quality of the product. Packaging also improves handling in terminals and efficient loading on trucks, vessels and other transport means (V. Roso, personal communication, 2021, November 3).

Along with fierce competition and high pressures on costs and efficiencies, companies also face the challenge of redirecting to sustainable operations. The increasing environmental pressure on the economic system forces societies and companies to reconsider their daily activities, one being improving the packaging material usage with the goal to make it more efficient (Coelho et al., 2020). Coelho et al. (2020) mean that packaging in Europe today represents 36% of municipal solid waste and that packaging is a primary user of virgin materials and that in Europe, 40% of virgin plastics and 50% of virgin paper is used for packaging. How and where packaging is used has gained more interest within companies, as the packaging is relevant all the way throughout the supply chain. The way we pack and transport our products is an important factor in becoming more efficient along with reducing the environmental impact.

The pressure on environmentally friendly solutions and sustainable supply chains has brought circular flows and reusable packaging into the automotive industry combined with a focus on using recyclable materials. In the automotive industry it is therefore common to use a pool system of plastic packaging for delivery of parts, as the standardized and customized packaging reduces overall costs and improves reliability and productivity in the handling and usage in assembly lines. The plastic packaging is often used in a closed-loop supply chain, which is referred to as a bi-directional supply chain between sender and receiver and aims to achieve both business related and environmental benefits (Na et al., 2019), and these solutions can be seen as more environmentally responsible. Packaging, and its transportation, is with this as background argued to be strategically important and has significant impacts on the performance of the supply chain. If informed decisions on solutions are implemented it can reduce both supply chain costs along with lowering the environmental impact, and increase the value of packed products (Pålsson, 2018).

1.2 Company description

The thesis is conducted in collaboration with Aurobay. The company is at the start of its journey of being a standalone company acting as a supplier of sustainable engines and hybrid solutions within the automotive industry. The company takes part in creating world-class powertrain solutions for a global market, with a heritage of more than 100 years of continuous powertrain innovation. The company has two production sites, one in Sweden and one in China and for this thesis the factory in Sweden is involved and the one referred to further on. Aurobay has two major customers both situated in Europe, Volvo Cars Torslanda and Volvo Cars Ghent, supplying them with combustion engines, hybrid engines, technical solutions and expertise. The company has its production in Skövde where an engine plant and supporting departments are situated, while the central functions and R&D operate from Gothenburg.

The engine plant in Skövde can be divided into machining factories and assembly lines with a total plant area of roughly 140 000 sqm. The factory inaugurated in 1991 and today has around 1500 employees, where 1400 works in production and 100 works in manufacturing engineering. One of the final products leaving the plant is shown in figure 1, consisting of around 200 different parts. The plant produces approximately 400 000 engines per year.

Figure 1

Finished product from Aurobay: VEP4 engine

1.3 Problematization

The company is in a shift from being owned by, and previously known as, Volvo Cars to becoming an independent actor. This shift comes with challenges and opportunities, one being how to solve their packaging flow both outside and inside of the factory in the most suitable way. Currently the company has a collaboration with Volvo Cars, using their packaging material and supply chain infrastructure. The solution today consists of a pool system of reusable packaging and disposable packaging. The company rents the reusable packaging

system from Volvo Cars Corporation (VCC) but has ownership rights when it comes to operational decisions, such as how the material is placed within the packaging, in which quantities the material should be sent from the supplier and how the packaging is dealt with in-house. The circular pooling system in use is beneficial in terms of volume production and when many article numbers are involved, but does not facilitate a sufficient parts presentation for the assembly line and there are multiple handlings of the packaging required in-house. The current packaging systems together cost about 200 MSEK/year to maintain, making it an important area to evaluate to make sure the outcome is worth the price tag. The supply chain department of Aurobay wants to investigate how the strategies for packaging and transportation should be formed and if better solutions opposed to the current one can be developed. Hence, the company is requesting an evaluation of solutions on the market and a comparison with their current solution.

1.4 Purpose and research questions

The thesis focuses on conducting research on suitable packaging solutions in the automotive industry, regarding both operational use of packaging and the packaging system and its flow. The purpose is to review the current state and evaluate options available to the company to possibly improve the system and usage of packaging. The work aims to present feasible solutions where the flow of packaging from supplier to Aurobay as well as the packaging handling inside the factory is solved in a way that secures the quality of the parts while being efficient in terms of handling and costs, and is in accordance with the company's strategy and philosophy. In order to clarify the purpose of the project and support the work, two research questions have been established:

RQ1. What are the feasible packaging solutions for the company?

In research question 1, the packaging solution of today is analyzed and new solutions are to be presented. The answer to this question will be based on literature on the topic, best practice found in automotive industry and the qualitative data collection.

RQ2. Which is the most suitable packaging solution for the company?

In order to answer research question 2, two sub questions have been stated:

RQ2.1 What are the criteria used to evaluate these alternatives?
RQ2.2 How do each solution rank based on these criteria?

In research question 2, the feasible packaging solutions found in research question 1 are to be evaluated based on criteria, key performance indicators (KPIs) and demands from employees expressed in interviews. This research question aims to provide the company with alternative solutions other than the current one, fulfilling different criteria and therefore being of different value to the company. The most suitable solution is the one where criteria are met and most benefits are seen.

1.5 Delimitations

The thesis is restricted to the case company and focuses on the market of an engine supplier in the automotive industry in Sweden. The supply chain of the packaging material used in circulation of the company is of interest, where inbound movements, from supplier to the

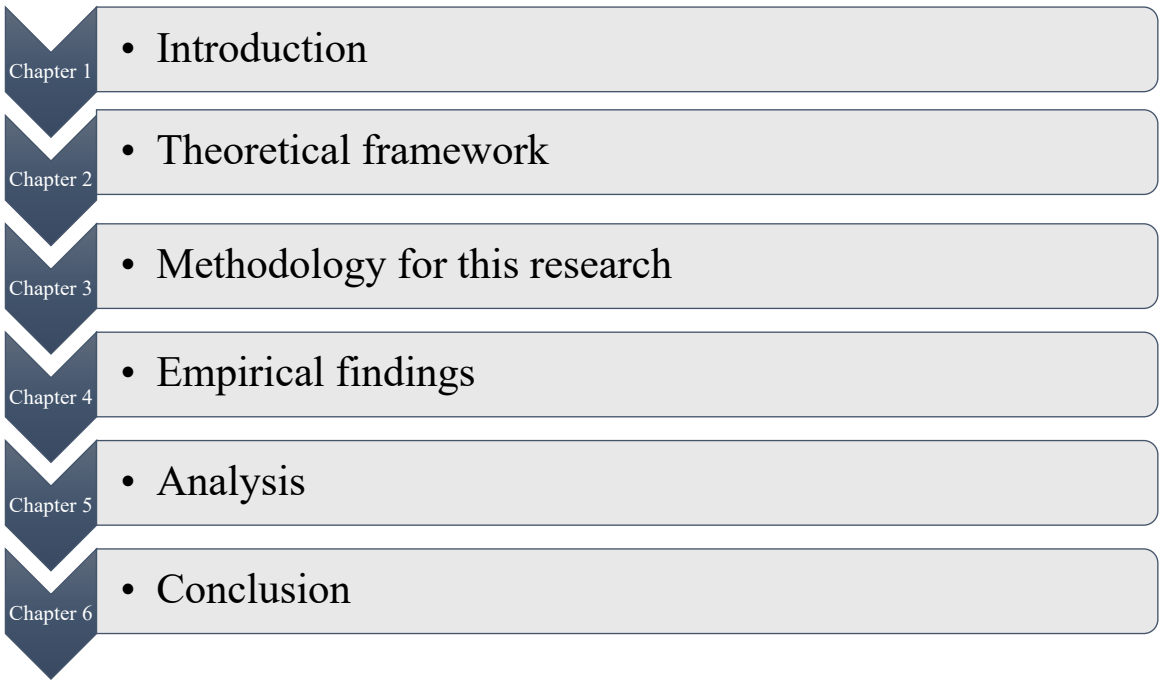
engine plant, is covered but restricted to the boundaries of Europe. Suppliers outside of Europe are not within the scope nor are the outbound deliveries considered. Packaging materials used to provide parts in the assembly line of a combustion engine is looked at where the usage of reusable plastic boxes and disposable packaging are of main interest. The full evaluation of different packaging systems' costs and environmental impact is not part of the scope, only overhead costs are included and anticipated costs and cost savings are presented. The perspective of the purchasing department will not be taken into consideration within this thesis work and there is no stated budget to be considered in the presentation of a solution.

1.6 Thesis outline

The report consists of six chapters, which are organized in the order depicted in figure 2. The introductory chapter gives a brief understanding of the background to the topic the thesis will evolve around, along with a short company description and the problematization which have created the research questions that are presented. Chapter two covers the relevant theoretical background for the subject of the thesis which is summarized in a conceptual model created to assist the researchers' analysis of the findings and process the information from theory and practice. The methodology chapter describes how the study was conducted by the researchers and presents a discussion of the quality of the research. Thereafter, the empirical findings are presented in chapter four, followed by discussions and analysis in chapter five where the theoretical framework is used as tool in answering the research questions. Lastly, concluding remarks and suggestions of future work and research are presented in chapter six.

Figure 2

Chapters of the report



2. Theoretical framework

A literature study is conducted with the purpose to obtain more knowledge of the subject and to understand what is already known on the topic, what concepts and theories have been applied to similar issues and what research methods have been used to study it (Bell et al., 2019). The literature study extends into a theoretical framework with a conceptual model as result. The theoretical framework is a tool to analyze theoretical as well as empirical data, and is presented as sections of importance when looking at the choice of packaging system according to literature. The theoretical framework is concluded in a conceptual model, where the areas of importance are grouped and correlations are clarified.

2.1 Supply chain management of the automotive industry

Typical objectives of logistics within automotive industry are increased quality and cost savings, however, according to Dörnhöfer et al. (2016), the prioritization of cost reduction or enhanced productivity is a common trade-off. The automotive industry has faced several challenges with dealing with heavy cost pressures (Dörnhöfer et al., 2016), therefore, more work is emphasized on increasing the effectiveness of logistics. The automotive supply chain is also known to be sensitive for disruptions, which is due to the increased use of Lean manufacturing in the automotive industry (Reeves, 2007). Interruptions in supply becomes more disruptive due to the Just-in-Time (JiT) shipments, focusing on only producing and shipping what has already been ordered, and lower raw material inventories, thus making the logistics services critical (Reeves, 2007).

A cost-driver within the automobile industry is the expensive raw material and components which require robust packaging to avoid damages and potential waste (Na et al., 2019). This is also supported by Škerlič and Muha (2020) who further argue that packaging management has become a vital issue in automotive logistics due to the industry's cost-cutting pressures and lower profit margins. Circular flows of packaging systems with reusable packaging have received greater attention since costs can be reduced and it enables a more efficient supply chain (Škerlič & Muha, 2020). According to Na et al. (2019), customized packaging in circulation has been proven to not only reduce costs but also improve reliability and productivity in production.

2.1.1 Collaborations within the automotive supply chain

A supply chain extends across several functions and many companies, each with their own goals and priorities. Even though the network is built on multiple companies acting as suppliers and customers to each other, most of them do not worry about their partners while delivering and receiving products or services (Narayanan & Raman, 2004). Decision makers mainly pursue their own local objectives and each firm behaves in a way that maximizes its own interests with the wrong assumptions that this also maximizes the entire supply chain's interests (Narayanan & Raman, 2004). Aligning the incentives of the companies in the supply chain results in increased operational efficiency and has shown to reduce excess inventory, stock-outs, incorrect forecasts and improve sales efforts and customer service (Narayanan & Raman, 2004).

MacDuffie and Helper (2007) present different trends over the past decades that have had an impact on the way companies collaborate within the automotive supply chain. One important being the global competition that, in the automotive industry, began with Japanese

manufacturers being brought to the USA. The globalization came with the need to compete on quality and Lean production. Achieving this increased quality required a more closely coordinated relationship between the supply chain partners (MacDuffie & Helper, 2007). Another trend is the global overcapacity on both automakers and suppliers. The globalization brings new sophisticated suppliers in low-cost countries, resulting in increased price pressures on the market and a greater availability of supplier choice. These trends, together with other factors, have resulted in a higher level of collaborations between the companies and there is an increasing degree of collaboration in automotive supply chains (MacDuffie & Helper, 2007). Companies are with that more commonly operating in consensus with their suppliers and customers, where one of the views mentioned by MacDuffie and Helper (2007) is based on mutual trust. One example of a collaboration with trust is when a company promote horizontal communication and sharing of experience and knowledge between as well supply chain partners as competitors, so called ’best practice’ sharing. This is commonly seen from Japanese automakers, like Toyota, being willing to share their findings and solutions with other companies. This kind of knowledge sharing is a highly strategic collaboration, and more common are horizontal collaborations that can be seen when looking at the logistics and transportation solutions at companies. In the beginning of the 21st century, studies showed that almost a quarter of all vehicles transporting goods in the European Union travel empty and the average loading factor was as little as 57% (Pomponi et al., 2015). The lack of efficiency in logistics along with increasing concerns about climate change led to companies starting to align their logistics activities in order to better manage them (Pomponi et al., 2015).

Horizontal collaborations in logistics can take the form of aligning transport routes, which increases the carrier’s load factor and makes the transport more efficient, and higher frequency of delivery which makes it possible to lower the inventories and with that the warehousing costs (Cruijssen et al. as referenced in Pomponi et al., 2015). Pomponi et al. (2015) mention how the collaboration can take place on different levels at the involved companies, where for example sharing of data and sharing of carriers is on an operational level, while sharing logistics facilities is on a tactical level. Many companies are involved in strategic collaborations where they for example share their order planning to make the variations as small as possible regarding supply and create a resilient flow with little disruptions. These collaborations result in superior performance for all involved parties, which would not be possible to achieve individually. Cruijssen et al. as referenced in Pomponi et al. (2015) point out that horizontal collaborations in logistics is useful to reduce costs and improve productivity, customer service and market position. However, collaborations also come with challenges, and trust is something to be earned. MacDuffie and Helper (2007) further discuss the collaborations that exist with very little or without trust. In collaborations without trust the possibility to switch supplier is not connected with breaking a partnership and it is easier for companies to benchmark the market and choose the supplier with the best offer for the moment being. This is more common where economies of scale and the possibility to squeeze suppliers for every last nickel is of high importance (MacDuffie & Helper, 2007). With the trend of increasing competition and cost pressures this is beneficial for many companies. Although MacDuffie and Helper (2007) predict these supplier relationships will not perform as well as those with trust in the long run, it is not expected to disappear any time soon. Another challenge that come with horizontal collaborations is the need for constant attention, and in some cases, it is necessary to have an adequate governance mechanism to cope with conflicts and to prevent opportunism (Pomponi et al., 2015).

2.1.2 Lean production in automotive industry

There is a common agreement in academics in Lean production's ability to provide competitive advantage and superior performance, thus making it the standard manufacturing mode of the 21st century (Shah & Ward, 2007). According to Sahoo (2020), the concept of Lean is recognized to improve the overall operational performance of a company where it delivers the highest value to the consumer while using the fewest resources possible. The benefits achieved with the Lean philosophy are reduced lead time, inventories and production costs and increased supply chain efficiency and productivity through maximization of workstations (Sahoo, 2020; Azevado et al., 2019). The benefits are a result of the Lean "thinking" where improvement opportunities are gained through constant focus on waste elimination such as transportation, overproduction or other non-value adding processes (Azevado et al., 2019). The elimination of waste is the primary focus of Lean which is achieved through one of its core principles: continuous improvements (Duarte & Cruz-Machado, 2017), with the objective to reduce variations in processes and supply, ultimately resulting in reduced throughput time and accomplishing a continuous flow (Shah & Ward, 2007).

Duarte and Cruz-Machado (2017) explain that adoption of Lean in the supply chain implies close supplier relationships, standardized work, value stream mapping and preventive maintenance. The aim of Lean logistics is to follow the concept of a "pull system" where materials are only delivered when needed through different forms of signals while always pursuing the elimination of waste throughout the supply chain (Baudin, 2004). Furthermore, Baudin (2004) means that inventory is kept at a minimum level to support production, thus only producing according to demand.

According to Alves et al. (2012), the Lean strategy alters the way operators work by constantly challenging them to improve processes and operations. This is achieved through standardization of work and minimized processes and activities, thus visualizing potential improvement opportunities and bringing them up to the surface for easy identification of unnecessary activities. Sahoo (2020) explains that the benefits associated with Lean philosophy are the primary drivers that have led to the implementation of Lean in the automotive manufacturing where it is critical to achieve supply chain efficiency and reduce operational costs.

According to Blomquist et al. (2013), within the Swedish automotive sector, it is frequently maintained that implementing Lean production necessitates the usage of assembly lines. Furthermore, adoption of Lean production has been shown to have negative consequences for a variety of crucial human health aspects, including musculoskeletal problems (Blomquist et al., 2013). The implementation of Lean philosophy in former TPS has resulted in faster production with increased quality at lower costs, which justifies the use of Lean production in the automotive industry (Netland & Aspelund, 2013). As stated by Singh and Modgil (2019), the automotive industry is very energy intensive in the assembly process and procurement of raw material which are primary cost-drivers. Therefore, the authors argue that it is important to identify sources of waste in the automotive supply chain to achieve reduced costs and improved productivity, which can be maintained through the Lean philosophy.

2.2 Reverse logistics and the closed-loop network

Supply chains and logistics have traditionally focused on the one-way flow from raw material to the end-user, often referred to as the forward flow. Over the last decades reverse logistics has gained increased attention where looking at how the goods are moved from the customer towards the producer in a channel of distribution, meaning looking at it the opposite way compared to the traditional forward logistics focus. The reverse flow affects the overall performance of the supply chain and optimizing it increases the value creation (Abdallah, 2017). One of the earliest descriptions of reverse logistics was given by Lambert and Stock in 1981, describing it as ”going the wrong way on a one-way street because the great majority of product shipments flow in one direction” (Lambert & Stock as cited in Rogers & Tibben-Lembke, 2001). Since then, the view on reverse logistics has developed and with today’s focus on environmental issues the area of reverse logistics has begun to take part in all businesses on as well operational as strategic level as it contributes to sustainable developments in the supply chain by for example enhancing the reuse of materials, putting the focus on how we regard waste and source reduction. Rogers and Tibben-Lembke (2001) further write that reverse logistics ”has become a blanket term for efforts to reduce the environmental impact of the supply chain” and emphasizes that efforts to measure and reduce the environmental impact falls under green logistics which includes the entire chain, both forward and reverse, whereas reverse logistics only applies to the flow of products and materials moving from consumer to producer. Integrating the forward and reverse flow in the distribution channel creates a closed-loop supply chain.

The closed-loop network is a chain between a sender and a receiver that aims to achieve both business and environmental benefits, and has gained increasing attention among industries due to the growing interest in sustainable actions and solutions (Na et al., 2019). The closed-loop supply chain includes both the forward and the reverse flow, making it a bi-directional system. It can be classified based on the area of usage, such as production, distribution, use related and end-of-life related returns as the type of return and the return item have major effects on the design and management of the closed-loop network (Hellström & Johansson, 2010). In production and distribution related returns, returnable transport items (RTIs) are used for transport of parts and products and are an important part of the closed-loop chain as they enable the circular flow and reuse of packaging.

Reverse logistics can be divided into two general areas based on whether the flow consists of products or of packaging. In the former we have reasons such as refurbishing, remanufacturing or customer returns while in the latter we commonly see a flow of reusable packaging such as wooden pallets or plastic totes (Rogers & Tibben-Lembke, 2001). In table 1 common distinctions within reverse logistics are put together.

Table 1

Summary of common distinctions within reverse logistics

Material	Common reverse logistics activities	Characterization of items in reverse flows based on their origin	
		Supply chain partners	End users
Products	Return to supplier Resell Sell via outlet Salvage Recondition Refurbish Remanufacture Reclaim materials Recycle Donate Landfill	Stock balancing returns Marketing returns End of life/Season	Defective/Unwanted products Warranty returns Recalls Environmental disposal issues
Packaging	Reuse Refurbish Reclaim materials Recycle Landfill Salvage	Reusable totes Multi-trip packaging Disposal requirements	Reuse Recycling Disposal restrictions

Note: Summary of reverse logistics distinctions. Based on *An examination of reverse logistics practices* (p. 133-134), by D. S. Rogers, and R. Tibben-Lembke, 2001, Journal of business logistics.

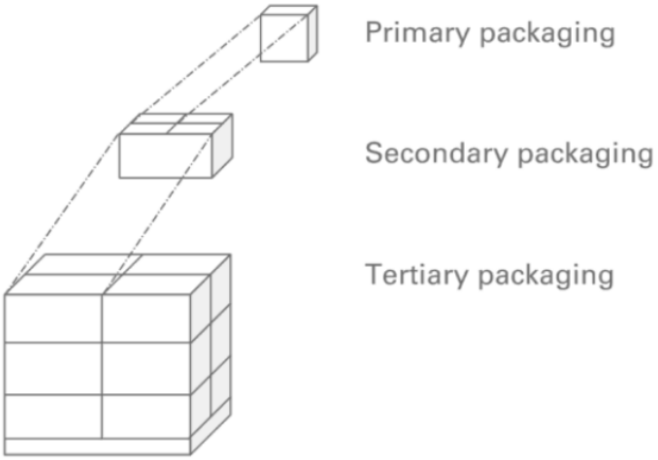
The return rates vary depending on industry where for example product returns are significantly higher within B2C and e-commerce compared to B2B since the customer returns make up a large portion of the total reversed flow. Learning to manage the reverse flow is therefore of high importance for all companies in the supply chain but of significant importance the closer the company is to the end consumer.

2.3 Defining packaging and its purpose

The main purpose of packaging is to protect its content from damage that can occur during transportation, handling and storage, but it can also enable more secure handling systems and a more efficient supply chain (V. Roso, personal communication, 2021, November 3). The packaging can take different forms throughout the supply chain, from being a carton box that the end-consumer holds to being a wooden pallet that the producers and manufacturers use to store and transport products. The packaging also differs depending on which industry we look at and how close to the consumer the product is. Pålsson (2018) explains three levels of the packaging system, figure 3, where the primary packaging is closest to the product and the one that the customer usually handles, the secondary packaging consists of a certain number of primary packages and finally the tertiary packaging can be a pallet or container, holding several secondary packages. Kroon and Vrijens (1995) further clarify this division by explaining the secondary packaging as the material most used for packaging products during transport from a sender to a recipient.

Figure 3

Interrelated levels of a packaging system



Note: Three interrelated levels of a packaging system. Reprinted from *Packaging Logistics: Understanding and managing the economic and environmental impacts of packaging in supply chains* (p.3), by H. Pålsson, 2018, Kogan Page Publishers.

Pålsson (2018) mentions six basic functions that the packaging system should fulfill:

- Protection: to safeguard the content
- Containment: to hold and maintain the content
- Apportionment: to reduce large-scale and high-volume production to manageable sizes
- Unitization: to modularize the packaging levels to obtain material handling- and transport efficiency
- Communication: to identify the packaging in the supply chain and provide product information
- Convenience: to simplify the use of products.

In addition to the six main functions presented by Pålsson (2018), packaging also affects the supply chain in several ways as it interacts with logistics, manufacturing, marketing and information systems (Pålsson et al., 2013). The environment is affected in terms of waste handling and fill rates in transport, where the latter also is a highly economic incentive. Furthermore, the size of the packaging affects warehousing and handling equipment and the design may reduce damage of the product being transported. Additionally, the material supply systems and the point of use (PoU) of the product need to be physically integrated in the workstations, where packaging can contribute to considerable time and cost savings (Pålsson et al., 2013). Hence, it is clear that the choice of packaging plays a key role because of its many interactions throughout the supply chain.

2.3.1 The use of packaging in industry

Due to marketing reasons the packaging design and materials often vary (Coelho et al., 2020). There is a difference between consumer packaging and industrial packaging and moving forward the focus will be on the latter. In industrial packaging the marketing aspects are not

taken into account and the main focus is on providing logistical efficiencies and in recent years also environmental efficiencies (Pålsson, 2018). Another distinction is made between open and closed systems, where the open system includes exchanges with the surrounding environment and often works one-way from the point of filling to the point of sale, and is often referred to as disposable packaging, whereas an example of the closed system is reusable packaging that circulates and creates a closed loop of packaging (Pålsson, 2018). The RTIs circulating in this closed loop are for example pallets and crates, and the automotive industry has broadly adopted this solution and increasingly focuses on developing these systems (Škerlič & Muha, 2020). As early as thirty years ago, solutions with returnable packaging were widely accepted within the automotive industry because of its contributions to reduced waste, costs and potential damage during transport, and today there are numerous studies and simulation models to optimize these system (Škerlič & Muha, 2020). Industries today often combine these systems and apply both reusable packaging and disposable packaging based on the product characteristics and the transport distance between supplier and manufacturer.

2.4 Packaging systems

Packaging systems can be divided into two different types; returnable and disposable (Baudin, 2004). The following section will present a description of reusable and disposable packaging systems followed by a comparison between them and a summary of when and how each system is applied.

2.4.1 Reusable packaging

Reusable packaging can vary in material and unit load but is defined as packaging that can be used several times before it is discarded (Kroon & Vrijens, 1995). A returnable packaging system requires a high initial investment cost in pallets, boxes and equipment, and it brings additional transportation costs since the packaging needs to be transported back to the supplier when emptied (Blomberg & Hallams, 2017). Bowersox et al. as referenced in Blomberg and Hallams (2017) state that the returnable packaging system generally is preferable when the geographical transport distance is short, the turnover rate of packaging is high and the flow consists of large volumes and little variations.

Returnable Transport Items
RTIs is a type of secondary or tertiary packaging that can be reused within the chain, and can be in the form of for example wooden or plastic pallets, plastic boxes, trolleys, containers and trays (de Jong, 2004). RTIs are applicable to both open and closed systems and is commonly used in the automotive industry due to environmental motivations, its reliability and long lifetime in the chain (Na et al., 2019). In the following sections the different types of return logistics systems using RTIs are presented.

RTI control strategies
Three types of return logistics systems can be distinguished: Switch pool systems, systems with return logistics and systems without return logistics (Lützebauer as referenced in Kroon & Vrijens, 1995).

In a switch pool system, the participant owns their own allotment of RTIs and is responsible for these when they are switched between the different participants. The agreement can either be that the number of RTIs are equal at every switch, or that they are equal in the long run. In the first solution the sender, receiver and carrier have responsibility and each pick up at the

sender means a trade of the same amount of RTIs, which the carrier is responsible for checking. The other solution is that only the sender and the receiver have responsibility of the RTIs, and with that the total amount of switches need to be equal in the long run rather than equal at every switch (Kroon & Vrijens, 1995).

Systems with return logistics have a central agency that owns and is responsible for the circulation of RTIs. The main prerequisite in this system is that the recipient stores a number of emptied RTIs until there is a sufficient number of them to make the pick-up and transportation cost-effective. There are two solutions within this kind of system: transfer or depot. The basic difference is that in the former the same RTIs circulate between the sender and the receiver, and in the latter the agency responsible for the RTIs have a storage that all the containers go through (Kroon & Vrijens, 1995).

Lastly, the systems without return logistics consist of a central agency owning the RTIs but the user of the system, the companies using circulating packaging, rents the RTIs from the company and takes responsibility for all activities themselves (Kroon & Vrijens, 1995).

In conclusion, the different types of return logistics systems differ in number of partners involved, who takes responsibility for what and the design of the system. Which system a sender decides to implement depends on the characteristics of the products to be carried, such as volume, weight, quantities involved, frequency of the deliveries and if the system is international or only national or regional and the size of the company and their willingness to invest (Kroon & Vrijens, 1995).

Na et al. (2019) explain the switch-pool system to be commonly used in automotive industry as RTIs with its customized and reusable nature reduces overall costs and improves productivity in the assembly line. Material and parts in the automotive industry is typically expensive and therefore require sturdy and reliable packaging, motivating the usage of RTIs. For supply chains within this industry, the handling and preparation of empty RTIs is particularly important since expensive machinery and responsiveness towards fluctuating demand leads to very high stock-out costs. To tackle the high stock-out costs, on-time delivery is often required among tier suppliers. Adopting a switch-pool system means being highly responsive in the matter of empty RTIs since the recipient must return empty packaging immediately (Na et al., 2019). Hence, the system enables rapid circulation and JiT delivery.

Kroon and Vrijens (1995) mention that border-crossing systems are yet to be developed and implemented, and that the systems brought up do not normally act on an international scale. Some of the issues an international system brings are that the carriers most likely would want to differentiate from their competitors, meaning less collaboration between them resulting in several closed systems with numerous types of RTIs in different sizes. The authors further mention an issue in using different types of containers and packaging, since each type and size of RTI needs its own handling system and administration. A more open international system would require collaborations between carriers and agencies. The issues an international system includes could be overcome by one owner of the RTIs manages the system, while each partner aims to only pursue their key activities.

2.4.2 Disposable packaging

Disposable packaging systems can be defined as packaging that is not returned to the sender and that is suitable for one use (Škerlič & Muha, 2020; VöröskőI & Böröcz, 2016). Some

examples of disposable packaging are carton boxes, cardboard pallets and plastic wraps. The common denominator for disposable packaging is that they are intended for low frequency delivery of parts and single use (Vöröskői & Böröcz, 2016).

According to Škerlič and Muha (2020), a motivation to use disposable containers is if the return rates are low and the authors mention that a disposable packaging system can result in reduced material costs, depending on the frequency of deliveries between supplier and customer. González-Boubeta et al. (2018) further support this by stating that disposable packaging is economically beneficial if the transport costs are high, leading companies to avoid the need for return transports. Another benefit with disposable packaging is that it can be seen as an unlimited resource since no limit on the amount of inventory in circulation between the customer and supplier is placed (Baudin, 2004). Therefore, delivery of material will not be limited by inventory of packaging within the logistics system. An important issue with disposable packaging is the excess waste created (VöröskőI et al., 2020; Baudin, 2004). According to Baudin (2004), this will cause the customer to handle the disposal of the packaging, such as bundle and collapse of empty cartons, which will require more work and investments and proper waste management.

2.4.3 Comparing reusable packaging systems with disposable packaging systems

According to Wu and Dunn (1995), returnable packaging appeared to increase the logistics cost because extra handling equipment and storage space are required to handle the backhaul of returnables, but since manufacturers add the costs of packaging in their prices to the customers, the total cost of the supply chain is reduced since returnables can be used several times. When environmental costs are included in the total logistics costs, using returnables is cheaper (Wu & Dunn, 1995). However, the research and case study results within this area seem to differ. The opposite was presented by Pålsson et al. (2013) in their case study of an automotive industry in Sweden where the use of newly developed, one-way packaging was compared with the sustainability of returnable packaging. Their case study showed that one-way packaging caused fewer economic and environmental impacts, thereby indicating the importance for companies to question their packaging systems (Pålsson et al., 2013). The complexity of supply chains and packaging logistics in the automotive industry is brought up by Škerlič and Muha (2020) where they stress the importance of properly managing the systems in order to reap the benefits. The interest in evaluating and improving current packaging systems is reflected in the industry as the number of publications on the topic grows steadily (Škerlič & Muha, 2020) and more companies tend to look into their choices of packaging and logistics.

Baudin (2004) explains that RTIs would become cheaper over time, while disposable packaging requires less attention since there is no return flow. By using a disposable packaging system there is no need for sorting of the RTIs and storage of empty packaging, while with a returnable flow there is less need for developing and investing in waste management. Vöröskői and Böröcz (2016) also mention that the production cost of disposable packaging is lower than the one for returnable packaging, but even if the cost is an important factor, several other aspects are considered when choosing packaging system. The choice heavily depends on the frequency of usage of the packaging, the complexity of the supply chain and the product to be transported (Vöröskői & Böröcz, 2016).

Table 2 summarizes the findings on packaging systems in literature and compares the two systems discussed based on situations when it is beneficial to use them and their advantages.

Table 2

Summary of packaging systems

Packaging system	Situations when used	Advantages	Strategy	Benefits of the strategy
Reusable	• When customized, more sturdy and robust packaging is needed • High frequency of deliveries	• Increased efficiency in transport • Possibility to align incentives with suppliers • Reduces overall cost and improves productivity in assembly lines	Switch-pool system	• Rapid circulation • Highly responsive • JiT delivery
			Return logistics system	• Possibility to outsource
			System without return logistics	• The company has complete responsibility and power over the rented RTIs • Free to choose system design
Disposable	• Long travel distance • High transport costs • Low delivery frequency • When the components do not require sensitivity and cleanliness	• Requires less attention • No initial investment • Less dependency in the system • Less handling and storage space needed	—	—

2.5 Studies on packaging systems in the automotive industry

Several studies of packaging solutions within automotive industry have been conducted in recent years. Two of them are presented in this section where the research area and researchers' findings are presented.

Selection of Packaging Systems in Supply Chains from a Sustainability Perspective: The case of Volvo by Henrik Pålsson, Christian Finnsgård and Carl Wänström, (2013)
Several studies suggest that returnable packaging reduces the impact on environment, mainly through more efficient handling and reduced total amount of packaging material, and that it has both financial and logistical advantages (Pålsson et al., 2013). However, according to Pålsson et al. (2013), these studies often lack of empirical evidence and few studies actually compare different systems, such as the one-way with the returnable, and even fewer include both the economic and the environmental aspect. Methods to evaluate packaging systems with regard to both these criteria are quite scarce, which is why Pålsson et al. (2013) develop a

model to evaluate and compare a returnable packaging system with a disposable packaging system.

The authors develop an evaluation model for comparing packaging systems from a supply chain perspective where both economic and environmental impacts are included, and test their model on an automotive industry supply chain, where material supply is to be presented to a production line. The model measures environmental impact in CO2-emissions and economic performance in cost (€). The case companies are VCC and Volvo Logistics Corporation (VLC) and the companies have used a returnable packaging system for more than 25 years, but during the writing of the article consider a one-way packaging system (Pålsson et al., 2013).

The case study involves the supply chain of cable harness from Bursa, Turkey, to Gothenburg, Sweden. VLC manages the supply of packaging from their packaging pools, the transport, packaging depot and cleaning of returnables, while VCC handles the packaging in the plant and carries out machining, manufacture and assembly. The distance between VCC and VLC is 7km. In short, the currently used system flow is as follows:
Cable harnesses are loaded into returnable packaging, V-EMB-780, that holds 12 components. Each pallet can hold 16 of these boxes. Pallets are loaded into Mega trailers and transported by road to Poland, where they are transshipped and transported by RoRo to Ystad, Sweden. The load is then transshipped back to a road carrier. The distance travelled by road is 3000-3300km. In Gothenburg, the trailer first arrives at VLC where it is unloaded, later to be pooled on milk-run lorries that will feed the factory with full truck loads running on a schedule. At the VCC plant, the pallets are unloaded and fed by pulling carts to a supermarket area and loaded into gravity flow racks. The V-EMB-780 boxes are then picked up by a milk-run tugger train that supplies the assembly lines on the basis of consumption. When new boxes are delivered to the line, empty containers are collected and scanned into the system which aggregates into new orders from the supplier. Used packaging is sent from the plant to the packaging pool at VLC where it is washed and sent back to the supplier for reuse.

The calculations regarding environmental impact show that the one-way packaging system causes the lowest level of CO2-emissions. Part of the reason being that the reusable packaging is designed in a conical way to make it stackable which is needed to transport the packaging back to the supplier, while the disposable packaging has perpendicular walls and therefore more volume can be used to transport the product. With the one-way solution, 15 cable harnesses can be delivered in each box, compared to 12 in the reusable system. With the annual consumption of around 200 000 cable harnesses, a change of packaging system would decrease the emissions with approximately 41 600 kg CO2, which equals half a revolution around the globe of fully loaded Mega trailers. The calculations regarding cost also result in the one-way system being of advantage, where the cost for supplying the components using one-way packaging is €0.37 less per component consumed than when using a system of returnable packaging. The authors also find that each one-way package required 63 seconds less work in the in-plant delivery of the components to the assembly line. The returnable system needs the extra time to pick up empty packaging, scan and remove labels and prepare the shipping back to the packaging pool.

A sensitivity analysis was conducted by the authors since the travel distance is quite long for this specific component. The transport distance was reduced by 90% and the fill rates were equal for both solutions in the analysis, but the results remained the same, showing that even in these cases the one-way packaging system is the most beneficial solution.

Impact of disposable packaging in automotive production by Anna Blomberg and Gabriella Hallams, (2017)

Blomberg and Hallams (2017) conducted their master's thesis in collaboration with Volvo Trucks where they look into the packaging system and test a pre-decided pallet solution. The authors compare the currently used reusable packaging system, mainly with a similar product but entirely made of cardboard and paper. Volvo Group has initiated the project Next Generation Packaging where they evaluate how future packaging trends, such as "right-sized" packages and increased use of product specific packaging, will impact on the current systems with the objective to harmonize and standardize the Volvo Group's packaging pool (Blomberg & Hallams, 2017). The authors mention that the project's two main themes are "to align the returnable packaging pool by reducing the different types of packaging sizes, and to replace the returnable packaging with disposable packaging in flows with a long distance with a long-distance repositioning of empty packaging to avoid the complexity of using a returnable packaging system". This would result in an increased turnover in the packaging pool and less tied up capital for the company.

Volvo Group wants to investigate whether this disposable packaging system could be used instead of the reusable packaging system. Blomberg and Hallams (2017) conduct two different comparisons, one where the pallet system is of focus and the second where the box system is of focus. These are both evaluated based on four perspectives, being: Protective perspective, Handling efficiency perspective, Ergonomic perspective and Information perspective. The authors compare how the disposable system performs based on these perspectives in pre-decided settings within the factory, where tests are conducted in order to see which solution performs better. The different stations where the packaging is tested differ based on if the box or pallet is of focus, since these have different flows within the factory.

The result of the study shows that the disposable pallet solution brought positive effects within the perspectives of handling efficiency and ergonomics at the settings of PoU and Internal sequencing. The operators found that it was easier to reach the disposable pallets. However, the solution brought negative effects in Goods receiving and Local storage. These effects are due to the decreased stackability of the disposables and the fragility of the material. The result of the disposable boxes however only shows negative effects in the majority of the tested settings. Furthermore, the attitude towards packaging differed between the supporting functions and those who worked directly with the packaging. Operators were often positive to the disposable pallet system and found that the light material favored their work. The disposable packaging brought immediate ergonomic benefits and did not affect the material handling in line. The supporting functions, such as packaging engineers and logistics engineers, were also positive to the disposable pallet as they saw potential in solving long distance and retrieval issues. Regarding disposable boxes the functions where mostly negative or neutral and the authors state that this solution did not bring any obvious benefits to neither production nor material handling. However, ergonomic experts did see potential for improving handling efficiency and ergonomic benefits after getting used to handling the new boxes.

Blomberg and Hallams (2017) also conduct a benchmark against VCC. Volvo Group and VCC have had a packaging pool together but stopped their collaboration in 2014. When the packaging pool split, it could not provide VCC with the amount of packaging they needed, which lead them to bring in disposable packaging to cope with the shortage. However, this system tuned into a collaboration with one of their strategic partners and developed disposable standard packaging based on the need within the factory. When Blomberg and Hallams (2017)

conduct their thesis, VCC had spent more than two years developing, testing and implementing the disposable packaging solutions and use this new system in high volumes, especially in aftermarket business. VCC instructs their suppliers to use both disposable pallets and boxes provided by their strategic partner, who manage the orders, distribution and invoicing.

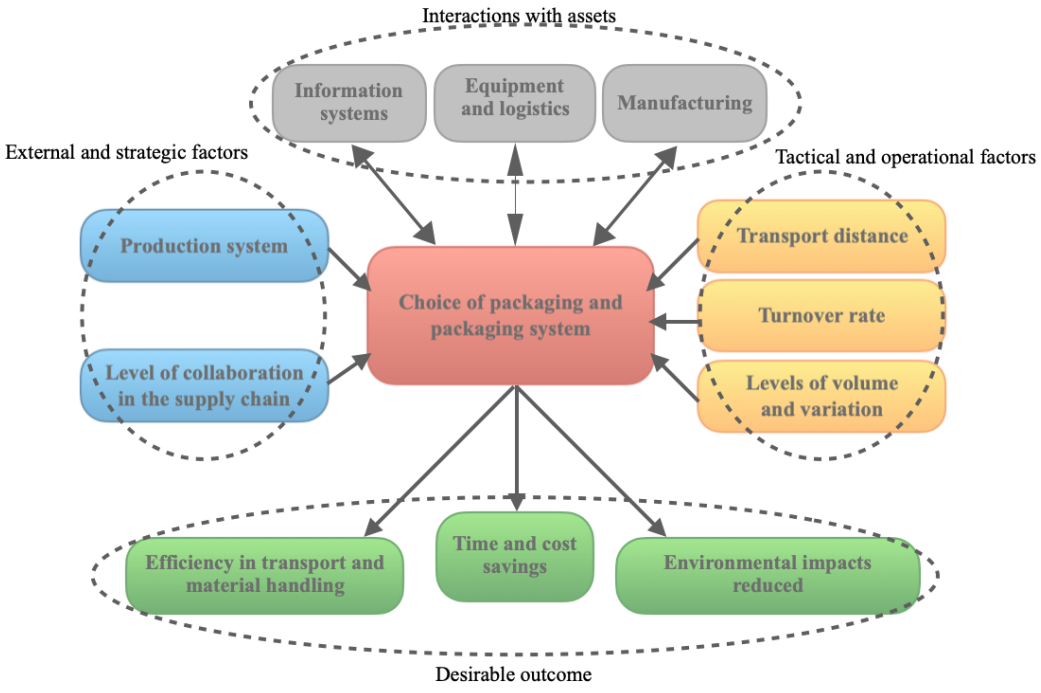
2.6 Conceptual model

The conceptual model presents the different areas of importance when looking at packaging logistics and packaging systems, and aims to guide the researchers in the analysis of the empirical findings. It is used as a structuring tool when collecting empirical data and understanding the findings.

The choice of packaging system is affected by several external factors as well as internal objectives within the firm. The conceptual model, figure 4, presents how the different aspects are connected to the choice of packaging and packaging system. The one-way arrows indicate a causal relationship, while the two-way arrows imply an interaction. The boxes in blue demonstrate an external or strategic factor affecting the choice of packaging system indirectly and having an effect on the efficiency of the chosen system, whereas the yellow boxes are direct variables having a concrete impact on the choice of packaging and which system is suitable for the company. If these factors are considered when choosing packaging and a packaging system, benefits in the form of the green boxes can be achieved.

Figure 4

Conceptual model of how the different variables are connected to packaging



3. Method

The following chapter presents an overview of the methodological process of the research to fulfill the aim of the study. The chapter begins with describing the strategy and process of the research followed by the research design and the main activities that were used for data collection. Lastly, a discussion of the research quality is presented followed by the ethical considerations that were taken in the research.

3.1 Research strategy

The research started in January 2022 and lasted for 20 weeks. This timeframe was a predetermined time limit for the study. Within business research, either qualitative or quantitative strategies can be used to conduct a study (Yilmaz, 2013; Bell et al., 2019). The purpose of qualitative research is to form a thesis based on empirical data from interpretations of social phenomena in certain situations (Yilmaz, 2013). Furthermore, Bell et al. (2019) explain qualitative research strategy as a way to collect data based on words and observations rather than numerical or statistical data. Hence, the qualitative research strategy was suitable for this study since the purpose was to present a suitable packaging system for the case company with regards to different criteria of relevant stakeholders and needs of the company. The necessary data could only be gathered through observations and interactions with representatives from the case company. In contrast, a quantitative strategy cannot be applied since the needs of the company or feasible packaging systems cannot be expressed through quantitative measurements. Moreover, the nature of the study had a holistic perspective since the flow of packaging was investigated throughout the entire supply chain between case company and suppliers rather than a specific setting. Yilmaz (2013) suggests that qualitative research provides flexibility and is applicable for a holistic perspective.

The authors of the thesis used an inductive approach by developing theoretical conclusions from empirical findings as opposed to a deductive process where a hypothesis is first developed whereby the study aims to test it (Eriksson & Kovalainen, 2008). The inductive nature fit this study since the authors aimed to present improved packaging handling solutions based on reviewing the current state and not to review a predetermined hypothesis on the subject. Moreover, this was appropriate for the study since the authors could conduct the study without any prior knowledge while the qualitative strategy could be used since emphasis is on developing theories instead of testing predetermined hypotheses (Bell et al., 2019). Therefore, these choices were supported by the fact that the company did not have any solutions that needed testing and the need for finding new packaging solutions by understanding the current state.

3.2 Research design

Research design constitutes the technique or framework used for the chosen study (Bell et al., 2019). Since the project was proposed by Aurobay, the choice of research design was therefore selected by the company as a case study with a specified issue at hand. This affected the choice of research questions, which was deemed by the authors as in line with the purpose of the project. Nevertheless, the choice of case study is explained by Yin (2018) as suitable when the aim of the research is to conduct a study of a current phenomenon and when the research questions tend to explain the “how” and “why” a certain occurrence works, which is the case for this project. Hence, this research design was suitable due to the nature of the specific exploratory research of the packaging system at Aurobay. Moreover, Bell et al. (2019) explain

that researchers aim to provide an in-depth understanding of an object of interest within a case study which is in line with the purpose of the thesis by the authors.

According to Yin (2018), the difference between single-case and multiple-case designs is a key distinction which must be considered during the choice research design. Aligned with Yin's (2018) rationale for selecting a single-case study, Aurobay's environment and contextual factors are unique which supports the justification for only studying the company's packaging solutions to draw conclusions rather than following a cross-sectional study. In addition, another factor that prompted the use of a case study was the project's limited scope, which made conducting longitudinal research difficult.

The selection of a case should be based on the anticipation of its ability to improve understanding of the research issue (Bell et al., 2019). Aurobay constituted the selected case for this research to study its packaging solutions, thus gaining a further understanding of potential improvement areas. Additionally, the researchers do not aim to use the case company as an example to produce a conceptual framework since the study and its research questions was initiated by Aurobay. Consequently, this study has suitable settings for data collection and good preconditions of gaining a deeper understanding of the research subject, which justifies the choice of a single-case study design for this research.

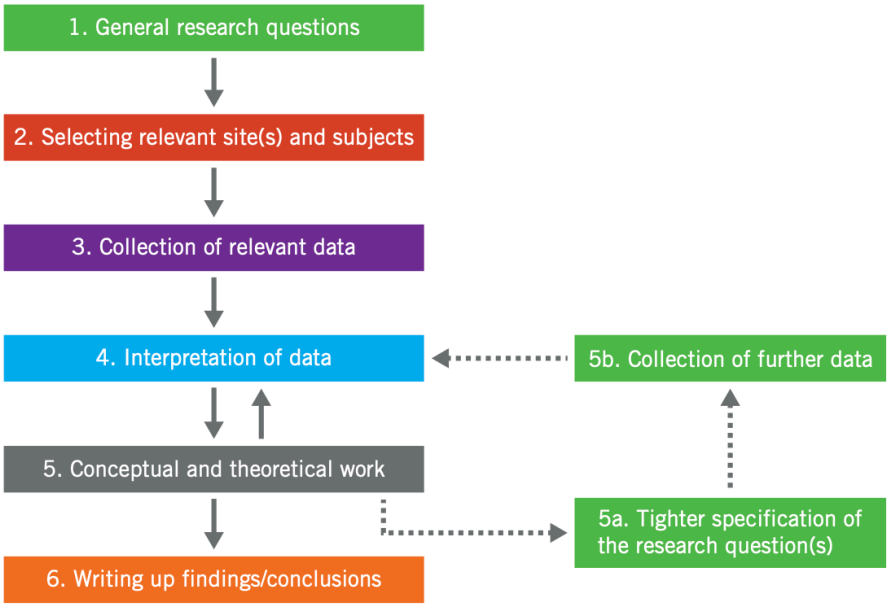
3.3 Research process

The study followed the main steps of a qualitative research process outlined by Bell et al. (2019), which is illustrated in figure 5. While the research process was linear and followed predetermined steps, there were several iterations. The steps follow an iterative process since the analysis and interpretation of data will modify the literature study related to the research questions. Consequently, this study also had elements of an abductive approach since findings from the data collection process could motivate expanding the theoretical framework into new relevant areas as well as adjusting the research questions (Dubois & Gadde, 2002).

The first step in the process outlined by Bell et al. (2019) is formulating research questions which were done through collaboration with the company after understanding the issue at hand. The gained insights from the literature study and empirical findings allowed the questions to be amended which made them more precise. The next step is selecting relevant sites and subject to study, which in this case was delimiting the problem at hand and choosing relevant literature to study. During this stage, the theoretical framework was developed early to gain a deeper understanding of the subject, which was necessary in order to choose the relevant data that should be collected for answering the research questions. Moreover, the authors set up a plan for the data collection and selected the research subjects. The third step of the process is data collection followed by an interpretation of the data which was conducted directly after each data collection event. The data analysis enabled the authors to adjust the theoretical framework and data collection procedure to change the project scope according to the gained findings. Lastly, the findings were presented in the report and the theoretical framework were used to analyze the findings to draw conclusions (Bell et al., 2019).

Figure 5

Schematic overview of the main steps in the research process



Note: An outline of the main steps in the research process. Reprinted from *Business Research Methods* (p. 358), by Bell et al., 2019, Oxford University Press.

3.4 Data collection

The main data that was meant to be used to answer the research questions derived from interviews with representatives from the company and personal observations in the production plant. The purpose of using different sources of data is argued by Jonsen and Jehn (2009) to add validity to a study by mitigating subjective bias through a method of triangulation. Therefore, more depth can be added to the data collected.

3.4.1 Interviews

The main part of the data collection was through interviews where the purpose of these was for the researchers to better understand the packaging problem of Aurobay by gathering necessary information from relevant employees of the company. According to Kothari (2004), interviews are suitable for data collection in exploratory research, which was the case for this study where it was necessary to understand the current packaging problem through experiences and opinions. The necessary data needed in order to answer the research questions could only be gathered from representatives from Aurobay since their knowledge and past experience of the packaging system could only be understood through interviews. Consequently, the authors gained an in-depth understanding of the packaging system from different perspectives.

Sampling

Sampling is necessary due to the constraints in time and cost put into the project (Bell et al., 2019). The sample design of the interviewees was purposive, meaning that they were selected based on the purpose of the study subjectively (Kothari, 2004). The reason is that, since the

aim of the study is "*review the current state and evaluate options available to the company to solve…"*, it was important that the interviewees were able to provide with sufficient and relevant answers to fulfill the aim of the study. Therefore, the employees from Aurobay were selected based on recommendation from the authors' tutors at Aurobay and from managers within the company, since they possess comprehensive knowledge of the organization. Hence, the tutors chose suitable interviewees based on their extensive background at Aurobay and knowledge in the subject of packaging.

The interviewees came from different fields of expertise to provide diversification and an advantageous base of information from multiple perspectives. Therefore, the interviewees could be divided into Packaging, Logistics and Production. As depicted in table 3, nine actors were interviewed for this study. After the sampling procedure, interview proposals were sent to the interviewees through email where each interviewee offered suitable dates and time. The authors could therefore better plan for appropriate time slots in which several interviews could be conducted in the same day.

Table 3

Interview objects

Area of expertise	Role	Date	Communication
Packaging	Plant Productivity Engineer	23/03–2022	In person
	Packaging Engineer	23/03–2022	In person
	Superintendent Logistics	23/03–2022 04/04–2022	In person Video meeting
	Senior Manager Plant Strategy & Launch	23/03–2022 04/04–2022	In person Video meeting
Logistics	Supervisor Logistics, Incoming Material	29/03–2022	Video meeting
	Supervisor Logistics, Internal Logistics	06/04–2022	In person
Production	Supervisor VEP G2	06/04–2022	In person
	Superintendent VEP G3	01/04–2022	Video meeting
	Team Leader VED G3	06/04–2022	In person

Interview process

The interviews were semi-structured with predetermined questions to address the main topics of interest while ensuring that the conversation could divert into new topics that the interviewee found relevant for the subject (Collis & Hussey, 2014). This benefit was therefore one of the main reasons for pursuing this type of interview procedure by the authors. Another reason as mentioned by Bell et al. (2019) is that this method allows for greater flexibility, thus potentially collecting more relevant information. The authors deemed this as necessary since the research questions was of an explorative type. Furthermore, a structured interview with fixed questions would have limited the possibility of gaining valuable insights from the interviewees, which can only be achieved through rich and detailed answers in a qualitative interview (Bell et al., 2019).

The predetermined interview questions were written in accordance with the aim of the study, with the theory from literature used as support to find relevant topics. The interview guides were adapted based on the knowledge area of the interview object, which means that the questionnaires were different depending on which area of expertise the interviewee had. These can be found in Appendix A. Furthermore, the questionnaires were sent in advance to the interviewees to ensure that they could prepare, thus providing more thorough answers (Kothari, 2004). While the questions hade a predetermined order, the authors chose to ask additional questions based on the interviewees' answers and instead use the questionnaire as support to ensure that the interview was steered into the right direction. According to Bell et al. (2019), this also allows the interviewees to clarify any misinterpretations.

The interview setting, physical meeting or remote meeting, was chosen with respect to the interviewees' preferences. Some interviews took place at Aurobay while other were conducted remotely with the use of a video conferencing tool, Zoom. The authors preferred face-to-face interviews since more rapport could be built with the respondents, however remote meetings allowed for flexibility since additional interview meetings could be booked last minute (Bell et al., 2019). Both authors attended all interviews which was deemed as beneficial since more data normally gets recorded (Trost, 2010). The authors also shifted the roles of interviewer and transcriber between each interview to reduce bias.

All interviews were audio-recorded after given permission, in order to ensure that no misinterpretations were made and to cover everything that was said (Bell at al., 2019). As argued by Bell et al. (2019), the authors could therefore focus more on the interaction with the respondents to catch up any valuable insights. However, one issue with recording interviews is that interviewers might become cautious to reveal information (Trost, 2010). The authors therefore made sure that the interviewees had any reservations about being recorded. The duration of each interview ranged from 30 minutes to one hour.

3.4.2 Company visits

Observations are a suitable approach for data collection in qualitative research (Kothari, 2004). Given the exploratory nature of the study, the purpose of the observations by the researchers is to gain a more in-depth understanding of the problem and comprehensive view of the organization through subjective experiences. This was also stated by several interviewees that expressed the necessity of visiting certain areas in the production plant to understand the information more clearly.

The on-site visits in the production plant of Aurobay had several purposes. First, the researchers aimed to familiarize themselves with the operations of the production plant to better understand the supply chain and obtain insights of the organization. Secondly, the observations were used as a part of the data collection to find challenges with the current packaging system to gain a better understanding of the problem, which is imperative for the study since the researchers aim to formulate solutions to solve the aforementioned challenges. Observations at Aurobay combined with knowledge gained from literature study of the packaging subject provided the researchers with new and interesting ideas for further research. Lastly, through observations in the production plant, the researchers could address the first research question by presenting alternative packaging solutions for the company through insights gained from the on-site visits.

3.5 Method of analysis

Bell et al. (2019) describe two main types of qualitative data analysis: Thematic analysis and Grounded theory. Starting with thematic analysis, when analyzing the findings, Ryan and Bernard as referenced in Bell et al. (2019) suggest looking for topics that occur again and again. Repetitions show a pattern within the data and can occur within one data source, for example one interview or article, or can be found across data sources, meaning several interviewees or articles bring up the same topics. Connecting repetitions in this way and grouping the findings into themes is called thematic analysis and is one of the most common approaches to analyzing qualitative data (Bell et al., 2019). The thematic analysis lacks a clear procedure and requires the researchers to reflect on the findings and sense the continuities and linkages between the different repetitions, hence being a flexible analytical strategy. In order to make the collected data more manageable, audio-recorded interviews are transcribed and coded. This supports the work in linking the findings in literature with the findings in interviews and observations (Bell et al., 2019). Coding is also a key process in grounded theory, where the data is broken down and given names according to the researcher's interpretation of it. The grounded theory further uses constant comparison, which means maintaining a close connection between data and conceptualization. This enables the theoretical elaboration of a category to emerge since not only data is coded but also phenomena observed (Bell et al., 2019).

When analyzing the data in this thesis, none of these approaches are used in its full extent, but rather a mixture of both approaches. From the thematic analysis, the coding and connection of repetitions is used but it does not result in themes presented. In the same way, one of the expected outcomes in grounded theory is to present categories and their properties, which is not done in this thesis. However, the tools of grounded theory are applied in the way of constant comparing the collected data and the concepts being evaluated. The researchers reflect on the findings and seek to link these, which is presented in the chapter 'Analysis'. Furthermore, the analysis of data is conducted in an iterative way, which is a common qualitative analytical approach, not belonging specifically to neither of the methods presented. This approach means that the collection and analysis of data is done in parallel and often several times in order to both understand the data from different perspectives and to form the next step in the process according to what is needed based on previous findings.

3.5.1 Method of evaluation

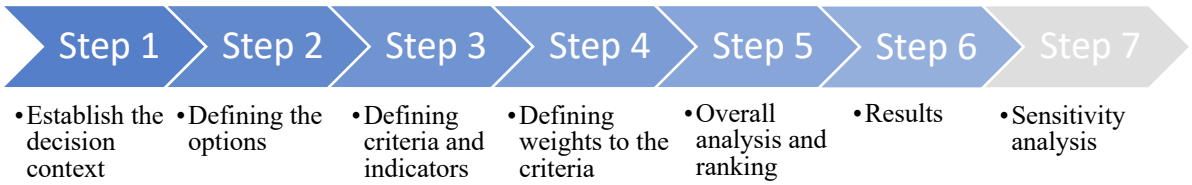
The method used in the evaluation and ranking of alternative packaging solutions was The Multi-Criteria Analysis (MCA). This method enables decision-makers to assess different options in a situation where multiple criteria exist; hence alternatives can be ranked based on their performances for the criteria and their weight of importance (Dodgson et al., 2009). This method of evaluation was chosen by the researchers since assessment of each packaging solution needed to be analyzed based on evaluation criteria expressed by representatives at Aurobay, thus justifying the choice of this method by the researchers. Figure 6 depicts the different steps of the MCA which are adapted from the eight steps outlined by Dodgson et al. (2009). However, the authors of this paper have only followed steps one through six since the last step is used to assess whether the results change if weights are altered. The researchers did not include this since this was considered to not affect the results or in line with the thesis.

According to step one as described by Dodsgon et al. (2009), the researchers first outlined the aim of the MCA where a recommendation of the most suitable packaging was to be provided. During this evaluation, the researchers of this paper act as decision-makers. During the second

step, the researchers identified feasible packaging solutions which was the purpose of the first research question. This is followed by defining criteria in step three, where the researchers outline the answers derived from research question 2.1. The criteria have been identified through data collection and interviewees' expressed objectives regarding packaging and the packaging systems. Indicators of the criteria are different measurements that are affected by each criterion. After defining the evaluation criteria, weights were allocated to each one to determine the importance of each objective (Dodgson et al., 2009). The researchers allocated a total of ten points where a higher number is deemed as 'most important'. These weights are based on the interviewees' perceptions and objectives within packaging solutions and thus come from the stakeholder. Step five comprises of the main part within MCA where the packaging solutions are analyzed based on the previous steps and given rankings. Finally, the results of this evaluation provide a quantitative measure for each packaging solution where the highest number shows the most suitable solution. Step seven is excluded from the study due to focus area of the thesis and time constraints, and is left as a recommendation to conduct in order to further support the outcome of the study and its results.

Figure 6

The process of MCA



Note: Adapted from Dodgson et el. (2009) description of the MCA evaluation framework.

3.6 Research quality

Bell et al. (2019) present three common criteria to assess research quality which are reliability, replicability and validity. However, it has been argued that reliability and validity are better suited to evaluate quantitative business research (Bell et al., 2019). In contrast, Guba and Lincoln (1994) suggest four other criteria which are more appropriate for evaluating the trustworthiness of qualitative research which are credibility, transferability, dependability and confirmability. Several efforts were taken throughout the study to examine these criteria, which will be explained further below.

Credibility refers to whether the research findings are a correct interpretation of the subject under investigation (Korstjens & Moser, 2018). A measurement suited for enhancing the credibility of the findings is respondent validation, where the results of the study are presented to the participants for confirmation (Bell et al., 2011). In this research, the key findings of the study were sent to the interviewees to confirm that the interpretations from the interviews were correct. Another measure discussed by Korstjens and Moser (2018) is triangulation where data

is collected from different sources. Bell et al. (2019) suggest that using multiple sources of data will ensure that researchers avoid making any misunderstandings by cross-checking empirical findings across different sources. Hence, the literature study, interviews and observations from company visits were combined in producing more trustworthy results.

As qualitative research usually entails a detailed study of a certain setting, Korstjens and Moser (2018) explain transferability as the degree to which the research findings can be transferred to other circumstances. The issue of transferability was due to the nature of this research being a single-case study in the specific setting of Aurobay's production system being unique. In addition, the aim of the research was not to provide any general conclusions but to evaluate the logistics of packaging at Aurobay and present improvement options. However, a way to manage transferability in this case study was by providing a thick description of the research setting combined with a general literature review, where Bell et al. (2019) argue that it is up to the readers to assess the possible transferability of the findings to other environments. Nonetheless, the authors maintain the view that this research can be used as theoretical groundwork for other car manufacturing companies in selecting an appropriate packaging system.

Dependability is used to assess the consistency and reliability of the findings to ensure that other researchers would draw the same conclusions if they would follow the same research procedure. Therefore, this criterion is referred to the extent of records being kept of all phases of the case-study thus enabling outsiders to audit and follow the research process (Bell et al., 2019). The researchers ensured high dependability by not deviating from the main steps of the qualitative research process outlined by Bell et al. (2019). In addition, other researchers are able to audit the reliability of the derived conclusions through the documented comprehensive description of the research process, problem formulation, data collection as well as procedures of data synthesis.

The last criterion of assessing the research quality is through confirmability. It concerns whether the interpretations of the findings are fabricated by the researchers' biases or own judgments (Korstjens & Moser, 2018). Bell et al. (2019) recognize the difficulty with complete objectivity in business research and that confirmability is used to show if the researchers have acted in good faith. While this was the case in this research, it is important to mention that there exist some biases since qualitative research comprises of communications between the researchers and the participants. Therefore, the goal was to minimize personal influences through different measures. First and foremost, the recorded interviews made it possible to make detailed transcriptions which reduced the risk of distorted results since the interviewees' answers could be documented exhaustively. In addition, both researchers worked collaboratively with data collection and analyzing the results, thus ensuring that no misinterpretations were made.

3.7 Ethical considerations

Research conducted in a social setting is expected to follow certain ethical manners where the data collection stems from researchers' observations or interviews (Denscombe, 2018). This is also in line with Bell et al. (2019) who mention that qualitative research requires ethical considerations and that researchers continually evaluates them during the study. Therefore, the authors have taken certain measures throughout the study to ensure correct code of ethics.

According to Bell et al. (2019), there are four main ethical principles which can be used as guidelines for researchers:

- Harm to participants – potential harm or injury to any participants involved in the study
- Lack of informed consent – refers to whether or not participants can decide to become involved in the study
- Invasion of privacy - pertains to the necessity to protect study participants' privacy
- Deception – when researchers do not disclose the truthfulness of their research.

All of the ethical issues aforementioned were taken into consideration, more specifically during the interview process. The project's nature eliminated the risk of physically harming research participants, therefore focus lied in mitigating risks of other violations. Bell et al. (2019) mention that participants may experience psychological harm such as stress or harm jeopardizing future employment. These risks were managed by ensuring that the participants gave their fully informed consent of presenting their names and roles in the report, and that possibility of anonymity maintained throughout the study. Furthermore, the risk of participants experiencing discomfort during interviews was mitigated by not deviating from the questionnaire.

The issue of informed consent is greatly linked to invasion of privacy since a participant recognizes that the right of privacy is compromised to a certain extent as consent is given (Bell et al., 2019). Since invasion of privacy is deemed as subjective, more effort was put on ensuring informed content. Before each interview, every participant was provided with informed the purpose and aim of the study, expected outcome of the results and opportunity to give permission regarding use of recording equipment. Furthermore, each participant was asked during the interviewees if certain disclosures are confidential to assure no intrusion on privacy. Another action in ensuring no invasion of privacy mentioned by Eriksson and Kovalainen (2008) is confidentiality of records, whereby the researchers in this study maintained safe storage of gathered data and no further distribution to any external part. Moreover, the researchers followed recommendations from Bell et al. (2019) in maintaining the confidentiality of records by having representatives at Aurobay giving consent to pictures published in the report as well as erasing any sensitive information.

Lastly, preventing deception towards research participants is an important principle of ethics. According to Bell et al. (2019), openness and honesty in communicating information concerning the research to the participants is important in being truthful. The researchers provided the interviewees with clear information about the study beforehand of each interview. Another ethical consideration in addition to the mentioned is data management (Bell et al., 2019). The researchers have managed the legal concern with copyright in accordance with Chalmers policies. Furthermore, during this study legal compliance with GDPR was taken into consideration as well as Aurobay's own policies for data protection and sensitive information.

4. Empirical findings

This chapter presents the results from interviews and observations at the company. In the first section the current packaging and their systems are explained, followed by four sections based on the focus areas presented in the conceptual model: strategic and external factors, tactical and operational factors, interactions with assets and how the desirable outcome is met by the choice of packaging systems.

4.1 Current state of packaging solution

Different packaging is used depending on the article being transported. The articles can be divided into three categories where the packaging for each group differs due to its weight, size, sensitivity and volume, to mention a few factors. The first category is “blanks”, as called within the industry, where for example cylinder blocks and camshafts are delivered on wooden pallets with plastic inserts between the layers of the articles. The pallet is covered in soft plastic and on the top is at least one wooden lid and the whole pallet is secured with plastic straps. The second group is volume articles, for example screws, that are typically delivered in huge amounts and are not sensitive to for example vibrations during the transportation. The volume articles generally come in carton boxes. The third group is main articles including for example turbos, spark plugs and electronics. These parts are more sensitive and expensive resulting in more robust, or even specialized, packaging to make sure the articles are not damaged during the transportation and handling. Specially designed packaging comes with some of the main articles and are developed specifically for one article. Some of the commonly used packaging for the three different categories are shown in figure 7, where the reusable plastic boxes and disposable carton boxes can be seen in the upper part of figure 7, with two types of reusable, specialized plastic packaging in the lower part of figure 7.

Figure 7

Examples of packaging used in the plant

4.1.1 Packaging at Aurobay

Aurobay's current logistics of packaging comprises of both reusable and disposable packaging. There are several variants within these categories of packaging which will be presented henceforth, followed by a comparison between them where advantages and disadvantages of the subsystems are outlined.

Reusable packaging

The standardized, reusable packaging includes plastic boxes, plastic pallets and wooden pallets with pallet collars. Most of the packaging used at Aurobay are plastic boxes and wooden pallets. The plastic boxes come in two different variants and sizes and are referred to as "blue boxes", which can be used to transport and package any article. In addition, there are specialized plastic boxes that are designed and intended for a specific part by molding them inwards to ensure the material is solid within the box. The last type of RTI is wooden pallets with wooden frames which are used to transport large items or materials. These have three layers where each layer is separated by inserts to separate the items.

Disposable packaging

The disposable packaging is intended for transporting material from suppliers outside of Europe since the long distances would lead to higher costs if a pooling system of RTIs would be used. However, these can be used inside a returnable packaging as well for further protection. In such a case, plastic or cardboard would wrap around the material to avoid the material scuffing against the inside walls of the packaging during shipments. The main disposable packaging are disposable Volvo-pallets and cardboard solutions. The Volvo-pallets are wooden, like the reusable ones, but are built with less solidity and strength and of cheaper wood. These differ in size compared to a standardized EUR-pallet by having the measurement 1225x820 mm. In addition, pallet wide containers are used for shipments in containers overseas and have the size 1140x790 mm. The difference in size for these pallets is for better fitting in the containers, however these are normally stacked on a standardized pallet when arrived at Aurobay to be able to store these into the warehouse. Lastly, cardboard solutions are either boxes or pallets with cardboard frames. These are used for shipments from China or for packaging small articles such as screws or bolts. However, these are also used as an alternative packaging solution in cases where the supplier does not have returnable packaging in-house to package the material.

Packaging evaluation

The advantages and disadvantages with the different types of packaging are depicted in table 4. While there is a common agreement at Aurobay to avoid using the disposable packaging due to its fragility and lack of robustness, several benefits with these can be shown. The main argument for adopting this system is the long distance to suppliers where returnable packaging would increase the transport costs remarkably and delay the shipments twice as much. In addition, cardboard and wooden material are less expensive than plastic and other returnable packaging. However, the disposable packaging lacks durability and are sensitive to damages as opposed to the returnables where they have proven to be suitable for protecting the material during transport and easier to handle as well in-house as during transportation. The benefit of using plastic pallets instead of wooden pallets is that they weigh less and are more durable in bad weather conditions and there is no risk of splintering which can injure the employees handling the pallets.

The main issue with disposable packaging is the deficient robustness and problem with ensuring the quality of the transported products, while the main benefit of returnable packaging is good protection. Neither disposable packaging nor RTIs enable a good parts presentation, hence, there is consensus at Aurobay that these packaging solutions are not optimal in the production. Operators experience difficulties in retrieving the material or products from their packaging since they require extra handling or the operator might need to take an extra grip or turn their hands in order to pick the parts.

Table 4

Evaluation of different types of packaging

	Advantages	Disadvantages
Returnable packaging	• Easy to handle • Weighs less • Durable • Very sturdy & protects the material well during transport • Weatherproof	• Requires handling after usage • High initial cost in packaging • Inadequate for presenting the material in production • Few variants in packaging solutions • Limitation of material due to weight limit
Disposable packaging	• Cheaper alternative • Lightweight material • No return transports	• More damage sensitive • Low stackability • Less clean • Requires recycling handling • Compromises the quality of the products • Mix of material

4.1.2 Packaging systems at Aurobay

All incoming material is checked at the entry gate where sign up and documentation is done regarding what material is delivered. The truck drivers then proceed to the unloading area, which for blanks that Aurobay will machine and refine is straight to the concerned part of the factory. For all other incoming material the truck drivers proceed to the logistics area called M3. The vast majority of the incoming material is delivered to M3, which is the focus area when looking into material flows and packaging systems. All incoming material is delivered on pallets, that are unloaded by forklift and placed on a conveyor belt. The pallets enter the factory and are visually checked by both an operator and a camera, and is scanned into the system. The scanning of pallets is checked against the documentation done at the entry gate to make sure the correct amount is received. The pallets then enter an automated warehouse, storing them until the system receives an order from the PoU.

The automated warehouse receives orders from the different departments in the factory. When an assembly line orders an article, the warehouse picks and delivers the pallet with this article to a conveyor belt, where the pallet can go into two different flows. If it is a full pallet that has been ordered it is delivered to an area where a forklift places the pallet on a wagon. These full pallets are directly transported to the assembly line where operators handle the unpacking of the parts. If it is a pallet filled with several plastic or carton boxes inside, it goes to an area

where M3-operators unpack and prepare the packaging. The packages that are handled here are then placed in another warehousing area called PLM3, where a tugger train driver can pick up the smaller packaging manually. Both reusable and disposable packaging can go through these different flows. After delivery to the PoU, the packaging is handled in different ways based on if it is part of a reusable loop or are of disposable material.

Reusable packaging system
The supplier footprint is global but the main supplier base is within the borders of Europe, where the loop of reusable packaging circulates. The reusable packaging is managed by an external company where suppliers express how much packaging they need in a computerized system and the external company makes sure they get the packaging. Starting from within Aurobay, the reusables are sorted after PoU by the operators in the assembly line, and collected by the M3-operators when delivering new material to line. The packaging goes back to M3 where it is loaded to a truck, figure 8, and transported from Aurobay to an external company operating less than one kilometer from the factory. Here the packaging is further sorted, cleaned and quality checked to be sent to the distribution central in Gothenburg, responsible for sending out the correct amount of packaging to the suppliers. The loop system is owned by Volvo Cars, and Aurobay pays to be part of it and also pays to make sure the packaging gets cleaned and quality checked. The returnable packaging system costs approximately 70 MSEK/year.

There is ongoing work with developing and improving the loop-system, where for example injection molded packaging made of plastics that can be ground down to granulates after usage have been tested. Tests have been done for sensitive parts that require more sturdy and robust packaging, and is done in collaboration with the company Boxon. The tests are yet to provide results regarding cost efficiency and ergonomics but are expected to be positive, and what can be seen in this stage is the improved protection of parts during transport and reduced packaging to handle in the assembly line. Although this packaging solution reduce the variation of packaging, operators interviewed express that it requires more frequent handling and is not optimally developed for gripping of parts and that improvements in parts presentation still can be done.

Figure 8

Truck with empty packaging to be transported to a sorting- and cleaning station

Disposable packaging system
The disposable packaging mainly comes from overseas transports and is used when the distance between Aurobay and the supplier is too far to make a reusable loop profitable. After PoU, the disposable packaging is thrown in a bin either for carton recycling or combustibles where different types of plastics go. These bins are handled by a tugger train driver operating in a logistics loop outside of the material supplying loop. The M3-operator picks up the bins when full and transports them to the M3 area where two compressors press the packaging. Aurobay is paid for the recycling of soft plastics and cardboard, however, it is expressed by several of the interviewees that this compensation is very small. When it comes to the handling of combustibles and hard plastics the company needs to pay for it to be recycled. The disposable packaging system does not require any extra administration, and the cost of the packaging is included in the part price of the product being purchased, but additional costs of 10-20 MSEK/year for waste handling and containers come with this system.

Evaluation of the systems
The reusable loop system is developed from a logistics perspective and is very efficient in its routes and how the packaging flows throughout Europe. Many actors in the chain share the system and it brings benefits regarding handling efficiency, and it is expressed by both a logistics superintendent and a logistics supervisor that you know what you get with this system, and it makes it easy to plan. The standardization of packaging enables preparations in the factory when it comes to equipment and storage space, and it is regarded as a stable and well-working system. However, the loop system is troubled with imbalances on a regular basis, partly due to the manual handling of the orders. The imbalance results in some suppliers holding too much packaging, either due to cancelled orders from customer if the production volume is reduced somewhere in the supply chain, or due to safe-guarding where a company orders more than they actually need to make sure they will get enough RTIs. The imbalance can also result in suppliers not getting the packaging they have ordered, which forces them to deliver their products in alternative packaging, which often is disposable boxes with the risk of compromising the quality of the product. Furthermore, Aurobay pays for cleaning and quality control, which is a cost of around 7-8 MSEK/year, but since the loop system is optimized from a logistics perspective, the cleaned packaging often serves several other companies before coming to Aurobay. An issue brought up is that Aurobay is one of the companies with highest quality- and cleanliness requirements in the system, and the one who pays extra for the cleaning, despite this the packaging brought into the factory is often dirty which compromises the quality of the products.

The disposable packaging system does not require any administration or managing which makes it the easier system to deal with of the two, but the system needs development in order to be efficient within the factory. The disposable packaging comes with the need to sort the different materials after usage, and it is difficult to separate the different materials. For example, the carton boxes come with a plastic strap glued to it, and there are several different kinds of plastics around the factory. This is brought up as an issue since it affects the operators working in the assembly line, and the company in its waste management and possibility to achieve the goal to continue developing sustainable solutions. As of now, it is easier to throw everything disposable into one bin. The different advantages and disadvantages with the systems are presented in table 5.

When asked how the perfect state of packaging would look like, two of the interviewees explain a new type of packaging solution that was not found in literature. They explain how injection

molding can be used to produce the perfect design of packaging for different parts, and that this packaging when empty can be ground to plastic granulates and sent back to their origin in a container. The packaging made of plastic granulates could improve the quality and cleanliness of the parts delivered, along with improving the ergonomics for operators handling the packaging and reduced transport costs as the return transports would be heavily reduced.

Table 5

Evaluation of different packaging systems

	Advantages	Disadvantages
Returnable packaging system	• Efficient logistics and route planning • Coordinated system with other actors in the supply chain • No empty transports • Flexible system	• Imbalances in the system • Quality and cleanliness vary due to several users • High investment costs
Disposable packaging system	• No administration or extra managing required • No return handling in-house • No return transports required	• Disposal fees

4.2 Strategic and external factors

There are several strategic and external factors that affect the logistics of packaging and the decisions made on packaging. This section will present the requirements and demands on packaging followed by a description of Aurobay's production system. Lastly, the collaboration between different actors within the supply chain of packaging system is outlined.

4.2.1 KPIs and demands on packaging

Aurobay has several KPIs throughout the organization and production plant which, according to the interviewees, directly impact the logistics of packaging. Overall, the company has formulated "QDFIPS-goals" which is an abbreviation for KPIs within Quality, Delivery, Finance, Improvement, Personnel and Safety.

Aurobay follows detailed delivery- and quality objectives. The aim is to fulfill the volume of demand per day which amounts to roughly 370 engines during daytime and 190 in the evening shifts. One part within quality goals is "FTT – First Time Through" which is a measurement of deficiency where the engines go through several control stations to detect any potential issues. The interviewees argue that packaging solutions can minimize defects through better protection of parts and that they have a significant impact on the workload for the operators by being ergonomically designed. Another important KPI is labor- and overhead costs where the assembly of the engine must not exceed costs of 0,95 SEK/engine. In addition, the KPI "hours per unit", HPU, adheres to the financial goals where the aim is only having value-adding activities which are directly connected to assembling engines to the customers. The effect of these goals implies that the management must always track the production to ensure that

unnecessary activities or over-staffing are reduced. Interviewees from production state that the logistics of packaging have a direct correlation with these KPIs since better packaging solutions entails less handling for the operators which leads to higher effectivity. Interviewees from the logistics department explain that there does not exist any formulated measurements for their specific department, however, deliveries of material to wrong sections in the plant, damaged goods from transport and other deviations from suppliers are continuously being measured. A central aspect within quality work is checking any potential damage of packaging solutions in the incoming goods area. A main goal is having material in the warehouse for only one day to reduce inventory and tied up capital costs. According to the interviewees, increased lead time of shipments implicates larger stock.

The company has KPIs regarding safety and ensuring the personnel are happy at work and that the production is ergonomically designed for them. According to the interviewees, it is imperative to maintain a comfortable work environment for the operators and avoid injuries. Regarding environmental issues, Aurobay works continuously with tracking waste and CO2-emissions which are important KPIs that stems from a desire of becoming a more sustainable organization. The company has fees of 15 000 SEK per 1 ton CO2-emissions. The interviewees state that the goal of reducing these costs and becoming more sustainable impacts on the logistics of packaging since Aurobay must reduce waste of plastics and recycle their disposable packaging.

Requirements on packaging

The two factors that determine the design of packaging most are the location of the suppliers and the characteristics of the transported material. Up until now, the design of packaging solutions has been determined from a low-cost perspective and to ensure protection for the component, however with no consideration to the needs of the operators in the assembly. A consensus amongst the interviewees is that a lot of handling with the packaging takes time from the value creation which is worsen by not being ergonomic or suitable for presenting the material to the operators in the assembly lines. The most important demands on the design of packaging from production are ergonomics and easy to handle. While low costs are a central objective, the goal of having more ergonomic packaging solutions has received more importance to ensure higher efficiency and minimize handling. Examples mentioned by the interviewees are that the operators must be able to carry or dispose the packaging without difficulty. In addition, they must be fitted well with lifting tools to allow these to pick up heavy material without any issues. There are also several quality aspects that must be taken into consideration in the choice of packaging. First, the packaging must meet the requirements set for the specific article such as fragility, cleanliness and ability to withstand oil. Secondly, depending on weight of the material, the packaging must adhere to certain weight limits. Lastly, an imperative quality aspect, mentioned by several interviewees, is the ensuring protection of the material during transport.

According to the interviewees, a concern is that there are too many variants with the current packaging solutions. There is a desire to minimize the complexity of the entire packaging system by choosing more similar packaging solutions. Additionally, some interviewees mention that reducing the density in the packaging would be beneficial since the effect would be higher fill rate of trucks, resulting in cost savings.

4.2.2 Aurobay's production system

The production system in use at the company is Lean production, where paced flow, waste reduction and working with continuous improvements are fundamental in the ways the operations are set up. The Lean philosophy is further noticeable in the packaging logistics where excess waste is aimed to be reduced and minimal handling of products and its packaging is stated as a goal within the plant. A vision that is expressed and is in accordance with Lean is to have single picking point in the assembly. According to the interviewees, it is a prerequisite in achieving a continuous flow and minimizing fluctuations in the assembly. Single picking point means the operator retrieves the material from the same place every time, otherwise there would be differences in time which could bring disturbances to the production pace that is set. An example mentioned by an interviewee is that it can take 1 second to retrieve the first part from a pallet while retrieving from the bottom layer would take approximately 4 seconds. In addition, there can exist inserts and plastics inside the packaging that an operator must handle which is time consuming. Therefore, the goal to have single picking point is argued to reduce these variations. There is also a vision amongst both logistics and production to reduce the usage of re-order buttons in the assembly line, and instead have a continuous flow of material delivery to the assembly based on the production rate. This would result in a more even and steady flow of materials.

Aurobay's production runs on full capacity during daytime and half in the evening due to lower volume demands. The rate of production follows a 60-second-cycle which entails that 60 engines are produced every hour in order to meet the demand from customer. However, the production is designed to operate at an overproduction of 54,8-second-cycle to better prepare for any potential disturbances or allowing time for improvement work. According to the interviewees, the logistics of packaging has a significant impact on ensuring that the rate of assembly does not deviate from the production plans. The reason is that there is an objective of having assembly stations without fluctuations and therefore it is critical that the packaging does not cause any disturbances.

4.2.3 Collaboration in the supply chain

Aurobay's supply chain of packaging differs between the returnable and disposable systems. The reusable loop system is the one that requires collaborations with other companies, as they rent this system from VCC and all administration and control is outsourced. Aurobay also has an agreement with the external company Logent that manage the breakdown and sorting of empty packaging. Aurobay alone has around 200 suppliers spread around Europe and many use RTIs to ship their products, hence, many actors and companies are a part of the loop system which entails a high degree of collaboration and long-term contracts.

The disposable packaging system have its own supply chain process where parts from China are shipped in containers to Aurobay. The long-distance transports often require several stops in cross-docks to deconsolidate the products. The reason is that suppliers could be delivering materials from a single shipment to both Aurobay and other customers. One handling station is placed in Skövde where some of the deliveries are transported to the truck company Olssons where they are either stored or repacked before sent to Aurobay.

In addition to the collaborations between different actors in the current packaging systems, Aurobay has also had a collaboration with the company Boxon located in Skåne, Sweden. This is an alternative packaging system which has been used to a lesser extent where packaging solutions are produced near the suppliers by Boxon. The suppliers in turn send the material in

these specialized plastic packaging and after usage they are shipped to Logent where they grind them down to plastic granules. Boxon retrieves the plastic granules and molds new packaging according to the orders made by Aurobay.

4.3 Tactical and operational factors

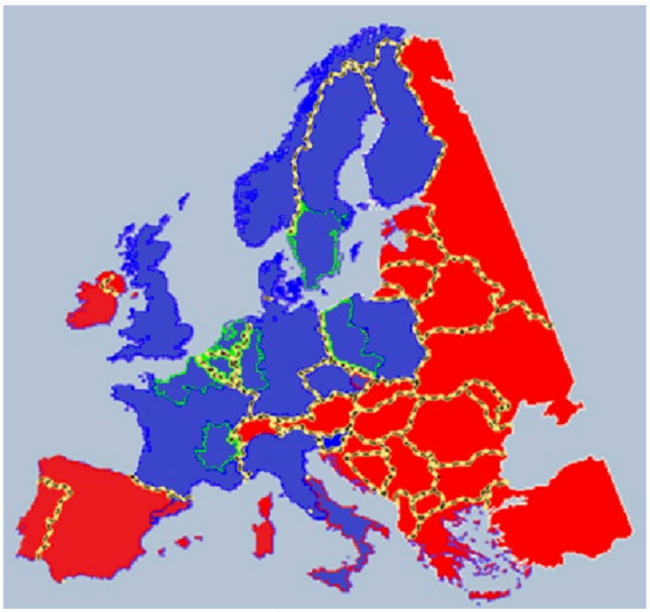
This section presents the tactical and operational actions brought forward in interviews, which are results from strategic decisions made in the company. The section consists of two parts, the first presenting how the sourcing decision affects the packaging system and the daily operations around it, and the second presenting statements from the operational level and how the packaging affects the daily work in the factory.

4.3.1 Supplier footprint

The strategic decisions affect the path a company will take, where for example supplier base is affected by if the company's strategy is to source locally or globally. Aurobay have a global sourcing strategy ranging from within Sweden, all over Europe to Eastern Asia and to North America. The distance to the supplier, together with the quality demand of the product, determines which packaging system can be used. The loop system of reusable packaging is cost efficient within Europe and parts of Russia and Turkey. Figure 9 shows the countries where the loop system is active and is built on a further division where the blue area is used for reusable plastics such as "blue boxes", while the red area only is used for wooden pallets, their lids, inserts and collars. Outside of these areas, only disposable packaging is used.

Figure 9

Areas where the loop system is used



Note: Figure provided by Åke Axelsson, logistics engineer, Aurobay.

The current loop system has three terminals where the packaging is handled. These are placed in Skövde and Gothenburg in Sweden and Ghent in Belgium. The central function at Volvo

Cars in Gothenburg sees all packaging orders from suppliers in the system, the balance and allocates accordingly. The lead time for ordering for example one pallet of blue boxes with lids is two weeks, and most suppliers order new packaging on a weekly basis. There is an estimate on how much should be ordered based on the production volumes from each production company in the network, but the suppliers are free to order any quantity needed. However, this along with the manual work made in the ordering system results in deficiencies in the system where there rapidly can occur imbalances between the different functions.

4.3.2 Operational perspectives

Aurobay's operational departments handle and manage the results of the strategies daily, where the international supply footprint is highly noticed in the packaging used. On an operational level, the packaging is handled by operators at the assembly line who unpack and prepare the articles for PoU and sort the packaging afterwards. In some cases, the preparation and sorting are done in the incoming material area, by the M3-operators.

Line back-principle

Aurobay works with a "line back-principle", meaning the point of value-adding activity is of main focus, and the surrounding operations aim to support this station to make it optimal. With the line back-principle, the work executed by the assembler is thoroughly documented and calculated, resulting in non-value adding work being identified easily. The unnecessary actions are pushed back in the flow, which in Aurobay's case leads to having a kitting area behind the assembly line to handle the main parts of the packaging and supporting functions. It is desirable to push back the non-value adding activities as far as possible, preferably all the way to the supplier and have them pack their products in a way that enables for little to no handling of packaging at Aurobay and perfect presentation for the assembly line. However, there is a trade-off where the cost of having a perfect presentation of the parts directly from the supplier exceeds the company's limit and is not in line with strategies regarding environmental impact. The need to keep down costs and achieve high fill rates and efficient loading of trucks makes it unprofitable to have the parts packed and presented in an efficient way, since this requires low fill rate and increased number of trucks. The main issue brought up by the interviewees is that the packaging does not enable both efficient transportation and loading of the trucks, and a good presentation of the material at the assembly lines.

Since the company cannot have the parts presented the desired way directly from their suppliers, the handling of packaging and preparation of the parts are done within the factory. An issue mentioned during interviews is the lack of area to create a good preparation of parts. The design layout of the engine plant is also mentioned where the placement of the logistics department with the incoming material is located inefficiently in the South-East end of the plant. The plant productivity engineer expresses that if the plant was to be built today, the logistics department would be placed more centrally and closer to the critical areas of operations. With today's layout it is important to create a continuous flow where the material is sent out in small batches with higher frequency, which is in line with the company's Lean philosophy.

Packaging in daily operations

Looking at the assembly line, several of the interviewees express they prefer to work with the reusable packaging over the disposable ones, saying the robustness and standardization of the packaging is more ergonomic and safer to handle. The plastic boxes roll better on the conveyors in line and have better grip design. The wooden pallets are the exception, where the operators

often get splinters in their hands, even with gloves on. Disposable boxes, mainly in carton, makes operators act more carefully and handle the packaging in a more sensitive way since it is common for the disposable packaging to break and are known to cause problems. The overseas pallets in disposable material are less stackable compared to reusable packaging. An issue with the disposable pallets brought forward by the logistics supervisors is that the truck driver unloading the material at M3 needs to put every pallet on a wooden pallet before it can enter the factory.

The specialized plastic packaging is perceived as one of the more difficult to handle, even though these are the latest developed. The packaging for the turbo, figure 10, is an example of a recently developed specialized packaging. It is made to fit the turbo and to ensure its high quality and cleanliness throughout the transport. However, interviewees mention it to be good for the product, but it is not ergonomic and made with the operator working with it every day taken into consideration. The turbos are placed in different directions, which leads the operator to shift their picking each time, and since the turbos are heavy the operator must use a lifting tool which does not fit into the packaging. Several interviewees say that it is of high importance to include the assembly perspective when developing packaging and ensure good ergonomics and grip technique for the operators.

Figure 10

Specialized packaging for turbo

4.4. Interactions with assets

Several interviewees discuss how the packaging system and packaging are interacting with different elements and assets, and that these must be taken into consideration in the designing or implementation of new packaging as they must be integrated with the different processes at Aurobay. Equipment and other assets must be considered when looking at possible packaging. For example, the incoming material is stored in an automated warehouse which is designed to hold pallets of a certain width and height, and forklifts are used at the M3-area to lift and transport the pallets. There has been issues with the warehouse where it has shown that some disposable packaging solutions cannot be stored and must be combined with a Volvo pallet at the bottom, which demonstrates the importance of warehouse integration. At PoU, lifting tools are used in production to retrieve heavy and big parts from the packaging and other helping tools are often formed to fit the packaging. Another process that the packaging is integrated with is the material distribution in-house. The material is transported to the assembly line on trolleys or wagons and the packaging must be able to be fitted into these modes of transportation. There is a current on-going process of eliminating the wagons and increasing the use of trolleys or tow-trains.

The current loop-system is beneficial since it is well-established and incorporated with the suppliers. The contracts with the companies in the supply chain are explained by one of the interviewees to be long-term which entails difficulties in terminating the collaboration with them. In addition, replacing the large size of this packaging system would entail large investments and significant efforts. A limitation in determining packaging solutions are the suppliers' manufacturing processes. One interviewee mention that the choice of packaging must be fitted into the suppliers' packaging process since they have their own requirements.

4.5 Desirable outcome

This section brings up the desirable outcome of the packaging and its systems, and how the current packaging solution meets these goals. The empirical findings in this area regard ergonomics, cost and efficiency of the packaging flow, and discussed is how the current solution performs within these three areas.

Ergonomics

The increasing focus on ergonomics is brought up by all interviewees at the company, stressing the importance of developing new packaging in consensus with production. The ergonomics regards for example grip design, material choice and weight and size of the packaging, where the requirements are mentioned to gain increasing ground and importance within the company. In the past, the production and manual handling of the packaging has been overlooked or misunderstood, which results in more time needed to fetch parts from packaging in the assembly line and in some cases the risk of injuries amongst employees handling the packaging. The ergonomic requirements are not met by the current packaging solutions, but of all packaging used in the factory, the reusable plastic boxes are mentioned to be the better solution, enabling good grip and no risk of injury while handling. The ergonomics of the operations falls under the KPI safety and is measured in several ways, one being how often the risk of injury is spotted in the assembly line. Aurobay works continuously with improving the work environment, but do not have any specific measurements for packaging handling.

Cost

The current sourcing strategy, and with that the packaging system, is based on part price. The purchasing department has big influence on which supplier to make a deal with and part price need to be kept low in order to stay competitive in the industry. The cost efficiency is further high regarding truck loads and utilization of transport means. The standardized boxes and pallets are key enablers of efficient loading and transportation of materials as it is designed to fit the different transport modes and is built to be stackable. Furthermore, as the company strategy is built on the Lean philosophy, the aim is to keep warehousing costs low and reduce the number of buffers in the flow. The chosen packaging solution is to a high degree based on price pressures and there are cost limits for the system, which makes sure it meets the company's expectations on what the actions related to packaging should cost and the current solution does not exceed the company's limits. KPIs on costs are brought up by several interviewees and is, together with quality, one of the more important KPIs to measure and adhere to, but the measurements brought up in interviews only regard assembly and operations. There are no stated measurements on packaging and how to handle and sort the packaging.

Efficiency in the flow

A desired outcome mentioned in interviews is efficiency in the flow, where efficiency is explained as high utilization of truck drivers and truck loads while delivering in the right format and in the right time to production. The company aims to have a stable and continuous flow of packaging entering and leaving the factory, and a supply chain supervisor mentions the company's aim to reduce the density in packaging. There has previously been a clear focus on cost when looking at packaging and its systems, but stated in interviews is that the focus now is shifting towards reducing density of packaging, and having a broader perspective when it comes to flow efficiency and total cost in the supply chain. The aim is to have a simple network with high volumes of packaging, which is not met by the current packaging solution. Connected to Lean, the packaging engineer interviewed mentions how the flow would benefit from a reduction of cross-docks in the system. This would speed up the flow and make it more continuous, while reducing warehousing costs. KPIs on delivery are for example JiT, no unnecessary buffers in-house and the shift towards continuous supply of material rather than having order-buttons.

5. Analysis

This chapter starts with a discussion section on the empirical findings compared to the theoretical framework and how practice can be connected to theory. How Aurobay operates in the automotive supply chain is explained and the company's choices and strategies are supported by the research within the area. In the remaining sections, the research questions are discussed and answered.

5.1 Analysis on strategies and packaging systems

This section compares the theoretical findings with the interviews and observations made at the company regarding Aurobay's strategies and long-term decisions, and how these affect the daily operations and affect the choice of packaging solutions.

5.1.1 Purchasing choice and supplier base

As discussed by MacDuffie and Helper (2007), the globalization within the automotive industry has increased the competition on quality and cost, and the global overcapacity comes with price pressures where companies such as Aurobay often need to choose a supplier on the other side of the world since they offer the lowest part price on articles, even with the transportation cost included. The way of making purchasing- and supplier choices highly affects what packaging is to be used due to the transport distance and geographical limits of the reusable loop system. As mentioned by MacDuffie and Helper (2007) the automotive industry is generally known for having sophisticated suppliers in low-cost countries, which brings price pressures on material and a high level of supplier choice. This leads to low costs but also long lead times, weeks of inventory in transit and the use of disposable packaging which compromises the quality of the articles. Aurobay follows the trend explained in theory, where the company bases their supplier choice on part price and the way of conducting business is strongly influenced by the price tag on products sourced. The logistics superintendent expressed concerns about the quality of the products being transported overseas, and mentioned a huge number of products being scrapped due to transport damages. The disposable packaging is not enough to ensure the quality of the product, but even with the scrapping cost and need to order more products, the price tag is lower than if the company would order the same product within the reusable loop area and source more locally.

The trends of globalization and price pressures discussed by MacDuffie and Helper (2007) also come with the need of working with other companies and have collaborations, either based on trust or on arm's length. Aurobay, before becoming an independent actor, had collaborations based on trust with other companies, where best practice sharing was common. Now that the company stands alone there should be a discussion whether they will welcome collaborations based on trust or if they should collaborate on arm's length with suppliers and customers and focus on aligning incentives to make their supply chain more efficient. As described by Narayanan and Raman (2004), aligning incentives of the companies in the supply chain can result in increased operational efficiency and has shown to reduce excess inventory, stock-outs, incorrect forecasts and improve sales efforts and customer service. During visits to Aurobay, there were concerns from employees that the company now is a relatively small actor, and since the packaging system is rented from a bigger actor, they experience difficulties in their demands being met regarding cleanliness of the packaging and receiving material with the right quality.

Several interviewees mention the fines from the external actor that sorts and controls the empty packaging before it is sent to the distribution central. If Aurobay sends a pallet with plastic boxes that has the wrong quantity of boxes in it, or if there is a mix of packaging in the same pallet, the external company will send a fine to Aurobay. The fines approximately reach a cost of 7-8 MSEK/year, which is mentioned to be an unnecessary cost since the basic sorting can be done easily within the factory. The main reasons the basic sorting of packaging is insufficient is when there is a lack of space in the plant or if there is a shortage of staff. An observation made by the researchers is that there is lacking information on how the packaging should be sent out from the operators, which can be solved through better information sharing amongst operators and logisticians and setting up standards and having an OIS on each sorting station for empty packaging.

5.1.2 Production system

As mentioned by Dörnhöfer et al. (2016) regarding the objectives of high quality and cost savings within logistics in the automotive industry, it can be shown that Aurobay follows these objectives throughout the production system. These goals also impact on the design of logistics of packaging since costs are always taken into consideration. The quality aspect is discussed to be crucial in this industry by delivering high-quality engines to customers from production. Therefore, the logistics of packaging is seen to have a significant role in ensuring that materials or parts are well protected with no defects when entering the factory.

Dörnhöfer et al. (2016) argue additionally that a trade-off exists between cost reduction and increased productivity which can be linked to the logistics of packaging at Aurobay. An example is the case of pallets or plastic boxes which costs less, but are deemed to have a negative impact on productivity by not being optimal for the operators regarding parts presentation. Instead, Na et al. (2019) propose using customized packaging which have been proven to improve productivity. This is shown to be desirable for Aurobay since packaging solutions, where materials would be better presentable for the operators, is considered to increase the productivity at the assembly lines. Moreover, since components are a cost-driver within the automobile industry (Na et al., 2019), it becomes necessary to ensure that these are without defects when they reach the assembly lines. A result of potential damages on the material would result in tracking whether the damage occurred in-house at Aurobay or during transport from the suppliers to determine the accountability and additional costs. Therefore, it is stated that the packaging plays a crucial role in minimizing damages on the material which would have a significant impact on production.

Lean production

The study of Aurobay's production system demonstrates that a Lean philosophy is adopted which is also mentioned by several interviewees to be a strategy for the company. Aurobay uses a pull-based system where materials are only delivered to the assembly lines when an order has been placed by an operator due to shortages in material, which is one of the main pillars of the Lean philosophy mentioned by Baudin (2004). In addition, other pillars of Lean explained by Netland and Aspelund (2013) are JiT and waste elimination, where Aurobay only produces engines according to placed customer orders and not to stock.

Aurobay uses several different measurements to minimize waste such as not overproducing, avoiding operators to wait for material and keeping a low inventory. The last mentioned is argued by Baudin (2004) to have the purpose of supporting production. Aurobay uses an inventory of one day to better respond to fluctuations or disturbances in production, but this

Lean approach of low inventory makes Aurobay more sensitive to potential disturbances in the supply chain, which Reeves (2007) states to be a common factor for automotive companies. However, transportation and unpacking material are some elements of waste found in Aurobay's production plant which affects the logistics of packaging. The first one is the long distance that material must be delivered to certain assembly lines which raises the question of where to store material. The second one is having an employee behind the assembly lines unpacking the material for better exposure to the operators. This is argued to be a waste by several interviewees since this is a non-value adding activity. Therefore, alternative packaging solutions could minimize this type of waste.

According to Duarte and Cruz-Machado (2017), waste elimination is achieved through continuous improvement. Aurobay works continuously with improving its production by pursuing inefficiencies that might exist. Approaches used is increasing visibility in the different processes and dedicating a certain amount of time each day for improvement work. The different assembly lines have divided the workstations to be standardized which makes it possible to understand improvement opportunities by formulating baseline standards. However, there seem to have been less work with improving the packaging due to numerous constraints such as supplier location, fit into the production plant and the properties of materials.

Another critical component of Lean production mentioned by Shah and Ward (2007) are production smoothing, which is argued to be a key focus at the assembly lines. Every workstation is aimed to have the same cycle time to prevent waiting time for the operators, thus achieving a continuous and paced flow. A key factor in achieving this is the logistics of packaging, since certain packaging requires additional handling which can increase the cycle time within certain workstations. In addition, reducing the variability within the processes is argued by Shah and Ward (2007) to be an objective within waste elimination through lowering the throughput time. This in turn demands an effective logistics of packaging. A common desire at Aurobay is to reduce the variability of packaging since different solutions requires different handling and sorting, which can increase the cycle time of the workstations.

Aurobay's use of assembly lines is common in the automotive sector as Blomquist et al. (2013) explain is a necessity in Lean production. This production layout has been chosen to achieve high productivity, standardization and create a continuous flow. Moreover, Blomquist et al. (2013) describe how the adoption of Lean in production can result in negative consequences on human health such as physical issues. This is also present at Aurobay which has resulted in having ergonomic requirement as one of the objectives of packaging solutions.

5.1.3 Packaging systems

The reusable loop-system and the disposable packaging system are discussed with regard to the theoretical framework and how theory explained the different systems and when it is beneficial to use them. The loop-system of Aurobay is connected to one of the control strategies explained in theory and a discussion of performances is done for both systems.

The reusable loop system of Aurobay

A returnable packaging system is generally preferred when the transport distance is short, the turnover rate of packaging is high and the flow consists of large volumes and little variations (Bowersox et al. as referenced in Blomberg & Hallams, 2017). This is applicable to the returnable packaging system used at Aurobay, where a geographical limit is drawn for the use

of reusables. Many article numbers are transported and supplied with reusable packaging, but the variation can be regarded as low since the articles do not differ based on season or trends. Hence, the articles transported are of low variety and the volumes are known in advance based on the production volume forecasts and can be regarded as high.

Aurobay's reusable loop system resembles the, by Kroon and Vrijens (1995) referred to as, System with return logistics. The system Aurobay uses is owned by another company with a central agency that controls the circulation of RTIs and is responsible for the distribution of packaging. In a system with return logistics, the packaging is kept at the company's site until they have enough empty packaging to fill a truck and make the return transport cost-effective and fully utilized. This was observed at Aurobay, shown in figure 8, where the M3-operators fill up a truck of empty packaging which is then sent out to be sorted, cleaned and quality checked before going to the distribution center.

The current loop system is used all over Europe, but the distribution is shared between two countries in northern Europe. Even though it is expressed by Kroon and Vrijens (1995) to be a challenge coordinating border-crossing systems, the loop system in use is well developed and optimized from a logistics perspective, making transportations and flows as efficient as possible. The system is perceived as well working and is established at Aurobay to the point where it is regarded as an asset, where for example racks and lifting tools are developed to fit the RTIs. The current system can be regarded as sustainable and cost-efficient since it utilizes the truck loads and optimizes the transport routes, thus the concerns about unnecessary transports and transporting air are few.

As explained by Na et al. (2019), the switch-pool system is the most commonly used within the automotive industry as it ensures responsiveness toward fluctuations and clear visibility in the system. The companies in this system receive the same amount of RTIs as they return at each switch, making the system resilient to imbalances and makes sure no inventory of RTIs is kept at the companies. Aurobay might benefit from using a switch-pool system instead of a system with return logistics, as the company's employees express concerns about the imbalances of RTIs in the system. The logistics superintendent explained how the imbalance and lack of reusable packaging in many cases causes suppliers to use disposable packaging instead, which results in huge amounts of scrapped products when they are received at Aurobay since the disposable packaging does not protect the articles transported as well as the reusable packaging does. Furthermore, Aurobay aims to operate with a Lean philosophy and the switch-pool system is known to enable on-time delivery and no excess inventory of RTIs. Some interviewees mentioned how the reusable plastic boxes in some cases is used in other contexts than what it is meant for. It is not uncommon to see "blue boxes" being used as filter collectors or tool boxes in the engine plant. These observations imply that there is a demand for box solutions in the engine plant that should be solved in another way and not by taking RTIs from the loop system. Using the RTIs in situations other than transporting material is one of the reasons there is imbalances in the system, and the lack of tracking packaging further complicate the control that the central agency has over the RTIs. With a switch-pool system, Aurobay would have to send out the same amount of RTIs as they receive, which would require extra control and administration from their side, but would result in a more rapid circulation of RTIs, JiT delivery and more visibility and control over the RTIs leading to less inventory and investment costs.

Disposable packaging system
The disposable packaging system is described by the interviewees to be used primarily due to the long distances to the suppliers, located outside of Europe. The shipments from China take approximately 12 weeks to arrive to Aurobay. Would a returnable system be used instead, one shipment of goods would take twice the amount of time since the packaging would need to be returned to the suppliers. Therefore, it can be concluded that disposable packaging solutions are inevitable when the suppliers are located further away, thus making the location of suppliers a constraint on the choice of packaging. In addition, as mentioned by González-Boubeta et al. (2018), a disposable packaging system would be cheaper compared to a returnable flow of packaging if the transport costs are high. A returnable packaging system used instead would require significantly more investments in RTIs which would increase the costs of the packaging system. Therefore, it can be maintained that since the transport costs are higher when shipping from China compared to suppliers within Europe, disposable packaging system is more feasible in such a situation.

Another driving force for having a disposable packaging system at Aurobay is when material is delivered less frequently such as screws or smaller parts, which is according to Vöröskői and Böröcz (2016) common for adopting such a system. In addition, the authors mentions that the production costs of disposable packaging solutions are less than RTIs. This could explain how it would become more expensive if Aurobay would implement a returnable packaging system instead for these parts with low frequency delivery. Škerlič and Muha (2020) nuances this by mentioning that another increasing cost, in adopting a reverse packaging system if the return rates are low, is operating costs. Hence, this could be an explanation for motivating Aurobay to use disposable packaging solutions instead in such a case. However, as Baudin (2004) explains, as RTIs would become cheaper with increased usage it becomes necessary to compare the investments in such packaging solutions compared to having disposable ones while considering the frequency of delivery.

Baudin (2004) discusses how delivery of material is not limited by inventory of packaging in the case of disposable packaging system since these are seen as an unlimited resource. This benefit has been proven at Aurobay in numerous situations where suppliers have been forced to deliver material in disposable packaging since sufficient RTIs have not been the suppliers' inventory. This demonstrates how shipments of material are not reliant on packaging if a disposable packaging would be used. However, the issue of excess waste created by disposables (VöröskőI et al., 2020), is highlighted by representatives from Aurobay to require extra handling. This additional work is performed in-house at Aurobay which occupies a lot of space in the production plant. Since space in the production plant is mentioned by several interviewees to be a limitation, it can therefore be viewed as a constraint for adopting a disposable packaging system.

5.2 Alternative packaging solutions

The current logistics of packaging used at Aurobay is a combination of both returnable and disposable systems. The long use of this approach shows how it is feasible, however, the case study highlights that there exist several issues with the current choice of packaging. Hence, there is a need for improvements or new packaging solutions. The authors have identified three different types of packaging systems that are both feasible and improvements of the current packaging system. This section aims to answer research question 1 where the feasible packaging solutions are presented and discussed.

5.2.1 Alternative solution 1: Move towards only using disposable packaging

The first alternative solution that would be feasible to implement at Aurobay is one where the company only uses disposable packaging. This means the company would step out of the reusable loop system and replace the RTIs with disposable packaging. The main benefits and drawbacks of this suggestions is presented in table 6.

Table 6

Summary of alternative solution 1

	Benefits	**Drawbacks**	**Cost savings [SEK/year]**	
			Environmental	Transport
Disposable packaging only	No return transports, no need for return handling	Risk of compromised quality of products	> 624 000	> 768 800
	Higher fill rate	Risk of compromised cleanliness of products		
	No administration necessary	More difficult to use in production	Total cost savings: > 1 392 800 (Savings for one component)	

Since the disposable packaging does not require return transports, they do not need to be of a conical shape to fit together when empty which the RTIs do. This means the disposables have perpendicular walls and with the extra volume they can hold more components. This leads to less truck loads to transport the same number of products. It is presented in theory that the use of disposable packaging instead of reusable packaging for a cable harness from Turkey results in 41 600 kg less CO2-emissions per year, which with the fees that Aurobay has at 15 000 SEK/ton is 624 000 SEK/year. The use of disposable packaging also comes with a lower cost of approximately 74 000 €/year, equal to about 768 800 SEK/year since they can load more parts into each truck, and this case study is only done for one single component. The total cost savings on transport costs and environmental costs would be close to 1,4 MSEK/year. Moreover, the disposable packaging system does not require administration and control which would reduce the costs further. The main drawback of this solution is the compromised quality and cleanliness of the products. Aurobay employees have stated that quality is of high importance, and the disposable packaging system does not ensure this. It is also stated that the disposable packaging is not as easy to handle as the RTIs since they tend to break more easily and does not have the same well developed grip design. On the other hand, the operators would not need to put away and sort the packaging. The disposable packaging system in theory showed to require 63 seconds less for each package in the in-plant delivery to production, mainly because it does not require the return handling and managing of empty packaging.

This solution is regarded as feasible due to the similarity between the context of the case company in theory, VCC in Gothenburg, and Aurobay. The settings and transport routes are very much alike, if not identical. In the study presented by Blomberg and Hallams (2017) it is stated that Volvo Trucks and VCC shared packaging pool until 2014, and that the split lead VCC to partner with a company producing and delivering disposable packaging. This company is Papyrus Supplies which is located in Gothenburg, and offer disposable one-way packaging to their customers. Papyrus Supplies offers the same dimensions of packaging that is used at VCC, and with that also used at Aurobay. It is possible for Aurobay to partner with this

company and have them produce disposable packaging for the suppliers that cannot solve the disposable packaging themselves, which ensures the assets is not affected since the packaging will remain in the same dimensions as in the current state.

5.2.2 Alternative solution 2: Develop own loop-system with plastic granulates

An alternative approach to the current returnable packaging system would be for Aurobay to partner with Boxon to enhance the use of packaging developed from plastic granulates. Such a system would be similar to a returnable loop system, however Aurobay would request packaging solutions from Boxon according to their needs based on orders of material from suppliers. The result would be ensuring that the packaging always adheres to Aurobay's requirements since Boxon can design the packaging according to Aurobay's demands. Instead of the current loop system that Aurobay is a part of, this solution would start with the packaging being shipped to Boxon's facility in South of Europe where they would be ground down into plastic granulates. Thereafter, these granulates would be used to produce new plastic boxes which are shipped to the suppliers. In addition, this alternative solution would continue using the current disposable packaging system with shipments from outside of Europe.

The aim of this solution would be to replace the current returnable system and move towards a switch-pool system. The reason is due to the aforementioned issues with the current returnable system such as imbalances in RTIs and no control. Hence, Aurobay would use a variant of such a returnable system as Kroon and Vrijens (1995) mention, where Aurobay and the suppliers have responsibility of the RTIs to send them back to Boxon where the company would reproduce new ones from the plastic granulates. Moreover, while this approach is relatively new, the ambition is to have the process of grinding down the packaging into plastic granulates in-house at Aurobay. The reason is to achieve the fully desired benefit of this alternative solution which is a high degree of filling in the trucks and only needing to send one shipment to one location.

The main benefits and drawbacks with this packaging system are depicted in table 7, where the costs or cost savings are presented in percentage based on tests done at the factory. The X in table 7 represents the cost or cost saving that can be achieved when using this packaging solution. The result of this solution would be to solve the issue with the current packaging not being suitable for the operators at the assembly lines. Aurobay would have customized packaging solutions to a greater extent by having Boxon developing these according to their demands. As a result, the current standardized packaging would be replaced by plastic boxes that are customized to each part. Additionally, the lead time of 36 days in the current returnable system would be reduced drastically since activities such as washing, sorting and storing the packaging in different terminals would be eliminated. However, one major issue with this alternative solution is that it only replaces the returnable system and thus includes the issues from the disposable packaging system. Moreover, while this approach reduces the several options of returnable packaging solutions by only using customized plastic boxes, there would still be several disposable packaging solutions that require different managing.

Table 7

Summary of alternative solution 2

	Benefits	Drawbacks	Costs and cost savings [SEK/year]	
			Tooling costs	Handling cost savings
Develop loop-system with plastic granulates	Suitable for production	Does not solve issues from disposable packaging system	40%<X<300%	100%
	Solves the issue with imbalance of RTIs	Many variants of packaging solutions		
	Reduced lead time	Not fully developed solution	Total: In all cases but one, it results in cost savings between 0<X<67% In one case the granular packaging is 7% more expensive	

5.2.3 Alternative solution 3: Continue with current system with modifications

Using the current packaging system can be motivated by the aforementioned reasons with benefits associated with disposable packaging system and the significant investments already made being in the pool system, which can be illustrated in table 8. First, continuing with the current system is justified by it being established and used traditionally amongst all actors in the supply chain. Second, the packaging solutions are integrated well throughout the production plant. However, the current issues with disposable packaging system would not be solved with this approach since those packaging solutions cannot be changed. Furthermore, other drawbacks are that Aurobay would still have less control of the system and imbalances of RTIs could still occur.

There are some minor changes that can be made to better tailor this packaging system accordingly to Aurobay's requirements and objectives. An improvement could be to perform the sorting of packaging solutions in-house rather than outsourcing this activity to Logent which is located about a kilometer from the engine plant. The main reason would potentially be lower costs since Aurobay currently pays 7-8 MSEK/year for this. In addition, interviewees mention that Logent have frequently sent out packaging solutions in the wrong amount. Therefore, sorting the packaging solutions in-house would also result in increased control and less errors.

A problem frequently mentioned by the interviewees is that the material is not presentable in the packaging solutions for the operators at the assembly lines. This has resulted in having an employee unpacking the material behind the assembly lines and perform the kitting which is deemed as a non-value adding activity. An alternative approach would be to introduce a large kitting area for several assembly lines simultaneously. This would be located in PLM3 where there exists vacant area. By merging the kitting of different assembly lines into one common place, the effect would be enhanced visibility and effectiveness.

Table 8

Summary of alternative solution 3

	Benefits	Drawbacks	Cost savings [SEK/year]
			Fines
Current packaging system with in-house modifications	An established system	Imbalances of RTIs in the system	> 7 000 000
	Well integrated with Aurobay's production plant	Low control/overview	
	Flexible system	Does not solve issues from disposable packaging system	Total: > 7 000 000
	Improves parts presentation to some extent	Requires space for kitting area/supermarkets and sorting area	

5.3 Evaluation of the different packaging solutions

To help the researchers answer RQ2, two sub questions were stated, RQ2.1 and RQ2.2. The answers to these sub questions are presented in table 9 as performance measurements and how the different systems rank based on the found criteria and demands. In the evaluation, the alternative systems are compared to the current one and the table is followed by three sections of discussion, one for each suggested solution, where the ranking is explained and trade-offs are discussed.

In the evaluation of the different packaging solutions, the MCA method is used and is presented in table 9. The found criteria are the ones stated in the left column in table 9 along with the alternatives to be ranked. Eleven criteria were found which are given relative importance where a total of ten points were split between the criteria. The higher number given, the more important is the criterion to the stakeholder. Each criterion has also been given indicators, such as CO2-emissions for environmental impact to illustrate the measurement or objective of each criterion. The alternatives are then evaluated based on their contribution to each criterion, also ranked on a scale 1-5, 5 being a well met criteria by the alternative and 1 being a poorly met criteria, and the result is given by multiplying the weight of importance with the goal fulfillment score.

Table 9

Evaluation and ranking of alternative packaging systems

Criteria and demands	Weight of importance	Indicator for each criterion	Develop own loop-system	Current system with in-house improvements	Disposable packaging
Quality of transported product	1,3	No scrapped products	5	2	1
Cleanliness of transported product	1,3	No scrapped products	5	2	1
Delivery to engine plant	1,2	No imbalances in the system, JiT	4	2	4
Cost efficiency (Transport costs)	1,2	SEK/year	4	2	5
Ergonomics	1	No injuries due to packaging	3	2	3
Easy handling in-house	0,8	Number of handling of packaging	3	3	4
Delivery in-house	0,7	JiT	2	4	2
Lean processes	0,7	Paced flow, continuous flow, JiT	2	4	2
Easy handling throughout transportation	0,6	Sturdy, standardized and works with equipment	3	4	2
Administration and management of system	0,6	No management needed	1	2	5
Environmental performance	0,6	CO2-emissions	3	2	5
Result	**10**	**-**	**35**	**24,8**	**29,6**

5.3.1 Disposable packaging

A solution where the reusable loop system is exchanged with only disposable packaging would result in lower transport costs, higher fill rates of trucks and with that, less CO2-emissions, leading the solution to be the most economic and sustainable choice. However, this solution comes with the trade-off of ensuring a high quality of the products transported and the

cleanliness is compromised as the disposable material is not as clean and robust as the RTIs in use. The quality and cleanliness of the products can however be argued to be compromised with the current system as well, since the imbalances in the packaging system forces suppliers to ship products in disposable packaging even if they require robust and clean packaging. This leads to huge amounts of scrapping costs and a decreased quality level, and these are issues that would come with an increased use of disposable packaging.

The operators in the engine plant expressed difficulties in the handling of disposable packaging and clearly prefer to work with the reusable packaging, however the handling of packaging in-house is regarded as positive in the ranking system since the operators do not need to place the packaging in a certain way and sort them when empty. There is about a minute per package to gain on using disposables instead of RTIs which will make the in-house handling more efficient. There would be a trade-off between time reduction regarding packaging handling and the ergonomics of the operator, as several statements were made in interviews about the poor grip design of disposable packaging and that operators need to handle them in a delicate way, hence, there are negative effects in ergonomics.

This packaging system will not suffer from imbalances and the packaging will not be an asset in the same way the RTIs are, which will make the supply flow more even and predictable, resulting in positive effects in deliveries to the plant. The eliminated need to store and sort emptied RTIs also result in positive effects in creating a Lean packaging flow as it reduces inventory and has a less complicated system, and the uncomplicated system requires less administration and control. In the meantime, the more fragile packaging comes with more difficult handling throughout the transportation since the packaging is less stackable, and as stated in an interview, the disposable pallets need extra handling and can take extra time to load and unload.

5.3.2 Developed loop-system

The alternative loop-system would result in several advantages as illustrated in table 9. Boxon would only produce customized plastic boxes which would improve the quality and cleanliness of the transported products. The reason is that these have been proven to be sturdy and protect the material well without any damages or deficiencies. Moreover, customized packaging solutions have shown to be more ergonomic for the operators at assembly lines since they are easier to handle and do not require handling of large pallets. However, this is not deemed as an improvement by the researchers since many disposable packaging solutions from outside of Europe would still exist. While customized packaging solutions are more adapted to each type of part compared to the current RTIs, the presentation of material would still be an issue in the total packaging system. There is hence a trade-off between improved quality and cleanliness of products along with improved ergonomics for the operators, and keeping costs low. Although the benefits of the system are many, this alternative's extent is relatively small and the possibility to use granular packaging for all suppliers in Europe is still unclear.

The main improvements are seen to be reduced transports which would result in less costs and improved environmental performance. The entire loop of the returnable packaging system would be significantly reduced as Aurobay would only send trucks of plastic granulates to one location. Non-value adding activities throughout the transportation such as washing or sorting at different terminals would therefore be eliminated. Moreover, the packaging would not require any storage as Boxon, or Aurobay in the future, would grind them down into plastic granulates directly after usage. However, the researchers have anticipated that a more 'Lean'

packaging flow is not created as a result of these changes. The reason is that these activities would be replaced by other activities, such as producing packaging boxes or grinding down boxes to plastic granulates after usage. Furthermore, the system would require extensive administration and managing from Aurobay's side as opposed to the current self-sustaining system since Aurobay would maintain more control, which is one of the trade-offs when looking to use an alternative loop-system.

The dimension criterium of delivery to engine plant is considered as positive since this approach allows for flexibility in the system as well as solving the issue of imbalances in RTIs. Aurobay would have less disturbances in the delivery of packaging since the production of these would be close to their suppliers and fewer actors are involved in the system, making the system less exposed to turbulence. Furthermore, by only having customized plastic boxes instead of several different RTIs, this solution is regarded to be easier to handle in-house at Aurobay since several interviewees have expressed concerns with having a large variety of packaging solutions.

5.3.3 Current system with improvements

The current system with in-house improvements is an alternative for the company to remain in the reusable loop system but further improve the use of it in terms of in-plant delivery, ergonomics and Lean performance in the factory. This solution is presented since the interviewees had several ideas on how the current packaging logistics and handling could be improved and there was a clear focus on how the system worked within the factory. The improved solution suggests introducing a common kitting area where the main handling of the packaging is done, and where operators prepare the products for the assembly line, improving the parts presentation. This would require a designated area suggested by the researchers to be placed in the current PLM3 area since several of the shelves today stand empty, and the products kept in this area could be rearranged to make room for a working area of kitting. Instead of having the kitting area right beside the assembly line, a common kitting area would in total reduce the space needed and make waste and unnecessary work more visualized, increasing the Lean way of working within the factory along with ensuring ergonomics of the handling. If the handling of packaging is mainly done in this prepping area, the non-value adding handling is minimized at the assembly line and the improved parts presentation enables for increased productivity at line.

The second improvement to be implemented is a thorough sorting of the empty packaging, which is suggested to be done at the M3 area. Correct sorting of the empty RTIs would minimize the risk of receiving fines from Logent, and saving up to 8 MSEK/year. The company could introduce OIS wherever RTIs are collected to make sure the operators sort and place them correctly on their pallets, and a control station could be placed at the M3 area. The main drawback of this suggestion is that it requires extra attention from the operators in line and at least one more operator in total, who would be working at the control station before the RTIs are sent out. The extra costs for an employee would be less than the cost savings from the fines, but this alternative requires rearrangements within the factory that is yet to be calculated and investigated.

This solution does not improve the system's supply chain and does not show advantages regarding sustainability, cost savings or transport efficiency, hence the trade-off of this alternative is creating optimal flows and usage of packaging within the factory while not considering the holistic perspective of the packaging systems. However, the interviewees stated

that one of the strategies of Aurobay is to work with line-back principle, optimizing the work environment for the operator at the value-adding activity, which indicates the importance of improving the in-plant flows and ergonomics.

5.4 The most suitable packaging solution

In this section research question 2 is to be answered. The answering of RQ2 is supported by table 9 and presents which of the alternative packaging systems is the most suitable one for Aurobay to look into for a possible implementation.

The evaluation of the different packaging solutions shows that developed own loop-system outperforms the other alternatives by receiving the highest number of scorings of 35, compared to 29,6 and 24,8 which the other packaging solutions received. Therefore, the results from table 9 show that the most suitable packaging solution for Aurobay is the loop-system with plastic granulates that would be developed by the company itself. Moreover, the final ranking results are showed in table 10 with a summary on what each system mainly would increase performance within.

The developed own loop-system performs better in terms of quality and cleanliness of the products transported, and ensures deliveries to the engine plant since the system is not troubled with imbalances as it would operate on a smaller scale than the current one. If the packaging is developed in cooperation with operators from production it would improve the ergonomics of the handling of as well products as the packaging itself. Drawbacks of the system to be managed is the need for control and administration, and Aurobay would have to attend to the system in a much higher extent than today since this part is mainly outsourced and controlled by VCC. This is a system that would require heavy investments and allows for long-term partnership with a company that offer granular solutions within packaging.

Table 10

Final ranking of alternative packaging systems

Ranking	Solution	Increased performance in
1	Developed loop system	Quality and cleanliness, delivery, ergonomics
2	Disposable packaging system	Transport costs and CO2-emissions
3	Current system with modifications	Parts presentation and in-house efficiency

6. Conclusion

This chapter concludes the thesis by answering the two research questions and future work to be done within the area is suggested.

RQ1. What are the feasible packaging solutions for the company?

The first research questions aimed to analyze the current state of the company's inbound delivery of material to be able to find deficiencies that could be improved in a new system, as well as benefits of the current system to understand what works well and is appreciated by the employees. The literature study combined with interviews at the company resulted in three packaging solutions that were regarded as feasible to implement, and were further looked into to understand and evaluate how each alternative system would perform. The three solutions found were:

- Step out of the current loop-system and introduce disposable packaging for all material,
- Develop own loop-system with plastic granulates,
- Continue with current systems but make in-plant modifications to improve performance.

RQ2. Which is the most suitable packaging solution for the company?

The results from the ranking system showed to favor the development of an own reusable loop system where Aurobay partners with Boxon for packaging made of granular plastics. This system improves the quality and cleanliness of the parts delivered and with that, the scrapping costs and imbalances in the system are reduced. However, this system requires heavy investments and further investigation on costs before proving to be possible to replace the current system. This packaging solution performs better than the other alternatives and is therefore the solution most suitable for the company to look into implementing.

From a supply chain perspective, the disposable packaging system showed to be favorable in terms of environmental and economic performance. With this solution the company will perform better within transport costs and CO2-emissions, while the deliveries to the plant will be more predictable since there will be no imbalances of packaging in the system and the suppliers do not have to await packaging before shipping. Although the system shows negative effects within quality and cleanliness of the products, this can be argued to be a smaller inconvenience since the current system also risks these criteria as the imbalances often forces suppliers to use disposable packaging instead of RTIs. If the quality and cleanliness of the material can be ensured, this is a system well suited for Aurobay to implement.

An alternative that is regarded as feasible and would improve the performance of the packaging system is to not replace the current system, but work with making in-plant improvements. Improvements found to increase the performance is to have a common kitting area in PLM3 where preparations of parts and packaging handling would be done for all assembly lines in the factory, which would result in better parts presentation at PoU and less non-value adding activities at the assembly line. Further improvements are to have a sorting station of empty packaging in the M3 area to reduce unnecessary fines from Logent for bad sorting and mixing of packaging. This alternative has the lowest ranking of the three solutions due to its inability to increase performance in the supply chain but mainly focuses on the in-house flows and belongs to production optimization rather than supply chain effectiveness.

6.1 Future research

The thesis has concluded that three different packaging systems are feasible at Aurobay as substitutes to the current system in place, where an alternative loop system is considered by the researchers as most suitable and therefore recommended. However, further research is now needed in conducting deeper analysis of the economic implications of this approach. The result from this study only considers operational and strategic factors rather than including cost perspective. As previously mentioned in the study, a justification for performing this study of packaging solutions at Aurobay is its large yearly financial costs of 200 million SEK. The researchers have only managed to perform a comparison of costs of current packaging system and disposable packaging system, due to lack of data on this subject. Therefore, further calculations will provide deeper understanding of the practical implications of these different options.

Another relevant area of further research is investigating potential synergies that could be gained through joint collaboration with nearby companies, such as other manufacturers close to Aurobay at Skövde. While the researchers in this study have identified all possible options of packaging solutions that are feasible for Aurobay, collaboration with nearby companies could uncover additional benefits with the packaging solutions as well as improve them.

Lastly, the researchers suggest studying the packaging solutions from a broader geographical perspective to gain a comprehensive understanding. Studying how packaging solutions is performed by other manufacturing companies in other continents could highlight best practices of packaging system. Thus, Aurobay could utilize this secondary data to optimize the recommended packaging solution or shine new light into the feasible packaging solutions identified.

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Appendix A – Interview guide

Appendix A.1

Interview guide - Packaging

What is your title and area of responsibility?
What is your department's main task within the company?

What is the company's requirements or demands on packaging?
Which are Aurobay's KPIs?
How do these affect the packaging system?

What types of packaging are used here today?
How does the flow look for the different types of packaging?
What companies or actors are involved in the flow?

What are the strengths and weaknesses of the current packaging system?
What decides how the packaging looks and which packaging is used for what?
What are the benefits and drawbacks with the different packaging?
Can you think of some future challenges that could affect the packaging system?
How would the perfect packaging system look like according to you? Your perfect solution.

Appendix A.2

Interview guide – Logistics

What is your title and area of responsibility?
What is your department's main task within the company?

Could you describe the department's functions and daily operations?
What are the department's KPIs?
How do these affect the daily operations?

Could you describe the process for incoming material?
How does the flow look for the different incoming material?

What strengths and weaknesses are there with the current packaging system?
What strengths and weaknesses are there with the current packaging?
How is your department affected by the chosen packaging system?

Do you see any future challenges that could affect the packaging system?
How would the perfect packaging solution look like according to you?

Appendix A.3

Interview guide – Production

What is your title and area of responsibility?
What is your departmen’ts main task within the company?

Could you describe the main functions of production and the daily operations?
What are the department’s KPIs?
How do these affect the daily operations?

How does the packaging system in use affect production and its effectivity?
What demands are there on the packaging from your side?
How does the fill up of material work?

What packaging do you have to handle the most? Which station requires most extra handling?

What strengths and weaknesses are there with the current packaging system?
What benefits and drawbacks are there with the different packaging?
Do you see any future challenges that could affect the packaging system?
How would the perfect packaging, and the perfect solution look like to you?

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