Improving Inbound Logistics through Standardised Packaging

A Case Study of Sansera Sweden AB

Master's thesis in Supply Chain Management

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SUMMARY

This thesis focuses on how standardised packaging affects inbound logistics, using the example of Sansera Sweden AB in Trollhättan, a manufacturer of precision engine components for the automotive industry. Sansera sources components from four suppliers, three of which use the standardised V-EMB containers (standard-shaped, stackable, returnable modules), while one supplier delivers parts in non-standard, non-stackable, and disposable cardboard boxes. Based on three interviews with Sansera's logistics coordinator, observations of Sansera's inbound logistics processes, and 2025 transportation data, the analysis identifies the non-standard supplier's packaging as a common cause of inefficiency across several performance measures. These measures include a trailer load utilisation of approximately 20 percent versus 95 percent for suppliers using standardised packaging, over four times the C02 footprint per part compared to the standardised flow, increased warehouse capacity pressures, and recurring production disturbances amplified by the company's sole-source reliance on this supplier. The thesis concludes that packaging must be considered part of a company's system-level inbound logistics decisions and proposes that the non-conforming supplier could be offered standard reusable packaging delivered through the existing reverse empty-packaging flow from another supplier.

Keywords: Inbound logistics, packaging standardisation, returnable packaging, automotive supply chain, load utilisation, case study.

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Isak Kristensen, Eshwar Rudresh Gothenburg, May 2026

List of Acronyms

Below is the list of acronyms that have been used throughout this thesis listed in alphabetical order:

CO2	Carbon Dioxide
DDP	Delivered Duty Paid
EDI	Electronic Data Interchange
JIT	Just-in-Time
ldm	Loading Metre(linear metre of trailer space)
OEM	Original Equipment Manufacturer
RES	Renewable-based Energy Sources
RTI	Returnable Transport Item
SCM	Supply Chain Management
V-EMB	Volvo Emballage
VL	Volvo Logistics

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1 Introduction

This chapter presents the overarching scoap and goals of this thesis report. It introduces the background of inbound logistics and packaging standardisation, describes the specific problem observed in the case company, and presents the research questions guiding the study.

1.1 Background

The business environment is increasingly turbulent. The need for organizations to continuously align their internal strategies with external market shifts has increased dramatically (Melnyk et al., 2014)[9]. The forces of globalization and market-oriented policies have pushed competition beyond the level of individual firms to include entire supply chains (Hood and Young, 2000)[7]. Companies will be able to maintain a competitive advantage only by relentlessly lowering their operational costs and eliminating all types of waste or muda from their logistics networks (Azevedo et al.,2019)[1], especially so within the automotive industry due to high product complexity and intense cost pressures, which demand highly efficient material handling processes (Dörnhöfer et al., 2016)[4].

In this context, inbound logistics becomes an important point where external supply chain conditions meet internal production requirements. Materials and components are expected to arrive on time and in the correct quantity, as well as in a physical form that can be efficiently transported, received, stored, and handled. Observing these systemic pressures highlights the strategic importance of packaging infrastructure; improving packaging efficiency has become an important strategic goal for the organizations managing intense supply chains (Vörösкői and Böröcz, 2016, p. 192)[21].

Planning for a company may happen at a very high level; however, the operational effectiveness of a supply chain depends upon the efficient utilization of pallets. Historically, pallets have been considered to be nothing more than an additional cost item, but they serve as a foundational component of global commerce, carrying around 80% of United States trade and stand as the most commonly used unit load platform in the world (Roy et al., 2016, p. 358)[17]. The vulnerability of this reliance becomes evident during an operational failure: when components or materials arrive without adequate palletizing, the entire process of the supply chain comes to a standstill.

1.2 Problem Description

The key problem identified through this research is that non-palletised merchandise cannot be stacked. Failing to unitise incoming loads has broad sytem implications and introduces severe economic penalties across two distinct stages of the fulfillment process, which in turn creates knock-on effects on the general value-adding operations at the plant (Pålsson, 2018)[11]. During transit, being unable to stack the load wastes the vertical area on each truck. This results in a lower load factor as compared to what could have been achieved using pallets, which directly contributes to increased transportation costs per unit (Roy et al., 2016, p. 360)[17].

Upon arrival at the facility, reserve storage is designed to use the greater height section of the building, known as high-bay storage (Rushton, Croucher, and Baker, 2010, p. 231)[18]. When non-palletized boxes cannot be stacked vertically, they cannot use this high air space and instead take up a massive amount of valuable floor area. That physical bottleneck traps operations within a paradox where managers are aware of changes in operating environments and require a shift towards better operations metrics, but fail to adjust metrics from old, outdated structures that will not meet any physical barriers required (Melnyk et al., 2014, p. 174)[9].

Choosing a sustainable and standard packaging solution in the automotive industry has many implications beyond merely protecting the product (Pålsson, 2018)[11]. Choosing such a solution will significantly influence the logistics strategy, especially relating to how a facility handles, recovers, and reuses packaging and materials to minimize the environmental footprint associated with them (Vöröskői and Böröcz, 2016, p. 191)[21]. The focus of this thesis is developing a plan to create a standardized, palletized material handling system aligned with those used by suppliers globally. By ensuring all incoming shipments can be stacked together, companies can maximize their available truck volume and warehouse space.

1.3 Case Description

In order to explore this topic, a case study has been performed in collaboration with Sansera Sweden AB at their plant site located in the city of Trollhättan. Sansera Sweden AB, henceforth addressed as “Sansera”, is a precision component manufacturer supplying finished engine components to the automotive industry. Sansera’s inbound logistics flow primarily processes a limited number of critical components for their parts manufacturing operation, raw forgings, bolts, and bushings. All three are required for the completion of the final product. Therefore, since all must be present in sufficient numbers in order for the manufacturing operation to function, continuity of supply of each category is critical to the business.

Sansera’s inbound flow structure consists of four main supply routes. One intermodal forging flow from Germany, and two trucking flows of bolts and fasteners use standardised V-EMB modular container system packaging for their deliveries.

The fourth supplier, henceforth referenced as “Supplier D”, delivers their bushings shipments as plastic wrapped cardboard boxes on top of wooden pallets. It is the only supplier operating outside the plant’s standardised inbound logistics packaging system.

This difference in packaging makes Supplier D an important case within the wider inbound logistics setup. While the other flows are connected to a more standardised packaging system, Supplier D’s flow creates a contrasting example that can be examined in relation to transport load efficiency, warehouse storage, inventory planning, and production supply reliability.

The case is further shaped by the governance structure of the inbound transports. Customer demand for Sansera’s products is communicated through call-off signals. These are then translated into delivery schedules by Sansera for their suppliers. However, under the current Incoterms DDP conditions, the responsibility for arranging and financing transport lies with the suppliers. Sansera is therefore not directly able to control carrier selection, routing, or transport conditions, instead limited to the influence of delivery timing and delivery windows. These sources of instability, combined with the requirement that all components be present for the manufacturing process to function, could prove hazardous to the business and should therefore be studied.

1.4 Research Questions

During the project, the following questions have attempted to be answered:

- How does Sansera Sweden currently operate their inbound deliveries?
- How are Sansera Sweden’s inbound logistics operations affected by the current setup, especially in relation to the use of standard and non-standard packaging?
- How could inbound logistics issues related to non-standard packaging be improved upon?

2

Theoretical Framework

This framework starts by introducing inbound logistics in the automotive industry and transitions to discussing warehouses and material handling before closing in on packaging characteristics as the prime focus point to analyse this case. The structure proceeds in a logical downward stream from the company supply network to the physical characteristics of unit load used to store products at the warehouse. Thus establishes the grounds on which to assess how specific packaging choice impacts the inbound logistics performance as presented in the next chapter.

2.1 Supply Chain Management in the Automotive Industry

2.1.1 The Evolution and Conceptualization of Supply Chain Management

Globalisation, liberalisation and deep integration processes have led companies to relocate their manufacturing facilities increasingly throughout the world, changing how they are organised and managed (Hood & Young 2000)[7]. Instead of depending on their internal capabilities alone, companies collaborate with other companies along their supply chain to meet customer needs with a wide array of individual goods, services or skills, each provided by a specific actor along the chain. In this process, competition no longer takes place solely between individual companies but between integrated networks, known as supply chains.

Supply Chain Management (SCM) has therefore emerged as a critical research field and professional discipline. Building upon foundational network concepts (Christopher 1998)[3], Stadtler (2005)[20] defines SCM as the coordination of activities, decisions and management across all involved organizational units and the flows of material, information and finance linking them across the supply chain to meet customer demand efficiently while also promoting the profitability of each firm along the chain. This broad description encompasses three intertwined flows: a forward flow of materials that passing downstream from suppliers to the final customer, a backward flow of information about the customer's demand moving upstream to inform upstream partners and financial flows moving backward along the chain to distribute the profit generated (Stadtler 2005)[20]. If any of these three flows fails, the others are adversely impacted. Even the most advanced delivery technologies cannot ensure overall effectiveness if they do not reflect the quantities and delivery windows associated with customer demand. Likewise, perfect information about customer demand has little value unless it leads to synchronised material flows across the entire supply chain.

Instead of treating the supply chain as a succession of independent relationships or transactions, SCM embraces an integrated, collaborative network view of the supply chain (Stadtler 2005). This means inbound logistics must be addressed on a system-wide basis rather than route by route, considering how suppliers, transport providers and receiving operations work together as a single network. Ultimately, these network flow depends on the physical predictability of inbound logistics, where standardized unit loads guarantees that material flows match the information pacing without operational friction.

2.1.2 The Complexity of the Automotive Supply Chain

The automotive industry is regarded as one of the most complex and tightly integrated supply chains in manufacturing worldwide. OEMs are facing constantly increasing product complexity, which stems from the growing range of model variants and optional equipment chosen by end-customers, as well as substantial cost pressure along the entire value chain that involving suppliers of parts and services (Dörnhöfer, Schröder and Günthner 2016)[4].

Since a finished car built at the the OEM's assembly plant integrates parts supplied by potentially dozens of companies located all over the world, each maintaining its own separate production systems, the inbound logistical task of bringing together all necessary parts and components at the line, on schedule, is an immense undertaking. To manage this complexity, suppliers to the automotive industry are usually organized in a multi-tier structure: a first-tier supplier delivers major modules and assemblies to the OEM, while second- and third-tier suppliers deliver smaller parts to upper-tier suppliers, which eventually reach the OEM line (Vöröskői and Böröcz 2016)[21].

Automotive companies also rely on the reliability of every actor within this system, regardless of its position in the tier structure, since a lack of synchronized availability of parts further up the tier chain can halt production further down. This shows that buyer–supplier relationships must cover more than the transaction of parts; they but also encompass coordination and cooperation and raise expectations of partners predictability. A key feature of the automotive supply chain is the high cost of late delivery. To use the capacity available at the OEM line and thus manufacture automobiles economically, the parts and components need to be available just in time. If inbound delivery parts are not available in the expected quality, time and quantities production output falls (Dörnhöfer, Schröder and Günthner 2016)[4].

As a result, the car company meet its production target without utilizing overtime, struggles to deliver cars to customers as promised,and its assembly line may halt, leaving skilled workers idel for hours and accumulating expensive unused capacity because cars and spare parts do not arrive on schedule, in the required quantity and quality, to ensure continuity of assembly-line operations(Vöröskői and Böröcz 2016)[21]. Emphasis is therefore placed on every incoming delivery of parts and components into the OEM,s manufacturing system.

The dependence becomes critical in the case of a single-sourced part, that is,when no second supplier is available that offers the same product and can fulfill the OEM's requirements. under sole sole sourcing, a disrupted supply line cannot be compensated by alternative sources and leads directly to a halted production line. Such situations arise because the required part may be protected by patents, designed by the customer or unique due to specific technical attributes of the required part. Regardless of the reasons, sole sourcing drastically alters the risk posture of an inbound automotive supply chain. Rather than a disruption by one supplier being a temporary hurdle that can be resolved by turning to another partner, it becomes a fundamental threat to production. Inbound delivery logistics must therefore ensure a higher level of reliability, particularly when a component is sole-sourced(Dörnhöfer, Schröder and Günthner 2016)[4]. Within this complex automotive network, managing the sole-sourced components demands a strict logistical reliability which highlights the need for robust packaging designs that secure the inbound flow against production disturbances.

2.1.3 Lean Philosophy and Strategic Measurement

To survive competitive and cost pressures such as these, Japanese automakers have long adopted the philosophy of lean manufacturing. Originating with the Toyota Production System and documented in many textbooks and managerial discussions over the years, lean has become synonymous with the pursuit of excellence in manufacturing. Lean management's aim is to achieve a maximum level of resource efficiency through the systematic reduction of waste, known in Japanese as muda (Azevedo et al. 2019)[1].

Muda is defined as anything beyond the minimum necessary equipment, materials, time, space, manpower and process steps required to add value to a product or service, and falls into seven categories: overproduction, inventory, transport, motion, waiting, defects, and over-processing (Azevedo et al. 2019)[1]. Waste occurs at each and every point in the value chain that does not create value for the customer, and the inbound logistics of a manufacturing plant offers no shortage of opportunities for it.

Overproduction takes place whenever more items or volumes are produced or brought to the warehouse than required.Excess inventory refers to surplus parts and raw materials held beyond what production requires, occupying warehouse space and tying up working capital that could be deployed elsewhere . Unnecessary transportation means moving items more often than required for their function or process. Motion is the unnecessary movement of workers, machinery or equipment used to complete a task.Waiting arises whenever parts, raw materials, information or instructions are idle or in a queue. Defects arise when items are damaged, not to specification or rejected in quality checks and repair or rework. Over-processing occurs when more labour or effort is applied to an item than is needed to satisfy the customer or the next step in the process. In short, waste is anything beyond the minimum necessary material, working time, equipment, space, workforce and process steps—including wasted material and energy (Azevedo et al. 2019)[1].

These seven categories of waste have direct consequences for inbound logistics. Overproduction occurs when deliveries to the plant exceed what is needed, requiring the surplus to be stored until later use. Excess inventory is a form of overproduction but refers not just to production outputs, it covers all stocks or buffer inventories of materials or parts,taking up space, typing up money that could be spent on other areas and increasing risk. Unnecessary transportation is the movement of goods from one place to another when the physical form of the items makes more journeys necessary than would be required if loads were optimised for container size. Motion and waiting occur when goods are stored, checked, processed or moved within the warehouse or when these activities are performed slowly. Defects require rework or scrapping. Over-processing involves performing work on the part at inbound facilities that ultimately adds no value for the end customer or for the production process (Azevedo et al. 2019)[1].

Within lean manufacturing principles, inbound logistics is a critical area for improving overall efficiency in a manufacturing system and should be closely managed and improved. Lean manufacturing also brings other substantial benefits, such as reduction in required storage space and inventory financing (Azevedo et al. 2019)[1]. Implementing these lean principles inherently requires a smaller safety stock buffers. While a standard buffer enables absorption of the usual uncertainties and variability in the order quantity and lead time for incoming goods. Operating with a lower level of safety stocks (only about 1-2 weeks of inventory, depending on a variety of criteria) leaves lean systems with less capacity to cope with variability and uncertainty stemming from upstream parts deliveries. Therefore, a central attribute of lean inbound manufacturing logistics must therefore be a high degree of reliability from the various parts delivery systems, in terms of both quantity and time of availability at the receiving plant (Dörnhöfer, Schröder, and Günthner 2016)[4].

The underlying spirit of lean SCM and its pursuit of efficiency ultimately requires that supply chain principles be put into effect through material flow. The coordination system built of information systems, planning rules, agreements, etc., provides the framework but supply chain performance is measured by material physically arriving at the location, at the specified point in time and under conditions promised. The point where the supply chain meets internal plant operations is inbound logistics (Stadtler 2005)[20]. because lean operations minimize safety stock buffer, the elimination of waste (muda) heavily relies on packaging standardisation to ensure stable material handling and reduce the process variability.

2.2 Inbound Logistics

2.2.1 Inbound Logistics within the Value Chain

The significance of inbound flows within the value chain can be illustrated through Porter's (1985)[16] value chain framework. Porter states that a company can achieve and maintain a competitive advantage by executing strategic value-creating activities better or more economically than its rivals. To establish this, Porter divides the firm's operations into five primary activities-those directly involved in creating, selling, servicing and supporting the product-alongside the support functions that underlie them. Significantly, inbound logistics sits at the front of these five primary activities that make up the company's value chain. Inbound logistics involves the management of all the tasks associated with the receiving, storage and distribution of manufacturing inputs internally.this scope explicitly encompasses materials, materials handling, inventory control, vehicle scheduling, and returns to suppliers (Porter, 1985, Ch. 2)[16]. Placing inbound logistics at the start of this sequence highlights the fact that downstream capabilities must build upon upstream execution (Porter, 1985, Ch. 2)[16]. The factory cannot assemble parts until they are delivered; Outbound carriers cannot transport vehicles that have not been built, and salespeople cannot sell inventory that has not been produced. Highly synchronized inbound logistics is therefore a crucial prerequisite for all subsequent activities in the supply chain.

When operational friction is introduced at the loading dock of a manufacturing plant, it almost never remains confines to that area. Bottlenecks associated with receiving materials are passed down the entire production process, adding extra cost to manufacturing workflows, warehousing and outbound shipping. An inbound trailer arriving to its full capacity may cost a company far more than the surfae freight charge of a half-loaded shipments. Materials that cannot to be stacked require additional hours for manual handling and forklift operation will, occupy valuable warehouse floor space and requires extra administrative support to track their movement. Improvements at loading dock such as packaging standardization and increased trailer utilization translates directly into substantial cost savings further downstream in the product lifecycle.

This principle is most pronounced in the automotive assembly environment. Operating under tight profit margins and holding minimal safety stock to buffer disruption, automotive companies depend heavily on incoming receipts of components at their loading docks. Inbound logistics Ultimately interfaces externally with global suppliers and internally with factory production, representing the critical operational junction where vvariability in the outside world meets the rigid scheduling demands of the manufacturing environment. As a primary activity that conditions the downstream operations, optimizing inbound logistics interface requires a packaging structures that facilitate the transition from external transport to internal plant operation.

2.2.2 Wrehouse Operations and Material Handling

A major function of industrial warehouses is to regulate the inbound flow of finished goods or manufactured items until they are dispatched to their final destination. Warehouse logistics has long ceased being just about storing inventory; it is a system designed for the fast processing of materials through the building, or a fast throughput of high-velocity inventory (Rushton, Croucher, & Baker, 2010, Ch. 12)[18]. Operational success therefore depends on the speed and regularity of performance.

The internal functions of warehouse operations follow a series of processing steps in order: receiving, storage in a reserve area, order picking, sorting, collation and value added services, marshalling and dispatch (Rushton, Croucher, & Baker, 2010, Ch. 12)[18]. Loading-dock employees first receive and unload the freight delivered to the warehouse, after which materials handlers store the items in designated reserve locations. Warehouse racks store the parts until the factory orders parts that are needed for the assembly process. Workers involved in order picking will retrieve the required number of parts for the assembly operation. Once picked, the parts are sorted and collated, they are placed on waiting trailers and sent to the production line. As these processing phases are highly interdependent any isolated issue in one area will inevitably disrupt the performance of the entire internal sequence.

Exploitation the total space within the building is essential to minimising overheads. Rushton, Croucher, & Baker(2010, Ch. 13)[18] argue that maximizing spatial utilization is key to achieving profitability in the warehouse, since warehouse space is an expensive and limited resource. Additional expenses include not only building rent, heating, lighting, security and maintenance, but also the time associated with traveling around the facility. Failure to use this resource properly leads to higher operational expenses, often forcing the business to pay for an expanded warehouse sooner than if all of the space were optimized for its needs. Once a warehouse floor is fully occupied by existing inventory, a firm may face costly choices beyond lease extensions, such as renting another warehouse, constructing a new warehouse building or enduring the severe inefficiencies resulting from operating out of an overcrowded warehouse floor.

The most cost-effective way to make full use of horizontal floor space is by maximizing use of the warehouse's vertical cubic volume. Racking and a high-reach forklift or similar technologies, enable companies to stack products on multiple levels in the warehouse (Rushton,Croucher, & Baker, 2010, Ch. 12)[18]. All vertical storage racking systems are dependent on the structural soundness of incoming goods. If a supplier ships materials that are unstackable, have soft corners or are irregularly shaped, the forklift operator will not be able to stack the units high on the racks. When the warehouse begins to occupy all the space in two dimensions, but no valuable space in three dimensions (height), companies end up wasting much more space than they actually use because of the weight and nature of the cargo; therefore, it leads to needing larger floor space than higher levels of space.

Warehouse utilization, or its efficiency is determined at the supplier's shipping dock, not on the warehouse's receiving dock. Goods that arrive packed to a standard suited to accommodate automated put-away routes in allow management to calcualte the space required for given orders and allow warehouse operators to handle the units efficiently with the appropriate equipment. Poorly packaged or irregular inputs can prevent the automated routine of put-away into storage racks, forcing warehouse operators to create custom floor spaces for each shipment. Because warehouse performance does not happen solely within the four walls of the warehouse, but depends in part on how goods were packed at the supplier, packaging is integral to warehouse efficiency. Consequently, maximizing warehouse cubic utilization relies on the physical trait of stackability; without that, incoming materials create immediate storage capacity pressure and operational friction.

2.2.3 The Unit Load and the Transition to Packaging

The physical consolidation of items together into a unitized form called the "unit load" links supplier packaging to warehouse and transport effectiveness. A unit load is the most basic building block of material flow: one or more items aggregated into a single, stable module ready to be mechanically handled as a single, unified entity. Historically, the adoption of unit loads has revolutionized industrial operations: it makes mechanized handling possible, allowing for rapid increases in throughput speed and volume (Rushton,Croucher, & Baker, 2010, Ch. 12)[18]. Without a stable unit load, an operation is forced to move each item by hand, which is neither productive nor timely.

The unit load is structured around the pallet, which is far more than a wooden platform used to stack and safely contain cargo, it is a structured foundation capable of safely moving cargo through a widespread supply network (Roy et al. , 2016)[17]. The pallets purpose is to provide absolute consistency. Because all pallets conform to standards governing their measurements, weight and structure, both carriers and warehouses can plan all of their infrastructure (e.g. , shipping trailers, racking and docking procedures) with a completely predictable and standardized base (Roy et al. , 2016)[17]. Standard pallets eliminate the uncertainties that result from variations in dimensions, weight or structure, ensuring reliable and consistent transport and warehouse operations.

Incoming logistics operations are largely determined by packaging choices at the source, these choices determine whether materials arrive at the warehouse packaged to form a stable unit load that can be mechanically consolidated. Unstackable shipments packed in soft containers that are easily damaged , stackable surfaces mean that materials arrive unprepared to be integrated into standard mechanical material handling. Friction then builds throughout the process: inbound transportation load factors fall because unstackable shipments cannot use trailers full vertical capacity, driving up shipping costs per item since freight charges can apply to each unit or case regardless of vertical density (Roy et al. , 2016)[17], warehouses unable to take advantage of vertical racking space are forced to arrange unstackable shipments across only one horizontal layer within a rack bay (Rushton,Croucher, & Baker, 2010, Ch. 12)[18] and labor hours rises as handlers must contend with awkward units when placing or retrieving inventory, eroding the baseline predictability needed for flow processes to function efficiently.

The automotive supply chain's reliance on packaging choices creates close ties that extend across organizational boundaries shaping how suppliers manage third-party carriers, and how those carriers are positioned to deliver components to factories. Factors such as the choice of reusable containers over expendable ones, standardization of container footprint dimensions and management of container life cycles, though perhaps conceived of and implemented autonomously within an organization, actually commit companies to outcomes that extend to multiple stakeholders in the supply chain (Vöröskői & Böröcz, 2016)[21]. Therefore, standardizing packaging is a much deeper commitment than the management at the loading dock of an industrial organization, it is an integral part of a truly lean inbound logistics operation. This shows the importance of packaging standardisation which ultimately governs whether an incoming unit load can achieve optimal vertical stackability in both transport trailers and the warehouse racking systems.

2.3 Packaging

2.3.1 Defining packaging and its functions

In supply chain management and logistics packaging does not only describe the physical containers around the product, but also a broader system in goods transportation. Pålsson (2018)[11] defines packaging as a coordinated system for preparing goods for transportation, distribution, storage, retailing, and end use, with the purpose of ensuring that products reach the user in sound condition at minimum overall cost. This definition points out that packaging is part of a broader system, appearing as a critical component all throughout the supply chain, rather than just the material in which products are brought.

Pålsson (2018)[11] defines different types of packaging using a systems approach and divides them into three interrelated levels: primary, secondary, and tertiary packaging. The primary packaging level consists of packaging solutions that are in direct contact with the product being transported, a secondary level packaging groups a number of primary packages, and a tertiary level packaging further groups secondary packages into larger load units that facilitate transport and handling, such as pallets and containers. This distiction can be seen visualised in figure 2.1. As described, all levels of packaging are interconnected and therefore also interdependent. Packaging performance can thus not be evaluated within each level but must function together as a system, since a change at one level may have consequences across the different levels for the purposes of handling, space utilisation, and transport performance. These consequences may also differ in severity across different activities with improvements in some, and detriments for others, with sometimes unclear knock on effects for different actors in the supply chain.

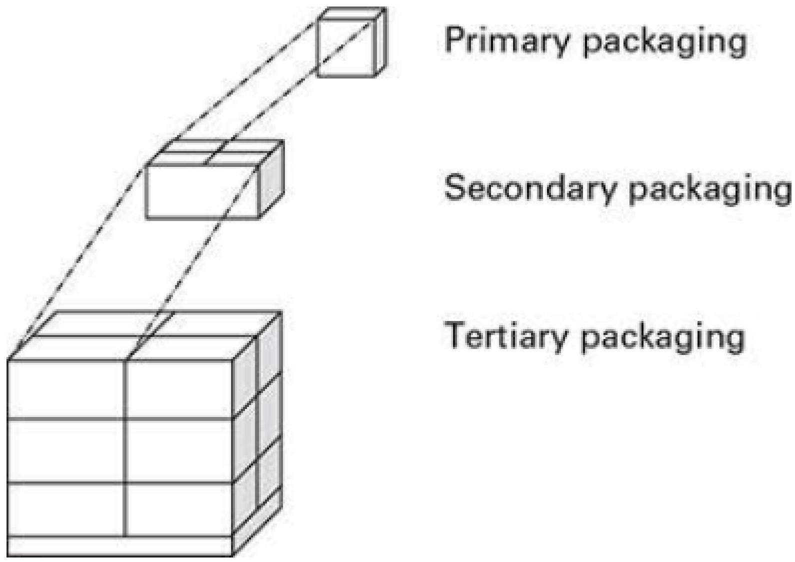

Figure 2.1: Pålsson (2018) "Three interrelated levels of a packaging system"

Packaging can in general be described through six basic functions: protection, containment, apportionment, unitisation, communication, and convenience. Pålsson (2018)[11] explains each of the functions as follows. Protection works to reduce risk of damage to the products during handling, storage, and transport. Containment means holding the product in a way that avoids leakage, diffusion, or external contamination of the product through the packaging. Apportionment refers to the packaging's ability to divide from a larger unit into smaller sub units that are more manageable quantities. Unitisation, in reverse to apportionment, describes the packaging's ability to come together in greater numbers to form a larger whole for standardised handling while in transportation or bulk handling. Communication concerns the ability of the packaging to identify and describe the packaged goods through labels, codes, and form and design among others. And lastly convenience, which refers to features that enable or simplify handling and use. Taken together, these functions exemplifies the broader usage of packaging for different and sometimes conflicting purposes, beyond as just a protective shell, but as a mechanism for improving logistic efficiency and to coordinate supply chain operations across many industries and actors.

In an industrial inbound logistics environment, some of these functions are more significant and impactful. Industrial packaging is most impacted by the protection, containment, unitisation, and industrial communications functions. While still important to keep in mind, as they have importance further down the supply chain and may therefore have an impact on the industrial level, convenience and promotional aspects of communications functions are more commonly discussed in regards to consumer packaging. In an industrial setting, packaging must support efficient production, warehousing, material handling, and transportation processes. This system-oriented understanding will serve as the basis for our further discussion as it relates to packaging alternatives, and their logistics implications.

2.3.2 Industrial packaging and packaging requirements

Industrial packaging differs from consumer packaging in both purpose and evaluation criteria. Whereas consumer packaging often includes promotional and sales-related functions, industrial packaging instead focuses on functions that enable logistics and production processes. Its main purposes are to protect and to facilitate efficient production, material handling, warehousing, and transportation. Its design therefore usually reflects these characteristics and is judged based on their ability to fulfill these functions.

With this perspective in mind it should be clear that a central concern in the designing of industrial packaging is its ability to function well across multiple different activities and industries and should therefore be evaluated as part of a broader packaging system rather than isolated boxes, pallets, or containers. Pålsson (2018)[11] explains that industrial packaging affects several interconnected processes, from purchasing, production, material handling, transportation, and eventual recycling or disposal, and that its total effect can only be understood when these interactions are considered together. The requirements set on packaging in an industrial setting will therefore likely not be optimised for the actor using it in every instance, but rather sufficient for multiple activities and actors. A packaging solution designed optimally for road transportation may perform poorly in repacking or recycling. Industrial packaging is therefore designed and decided upon by multiple actors working together with regard to the full material flow.

The requirements for industrial packaging are strongly shaped by their operational context. In Pålsson's (2018)[11] packaging performance methodology, a packaging system must first be mapped in relation to the product characteristics, the actors in the supply chain, and the activities that bridge the material flow. Requirements must not be universal, and can depend on product attributes such as weight, volume, and fragility, or on the logistics processes in which the packaging will be used. But, they must perform well in multiple environments and for multiple activities.

Industrial packaging requirements are also closely related to standardization and compatibility across the supply chain. Standardized packaging dimensions and packaging systems can support unitization, handling efficiency, and smoother coordination between supply chain actors, while non-standardized solutions may increase the need for special handling or reduce the efficiency of loading and storage. In industrial settings, packaging therefore functions not only as a protective medium but also as an interface between products, handling systems, transport equipment, and operational routines. This makes packaging design an important part of inbound logistics design rather than a separate technical issue.

In summary, industrial packaging should be understood as a logistics-oriented packaging system whose requirements arise from both product needs and process needs. It must protect the product, but it must also support efficient handling, transport, storage, communication, and, where relevant, waste management and return flows. This understanding is particularly relevant for studies of inbound logistics, where packaging design can directly influence how efficiently materials are transported, received, and supplied to production.

2.3.3 One-way, disposable, and reusable packaging systems

A fundamental distinction in the packaging literature is between one-way packaging systems and reusable packaging systems. One-way packaging is typically used once and then discarded, recycled, or otherwise treated as waste after use. By contrast, reusable packaging is designed to be used multiple times in the same form without losing its protective function. In industrial logistics, this distinction is important because it affects not only the packaging material itself, but also the surrounding logistics system, including handling routines, waste flows, return flows, and total cost structure.

Reusable packaging systems usually require more robust and durable packaging units than one-way systems. As a result, reusable packages are often stronger, heavier, and more expensive to acquire initially, while one-way packages are often lighter and less costly per unit. However, the higher initial cost of reusable packaging is distributed across multiple usage cycles. At the same time, reusable systems involve additional operational activities and costs, such as collection, return transport, storage, cleaning, repair, administration, and control of losses or misplacement. One-way systems, on the other hand, avoid these reverse logistics requirements but instead generate packaging waste that must be handled after use.

From a logistics perspective, the key difference is therefore that reusable packaging requires a closed-loop or return logistics system, whereas one-way packaging is generally associated with an open flow that ends in disposal, recycling, or recovery. Kroon and Vrijens(1995)[8] describe returnable packaging as a secondary packaging type that can be reused several times and show that its use necessitates a return logistics system involving transport from recipient to sender or to another point in the network, along with cleaning, maintenance, storage, and administration. Similarly, Pålsson(2018)[14] emphasizes that reusable packaging uses a closed-loop process in which return transport and reverse-flow management are central features. This means that packaging choice is not only a matter of choosing between containers or materials, but also a matter of choosing between different logistics system designs.

In industrial and automotive settings, reusable packaging has attracted particular attention because of its potential logistics and environmental benefits. Returnable transport items (RTIs), such as pallets, trays, crates, and containers, can reduce packaging waste, improve product protection, support standardization, and facilitate more efficient handling and material supply processes. This is one reason why RTIs have become widespread in automotive supply chains. Na, Sim(2019)[10], and Lee note that automotive firms often adopt RTIs because materials are valuable, on-time delivery requirements are strict, and the costs of disruptions are high. Škerlič and Muha(2020)[19] similarly argue that returnable packaging is widely accepted in automotive logistics because it can improve handling efficiency, lower waste, and support standardization, although these benefits depend on proper management of the system.

However, the literature also cautions against assuming that reusable packaging is always superior. Reusable packaging can only be efficient if the surrounding system is well designed and managed. Pålsson(2018)[14] points out that reusable packaging is generally more suitable when shipping distances are relatively short, cycle times are short, the handling and cleaning of empty packages are efficient, and there is sufficient control over the packaging fleet. He also notes that volume efficiency matters: if reusable packages have shapes or dimensions that reduce space utilization, they may be less competitive than one-way packaging. Na, Sim(2019)[10], and Lee show similarly that the optimal use of reusable packaging depends on operational duration, demand variability, and return lead time variability, while Škerlič and Muha (2020)[19] show that transport distance and demand volume affect the relative attractiveness of non-returnable and returnable alternatives. Together, these studies suggest that the suitability of packaging systems is context-dependent rather than universal.

The literature on disposable packaging reinforces this need for contextual evaluation. Blomberg and Hallams show that disposable packaging can in some cases be handled through many of the same internal logistics processes as returnable packaging, at least until the point where empty packaging must be broken down and managed as waste. Their study also highlights that disposable solutions create new requirements for waste handling, collection, and space for empty packaging. More broadly, Pålsson, Finnsgård, and Wänström (2013)[15] argue that one-way and returnable packaging systems should be compared holistically, since packaging choice affects transport, material handling, waste handling, packaging material use, and overall supply chain performance. Thus, the choice between one-way and reusable systems should be based on system-wide effects rather than on purchase cost alone.

For the purposes of this thesis, the distinction between one-way, disposable, and reusable packaging systems is important because these systems shape how efficiently packaging supports inbound logistics. Reusable systems are often associated with greater standardization and better integration with logistics routines, but they also depend on reverse flows and system control. One-way or disposable systems may reduce the need for reverse logistics, yet can create disadvantages in waste handling, handling efficiency, or space utilization depending on their design. The relevant theoretical implication is therefore that packaging systems should be analysed as alternative logistics arrangements with different consequences for transport efficiency, handling, and cost.

2.3.4 Packaging characteristics that affect logistics efficiency

The logistics performance of a packaging system is shaped not only by whether it is one-way or reusable, but also by a number of specific packaging characteristics that influence how efficiently goods can be stored, handled, loaded, transported, and supplied to production. In the packaging logistics literature, several characteristics are repeatedly emphasized as especially important for logistics efficiency: unitization, stackability, volume efficiency, weight efficiency, handleability, standardization, and communication through labels and identification systems. These characteristics are significant because they influence multiple logistics activities simultaneously and therefore affect total supply chain performance rather than isolated cost elements.

One of the most central characteristics is unitization. Pålsson(2018)[11] describes unitization as the packaging function through which smaller packaging units are combined into larger, manageable handling units in order to improve material handling and transport efficiency. Through unitization, a number of primary packages can be grouped into secondary packaging and then further into tertiary packaging such as pallets or roll containers. The logistics benefit of this is that fewer handling units need to be moved, stored, loaded, and unloaded throughout the supply chain. Efficient unitization therefore supports both transport and warehouse efficiency while also reducing handling time and effort.

Closely related to unitization is stackability, which is especially important in warehousing and transport. Stackability affects the extent to which vertical space can be used efficiently when packages are stored or loaded onto transport equipment. Pålsson(2018)[13] stresses that packaging contributes to environmentally and operationally efficient logistics when it provides appropriate stackability, handleability, and volume efficiency, as these features improve consolidation, loading, and warehouse space utilization. Similarly, Blomberg and Hallams show in their Volvo-related study that stackability is an important packaging precondition in internal logistics, since it influences how packaging can be received, stored, and handled in the plant. If packaging lacks stackability, unused air space may arise both in storage and in transport, reducing load efficiency and increasing the logistics cost per transported unit.

A third important characteristic is volume efficiency, sometimes also described as cube utilization. Volume efficiency concerns how well the internal and external dimensions of packaging make use of available space in storage and transport. Pålsson, Finnsgård, and Wänström (2013)[15] argue that the shape and dimensions of packaging affect cube utilization efficiency in transport and that packaging size directly affects warehousing and transportation space use. In his later work, Pålsson also explains that industrial packaging evaluation should account for the costs and environmental impacts of packaging volume utilization, for example whether packaging is filled to its potential or whether slight dimensional changes could increase the number of items that can be stored or transported. This makes volume efficiency a key packaging characteristic in inbound logistics, where transport capacity and storage space are limited and costly resources.

In some contexts, weight efficiency is also critical. Pålsson(2018)[11] notes that the relative importance of weight and volume efficiency depends on the transport mode: when air transport is involved, both weight and volume are highly influential, whereas in sea and rail transport, volume efficiency is often more decisive. Even in road-based inbound logistics systems, however, packaging weight can affect the amount of goods that can be transported within payload limits, as well as the ease of manual or semi-automatic handling. Weight efficiency therefore interacts with both transport performance and ergonomics. A packaging solution that provides high protection but is unnecessarily heavy may reduce transport efficiency and handling performance, while an overly light packaging solution may create product protection or stability problems.

Another important characteristic is handleability. Handleability refers to how easily packaging can be moved, gripped, lifted, turned, opened, emptied, or otherwise managed through logistics and production processes. In packaging logistics research, handleability is repeatedly linked to warehouse efficiency, loading and unloading routines, and manufacturing support. Pålsson (2018)[11] highlights that packaging affects material-handling processes directly and that unitized and well-aligned packaging can minimize energy use and improve efficiency in manual and automated handling. Blomberg and Hallams similarly identify handling efficiency as one of the four main practical perspectives for evaluating industrial packaging, showing that packaging must be compatible with receiving, storage, line feeding, and empty packaging handling in order to perform well in an industrial setting. This makes handleability a particularly relevant characteristic in inbound material supply systems where packaging passes through multiple operational stages before use in production.

Standardization is another packaging characteristic with strong logistics implications. Standardized packaging dimensions and designs support co-loading, easier handling, stable stacking patterns, and compatibility with handling equipment, transport assets, and storage systems. Pålsson points out that standardized dimensions in reusable packaging can provide efficiency benefits such as co-loading, although they may also create lock-in effects if the packaging becomes difficult to adapt to new products or changing order sizes. In automotive and pallet-based systems, standardization is often a major reason for using reusable transport items, since it enables more predictable handling and stronger integration between supply chain actors. Roy et al.(2016)[17] and Elia and Gnoni (2015)[6] reinforce this point by treating pallets and load carriers as logistics assets whose management strategy strongly influences logistics cost and performance. Standardization can therefore be seen as a means of reducing operational variability and improving the fit between packaging and the logistics system in which it is used.

Although physical characteristics are central, communication and identification features also affect logistics efficiency. Labels, barcodes, and other identification systems make packaging easier to identify, trace, sort, and control in material flows. Pålsson (2018)[12] notes that packaging communication supports supply chain control and that track-and-trace capabilities can improve logistics performance by enabling visibility, consistent quantity control, and responsiveness to changes in logistics operations. In industrial packaging, these features are especially relevant when standardized packaging systems are shared across actors and when efficient return flows or waste flows must be controlled. While these ICT-related capabilities are not the main focus of this thesis, they remain part of the broader set of packaging characteristics that support logistics efficiency. Taken together, these characteris-

tics show that packaging design directly shapes logistics performance. A packaging system that supports effective unitization, good stackability, high volume efficiency, appropriate weight efficiency, easy handling, and operational standardization can improve warehouse space utilization, loading efficiency, transport utilization, and production support. Conversely, packaging that performs poorly on these characteristics can create dead space, extra handling, repacking needs, reduced stability, and other inefficiencies throughout the material flow. For this reason, the logistics implications of packaging design must be treated as a core analytical issue in studies of inbound logistics rather than as a secondary technical detail.

2.3.5 Load carriers, pallets, and closed-loop logistics systems

Load carriers constitute an important part of industrial packaging systems because they provide the physical basis for unit loads and thereby shape how goods are assembled, stored, moved, and transported through supply chains. In the packaging literature, tertiary packaging includes load carriers such as pallets and roll containers, which group secondary packaging into larger handling units. This function is central to logistics efficiency because it reduces the number of units that must be handled and improves compatibility with warehouse and transport equipment. In industrial supply chains, load carriers should therefore be understood not merely as supporting structures, but as logistics assets that influence material handling, transport efficiency, and supply chain coordination.

Among load carriers, pallets are the most widespread and important category. Roy et al.(2016)[17] describe pallets as the structural foundation of the unit load and emphasize their central role in the handling and transportation of products across supply chain echelons. Elia and Gnoni (2015)[6] similarly define the pallet as a portable, rigid platform used as a base for assembling, storing, stacking, handling, and transporting goods, and argue that palletized loading allows firms to transport and store goods as a single unit. In practical terms, this means that pallets affect both logistics costs and operational efficiency by shaping how products are loaded, moved, and stored. Because pallets are embedded in material handling routines and transport systems, the choice of pallet strategy has consequences far beyond the purchase of the load carrier itself.

The literature distinguishes between different logistics arrangements for pallets and other load carriers, particularly open-loop and closed-loop systems. In an open-loop system, the load carrier typically follows the goods downstream and is not physically returned to the original sender, even if economic arrangements such as resale or salvage exist. By contrast, in a closed-loop system, the load carrier is returned after use and recirculated within the supply chain. Elia and Gnoni (2015)[6] note that the latter is more complex to design and manage because it includes reverse logistics processes and multiple inbound and outbound flows, but it can also be more effective economically and environmentally when well managed. Roy et al.(2016)[17] similarly distinguish between single-use expendable pallet systems, buy/sell programs with salvage value, and leased pallet pooling programs, the last of which depend on return depots, collection, repositioning, inspection, and refurbishment. These distinctions show that load carrier systems differ not only by physical design, but also by network structure and management logic.

This system view is consistent with the broader returnable packaging literature. Kroon and Vrijen(1995)[8] explain that returnable containers, including pallets and other returnable packaging forms, require a return logistics system involving transport from recipient to sender or to another point in the network, as well as cleaning, storage, maintenance, and administration. Pålsson (2018)[14] similarly stresses that reusable packaging systems require reverse logistics and that their suitability depends on short return distances, short cycle times, efficient handling of empties, and sufficient control of the fleet. Thus, load carriers in reusable and closed-loop systems should be viewed as circulating resources that must be managed across the full cycle rather than as one-time packaging items.

A key reason load carriers matter in logistics is that they influence the formation and performance of the unit load. The pallet or equivalent carrier determines how packaging can be stacked, stabilized, handled, and fitted into transport and storage space. Pålsson(2018)[11] emphasizes that industrial packaging and load formation should be evaluated in relation to transport, material handling, packaging material, waste handling, and capital costs, while Pålsson, Finnsgård, and Wänström (2013)[15] show that load carriers are part of the tertiary packaging level and affect overall packaging system performance. This implies that the design and selection of load carriers influence not only the local handling of goods, but also transport fill rates, warehouse space use, and the total efficiency of material supply processes.

Closed-loop load carrier systems are especially common in industrial and automotive contexts, where standardization, asset control, and repeated flows make returnable systems feasible. Pålsson (2018)[13] points out that the automotive industry often uses pool systems of reusable plastic crates for component supply and that standardized reusable packaging can support co-loading and operational efficiency. Na, Sim, and Lee (2019)[10] likewise describe how automotive supply chains commonly use returnable transport items and switch-pool logic because of the high cost of disruptions and the need for reliable, responsive delivery. Škerlič and Muha (2020)[19] reinforce this view by arguing that returnable transport items such as pallets, trays, and crates play an important role in automotive logistics and that the benefits of these systems depend on proper management of the packaging flows. Together, these sources indicate that standardized returnable load carriers are closely linked to the design of efficient industrial material supply systems .

At the same time, the literature shows that closed-loop systems are not automatically superior. Their performance depends on how well the return processes are organized, how efficiently empty carriers are collected and handled, and how well the packaging system fits the product and material flow. Elia and Gnoni (2015)[6] emphasize the importance of factors such as the pallet logistics network and interchange system when designing effective closed-loop pallet systems. Roy et al.(2016)[17] show that the attractiveness of different pallet strategies depends on variables such as pallet cost, salvage cost, dwell fees, retention rates, and transportation costs. Pålsson (2018)[14] adds that reusable systems may become less suitable if return distances are long, cycle times are extended, or the package design reduces volume efficiency. Consequently, the choice of load carrier and loop structure should be treated as a contextual logistics design decision rather than a purely technical packaging decision.

For the present study, the most relevant implication is that load carriers and their associated loop systems directly influence the efficiency of inbound logistics. Pallets, containers, and similar carriers determine how materials are unitized, whether loads can be stacked effectively, how much transport and storage space is utilized, and how easily packaging can be integrated into existing logistics routines. Whether the load carrier belongs to an open-loop or closed-loop system further affects the need for reverse logistics, asset control, and waste or empty packaging handling. Load carriers should therefore be treated as a core element of packaging system design and as an important link between packaging choices and logistics performance.

3
Methods

3.1 Research Design

The Sansera Sweden AB factory in Trolhättan has been the subject of a single case study for this thesis, with a specific focus on their inbound logistics activities. This, according to Yin (2009)[22], is an appropriate approach for the investigation of current events as they take place in their real-world context, and is particularly useful when such events, and their consequences, may be difficult to fully understand without them interacting with their current surrounding conditions. Using the logic proposed in Pålsson (2018)[11], presented in the theoretical framework, that industrial packaging is best understood as "systems" with a wide area of influence on other operations in businesses, a case study was deemed to be the appropriate approach.

For this case study, an abductive research logic has been employed. The usage of an abductive logic in this project is supported by Dubois & Gadde (2002)[5] systematic combining approach for industrial network research case studies due to its emphasis on a continuous interplay between theory and empirical observations, allowing the research framework to evolve with the project through systematic matching. This has been important for the project due to the initial lack of a complete project description. In the beginning, theory was used in order to find the research questions, whereupon the collected data and the analysis of it served to inform any further theoretical readings, continuing as such throughout the project time line.

3.2 Data Collection

During data collection, three complementary methods have been employed: semi-structured interviews with relevant people at Sansera, observations made at the factory, and previously collected quantitative data provided by Sansera. This cross-sectional design, as it is described in Bryman & Bell (2007)[2], improves the credibility of the data by "canceling out" any limitations that may be found in a single data collection method.

3.2.1 Interviews

Three semi-structured interview sessions serves as the primary qualitative data source and was conducted with the logistics coordinator at Sansera over the time period spanning January to March 2026. The first session occurred on the 26th of January with the purpose of gaining an understanding of the company's supply chain structure and more thoroughly their inbound logistics organisation. The second session on the 24th of February, focused on the packaging of one of their suppliers. Lastly, the third session was held on the 16th of March, covering confirmatory and factual questions arising from the analysis of earlier data. Due to the scale of the subject used for this case study, the logistics coordinator acted over a multitude of fields that may be conducted by several people in other organisations, and was thus considered the best source for the questions asked.

Table 3.1: Overview of interview sessions with the logistics coordinator

Session	Date	Format	Focus
Interview 1	26 January 2026	In person, at plant	Exploratory: company overview, supply chain structure, inbound logistics organisation
Interview 2	24 February 2026	In person at plant and follow-up email	Detailed: packaging problem, fill rates, stoppages, inventory, supplier dependency
Interview 3	16 March 2026	Written email	Confirmatory: data verification, transport modes, CO_2 tracking, constraints

3.2.2 On-site Observations

Weekly on-site observations were conducted continuously throughout the project, where the inbound goods receiving area, the warehouse, and the production line area were observed. The standardised V-EMB containers and the non-standard Supplier D packaging routines were also observed in person and photographed to be used as visual evidence.

3.2.3 Quantitative Data

Two quantitative data sets were provided by the company. One data set detailed shipment dates, transport modes, cargo weight, loaded volume, transport distance, and CO2 per shipment for the year 2025. The second data set covered further transport related CO2 emissions at the individual shipment level using standardised tonne-kilometre calculation models, also spanning the year 2025. The logistics coordinator noted some limitations with the provided datasets. Some of the shipments lack complete volume or packaging information, and the CO2 values are estimations rather than directly measured. These limitations, however, do not materially affect the validity of the findings given the study's qualitative orientation.

4
Empirical Findings

This study gathered data using three semi-structured interviews with the logistics coordinator at Sansera Sweden AB,conducted on 26 January, 24 Febuary and 16 March 2026. In addition to the interviews,For questions that could not be addressed during the interviews logistics coordinator addressed them in written format via e-mail and informal on-site discussions during plant visits. On-site observations at the Trollhättan plant, as well as transport and emissions data for the full calendar year 2025, have also been collected. In accordance with confidentiality agreements, all interview material is paraphrased and all suppliers are anonymized.

The results are organized thrmatically. they begin with context about the company and its inbound logistics organisation, followed by packaging standard, the consequence of non-standard packaging, cost-related effect and emissions-related effects of logistics the remaining themes cover inbound flow inventory challenges, inbound flow map and the governance of logistics providers. A map of Sansera's inbound flows is displayed before each following section, with the relevant suppliers or warehouse nodes highlighted at each instance, guiding the reader throughout the flow map.

4.1 Company Overview and Inbound Logistics Organisation

Sansera Sweden AB is a Swedish component producer located in Trollhättan. the company produces finished engine components for the automotive industry. The inbound logistics function is led by the logistics coordinator, who has held the position for about three and a half years and has provided input on all three interviews. The centrepiece of the company's inbound logistics is three types of components: forged raw material, bolts and bushings. The final component requires all three types; without any one of them, it cannot be completed, which means that supply continuity from each supplier is a non-negotiable operational requirement.

Figure 4.1 maps the four inbound lanes: Supplier A (intermodal forging), Suppliers B and C (road bolts), and Supplier D (road bushings).

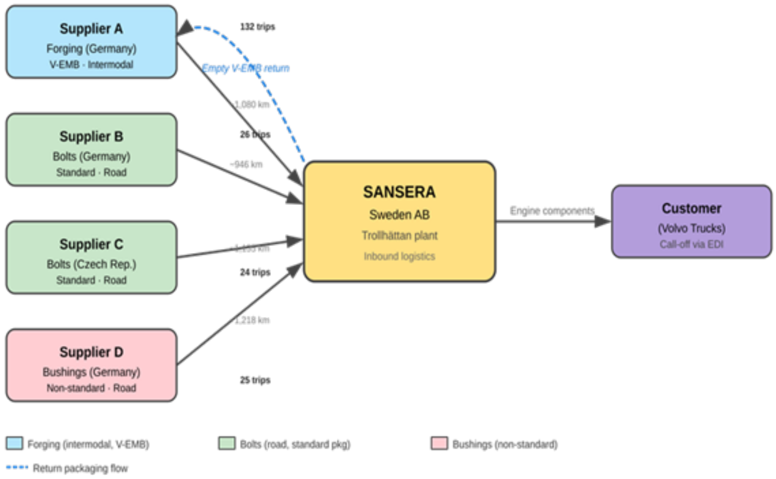

Figure 4.1: Inbound logistics network and supplier material flows.

The diagram shows independent supplier arrivals, the outbound customer flow to Volvo Trucks, and the V-EMB return loop to Supplier A.

The company's inbound transports are initiated through its demand-pull system, After customer submits thier call-off signal through EDI, Sansera generates their delivery schedules for its suppliers, whose goods must be ready for collection roughly three to four days in advance. The customer operates on a fixed weekly delivery pattern spanning four days a week (increased from three to accommodate higher demand). While customer demand is relatively constant year-round, the logistics coordinator stated that unexpected call-offs occur about once per month because of customers dual-sources from parallel supplier. Whenever a problem arises with other supplier, the customer increases their order to Sansera at short notice, which creates a knock-on effect for the company's incoming supplies.

Under the prevailing DDP incoterms, Sansera expects suppliers to cover the cost of transport to the Trollhättan plant. Sansera's control of the inbound flow relies solely on scheduling when the goods must be ready for collection and on the available delivery windows, while Sansera does not have control over transport provider, the number of carriers or the transport routes and therefore does not operate a milk-run or multi-carrier consolidated delivery system; insted all suppliers shipping independently.

4.2 Inbound Flow and Current-State Mapping

The inbound material flow at Sansera can be divided into four supplier flows and one structured return flow, mapped below. This mapping is based on interviews with personnel, e-mail correspondence, on-site observation and 2025 transport data. The current-state map brings together the elements highlighted in previous sections, combining them into one overarching visual.

Figure 4.2 details the 2025 current-state map, consolidating distances, trip counts, and packaging standards for each supplier lane.

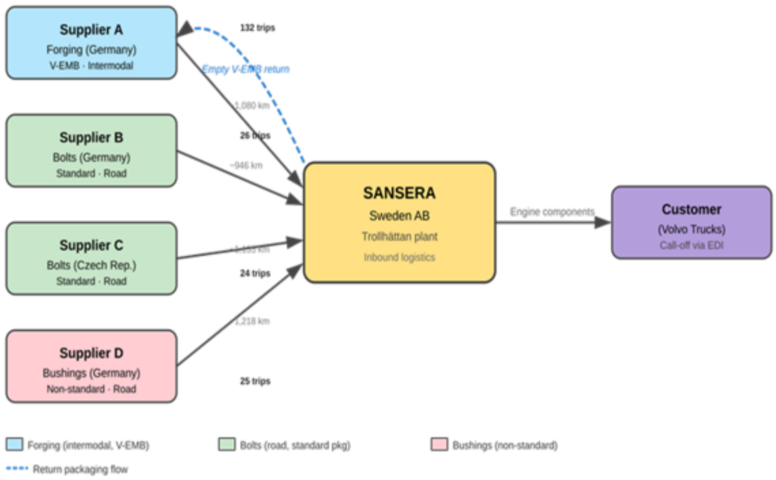

Figure 4.2: Figure 4.2: Current-state inbound flow map at Sansera (2025).

The map demonstrates network complexity by highlighting variations in transport modes and packaging parameters across the flows.
The primary, highest-volume lane is Supplier A, in Plettenberg, Germany, the supplier of raw material for forging parts. This flow consists of a truck to the German railway network, where parts are packed into V-EMB containers at Supplier A's facilities, rail transport from the German to the Swedish network, a transfer of parts to a road carrier in Gothenburg, and finally a truck delivery to Trollhättan. The total distance is approximately 1,080 kilometres. This lane accounted for 132 inbound trips in 2025 at near-full capacity. it is also the most environmentally sound, most cost-effective and most efficient way of transporting parts, measured in emissions per kilogram.

Two road-only inbound lanes serve bolt suppliers. Supplier B is located in Germany (approximately 946 km from Trollhättan) and made 26 deliveries in 2025. Supplier C is located in the Czech Republic (approximately 1,135 km from Trollhättan) and made 24 deliveries in 2025. These suppliers use standard boxes appropriate for groupage transport and, according to the logistics coordinator, neither supplier has produced incidents relating to supply or delivery logistics for Sansera.

The fourth lane is Supplier D for bushings, located in Germany (approximately 1,218 km from Trollhättan). This is the furthest road-transported item among Sansera's suppliers. In 2025, there were 25 inbound road deliveries on this lane. The items arrive in non-standard, non-stackable boxes and the loaded volume of these boxes averages about 2.3 linear metres per trip. The coordinator estimates this is around 20% of the truck trailer capacity. This is the only inbound flow for which production stoppages have occurred and that uses non-standard packaging, and the only one with consistently sub-optimal load volumes.

The outbound returns consist of collapsed V-EMB frames that are stacked and sent back to the supplier in Plettenberg, Germany. In 2025, this route accounted for 22 road trips. Forged scrap parts are batched and shipped in batches to the supplier rather than in small individual amounts, to make return transport more environmentally sustainable.

4.3 Packaging at Sansera: Standard and Non-Standard Solutions

Our initial focus was the overall inbound logistics system at Sansera. However, as we mapped the four suppliers, pattern that stood out was Supplier D operated entirely outside the V-EMB packaging system used by the other three lanes, and this difference was directly related to lowest fill rates, reported production stoppages, and vulnerability. This observation shifted our analysis from the general inbound system to packaging as the structural issue underlying Supplier D's performance

4.3.1 The V-EMB Modular Container System

The standard inbound packaging across most of suppliers is the returnable wooden packaging standard called V-EMB modular container (V-EMB system). This standard was set up through Volvo Logistics as an initiative available within the Volvo Group's global packaging management framework. The V-EMB consists of a pallet base and two additional sets of wooden frames (each at a 195mm in height), and a plywood or plastic lid. The V-EMB container systems comes in several series: L (outer dimensions 1225×820 mm), K (820×615 mm), and the larger F-, G- and H-series containers. Load-bearing capacities are proportional to its containers' size. The L-series container has payload capacity of up to 1000 kg, static stacking load of 4000 kg, dynamic stacking load of 2000 kg, and maximum empty-container stacking height of 5 m.

Figure 4.3 outlines the closed-loop logistics flow, highlighting Supplier A's forging lane and the return packaging loop.

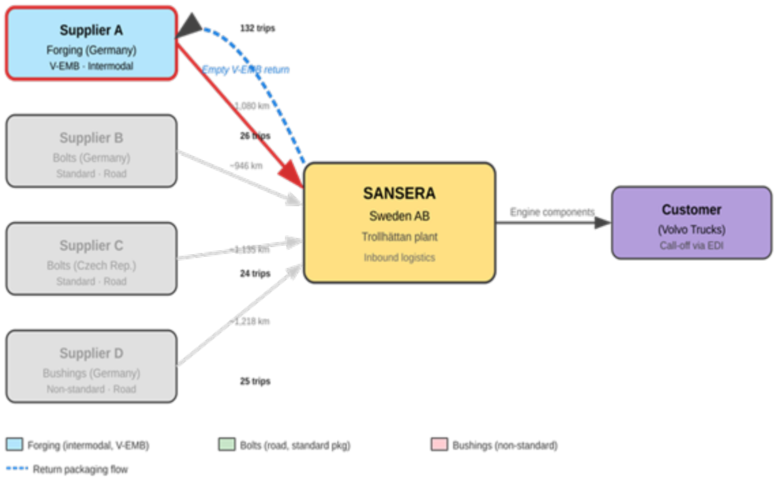

Figure 4.3: The V-EMB closed-loop packaging flow diagram

The diagram shows V-EMB containers traveling filled with forgings and empty collapsed frames returning through the same transport corridor.

V-EMB containers have the unique logistics benefit of being collapsible. When empty, the wooden frames fold down, reducing overall unit volume by between 70 and 85 percent depending on the series (from the largest H-series at 85% to smallest K-series at 70%). The Logistics Coordinator was asked to confirm the collapse function, explaining that the frames fold down over the base pallet, so what used to be a box shape is now flat and ready to return". this means the driver carrying the delivered V-EMB containers can take collapsed frames back in empty containers to large numbers of suppliers. The return of V-EMB containers can therefore operate as a closed loop that efficiently uses the truck capacity on return. The system is recyclable and meets IPPC standards for wooden packaging packaging.

In the Sansera warehouse, V-EMB containers stack reliably in standard pallet racking at multiple vertical layers, using the full height of the facility, as illustrated in Figures 1 and 4. Because of the uniform dimensions and calculated stacking capacity of the system, warehouse handling can be standardized, which also makes it space-efficient and supports rapid forklift-based handling.

Figures 4.4 and 4.5 display the physical handling of standard containers inside the storage and production environments.

Figure 4.4: V-EMB modular containers stacked in warehouse racking at Sansera (own photograph, March 2026).

Figure 4.5: V-EMB containers at the production line area (own photograph, March 2026).

These photographs illustrate how the uniform dimensions of the V-EMB system support vertical stacking and internal handling routines.

4.3.2 Non-Standard Packaging from Supplier D

While other inbound flows follows a uniform packaging standard, one Supplier (referred to as Supplier D throughout this study) sends their bushings in non-standard disposable packaging. This consists of cardboard boxes that vary randomly in height, width and depth from delivery to delivery, typically wrapped in plastic film. As evidenced by the photographs in Figures 3 and 4, boxes delivered by Supplier D do not conform to any consistent external size, meaning they cannot be safely stacked vertically during transit or storage in the company warehouse as there load bearing capacity is very low.

Figure 4.6 isolates the Supplier D bushing route, with all parallel standardized V-EMB container flows dimmed for contrast.

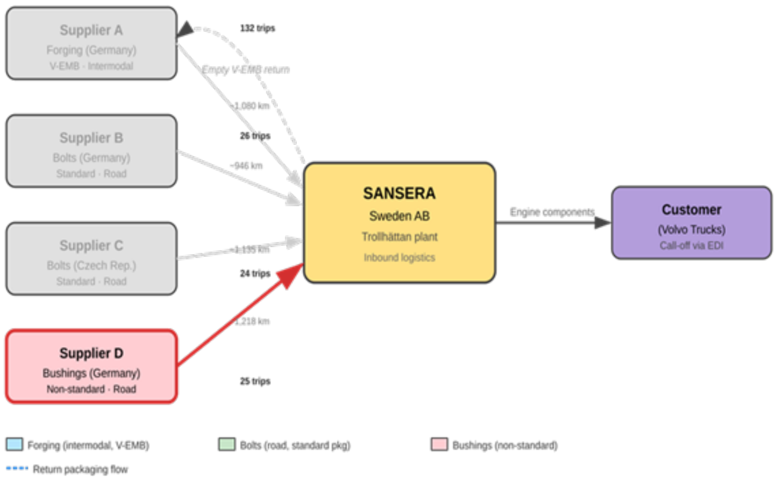

Figure 4.6: Non-standard packaging flow diagram for Supplier D.

This flow diagram visually highlights the only inbound lane operating outside the standard V-EMB loop and using disposable cardboard.

Figures 4.7 and 4.8 document the arrival condition and physical variability of Supplier D's non-standard packaging elements.

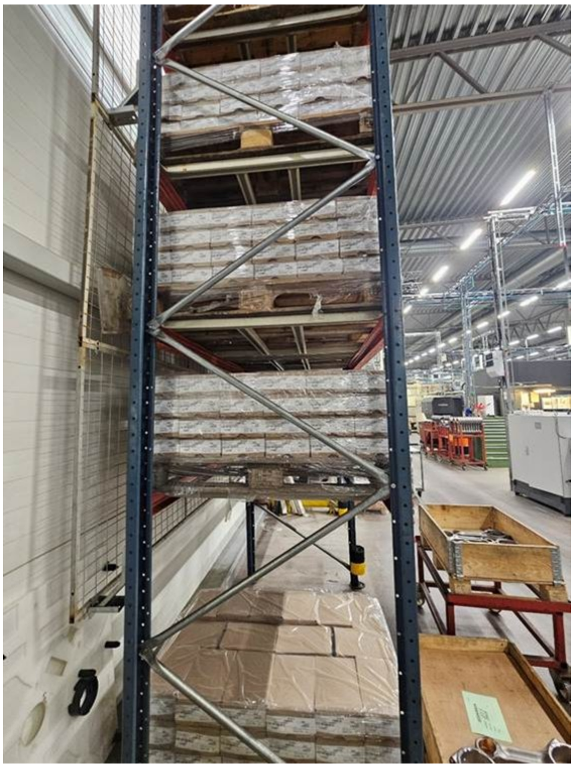

Figure 4.7: Non-standard packaging from Supplier D: cardboard boxes of varying sizes on an inbound receiving trolley (own photograph, March 2026).

Figure 4.8: Detail of non-standard cardboard boxes from Supplier D, illustrating mixed wrapping materials (own photograph, March 2026).

The photographs confirm the irregular dimensions and poor load-bearing strength of the boxes, which restrict standard pallet handling.

Since the bushings are patented components that the customer has mandated Sansera purchase only from Supplier D the only company capable of making them according to customer specifications-Supplier D's non-compliance poses a much more significant risk than it would for a less critical component or if the company could select another source. While Sansera is in discussions with its customer to obtain a second supply source for the forgings (covered in the following section), no such alternative exists for the bushings. The only solution to Supplier D's noncompliant packaging therefore lies within the existing supplier relationship rather than switching to a supplier that could meet the desired standard. The logistics coordinator, who has held this position for more than 3.5years, indicated that there have never been any supply-related logistics problems with the bolt or fastener suppliers. Problems affecting the reliability of production have occurred in the foring supply and, even more so, in the bushing supply from Supplier D, which is the only inbound supply that uses non-standard packaging.
Non-compliant packaging leads to insufficient supply because the maximum volume of bushings that can be loaded onto a truck is dictated by floor space rather than the total cubic volume of the trailer, since the non-stackable boxes cannot be stacked vertically during transit. The logistics coordinator stated, "It is one of the major limits on how much we can use the trucks. " According to the logistics coordinator, if the boxes could be stacked, at least two layers of could be achieved probably three.

If the company tripled the number of layers per truck, the component volume per shipment could also triple as well, so fewer trips would be required to meet customer demand. Without stacking, the space above the single layer of boxes which would be filled if they could be stacked becomes wasted space and requires more truck trips to meet customer demand.

When any delivery is late or contains fewer components than it should, the inventory buffer is consumed faster, since each individual shipment constitutes a smaller percentage of the overall weekly inventory requirement. In a lean inventory scenario, this leaves the production line short of the required components before the next scheduled shipment is scheduled to arrives. The logistics coordinator confirmed this and stated that the production line has stopped as a result of these shortages, specifically on the bushing supply.

The sole-source nature of the Supplier D purchase further increases this risk. With forgings, where the company and customer are exploring a second supplier, a failure by the part of the current supplier could eventually resolved through an alternative supplier. This is impossible for the bushings, since the customer requires a single-source supplier for these proprietary parts and Sansera has no other source. As a result, every shipment from Supplier D is critical in its regularity and every truck trip is critical in its cost and reliability, more so than for any other inbound flow.

Overall, the logistics coordinator characterized flexibility as the most important attribute in automotive inbound logistics, stating that, even with extensive planning, little ever goes as planned. By using non-stackable packaging and operating on a just-in-time basis under a single-source dependence, the bushing flow lacks the flexibility to accommodate disruptions without risk to production.

Table 4.1 provides a side-by-side technical comparison between the standard V-EMB system and Supplier D's disposable alternative.

Table 4.1: Comparison of standard V-EMB packaging and non-standard packaging.

Characteristic	**Standard (V-EMB)**	**Non-Standard (Supplier D)**
Material	Wood, plywood, plastic	Cardboard, fabric wrap, plastic film
Dimensions	Standardised modular series (e.g. L: 1,225 x 820 mm)	Irregular, varies between and within deliveries
Stackability	Up to 4,000 kg static; 2,000 kg dynamic	Not stackable, no structural integrity under vertical load
Volume when empty	Reduces 70–76% via foldable frames (confirmed by interview)	Disposable, not returned, generates waste per delivery
Warehouse compatibility	Full compatibility with racking and forklift	Single-layer storage only
System governance	V-EMB closed-loop managed by Volvo Logistics	No managed system, disposable, outside any return flow
Suppliers using this	All other inbound suppliers	Supplier D only (customer-mandated sole source)

The comparison highlights structural divergence in stackability, empty volume reductions, and warehouse equipment compatibility.

4.4 Costs of Transportation & Effectiveness of Load Utilization

In 2025, the transport dataset records a total of 229 shipment events across all inbound and outbound transport routes within the case. Most these events 207 in all consisted of inbound deliveries to the company from the four supplier entities involved in this study. The fill rate, defined as the percentage usage of truck trailer capacity across shipments,varies by transport route. Interviews with personals at Sansera confirmed this variation and provided concrte figures.

Figure 4.9 maps the load efficiency across all active inbound supplier flows.

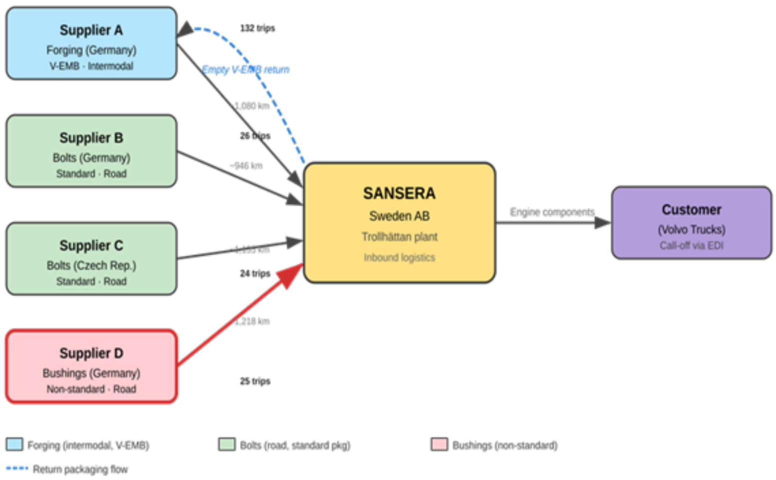

Figure 4.9: Comparison of load efficiency across inbound supplier flows.

The visual breakdown confirms that Supplier D achieves the lowest truck utilization at approximately 20

for the intermodal forge flow route, the logistics coordinator estimated the fill rate at about 95 percent. The transport data supports this by showing shipment weight in the range of 23,000-28,000 kg for this flow, compared with 28,000 kg benchmark for a fully loaded trailer . (On one occasion the interviewer noted in passing that a trailer on this flow slightly exceeded the standard, by roughly around 80 kg; this was not significant enough for the respondent to comment on.) The forge flow is therefore operating at optimal efficiency on both measures. It is important to reemphasize here that V-EMB containers were used here, uniformly packed, full of parts,occuping 13.6 metres of trailer space in full-container-sized groups for intermodal delivery.

For the bushings shipped by Supplier D, the logistics coordinator estimated Sansera's share of the groupage truck fill rate at 20 percent. The 2025 data indicates that the average load volume for Supplier D's deliveries is 2.3 linear metres out of 13.6 linear metres of trailer space about 17 percent of capacity with a range from from 0.4 metres to 5.2 metres. Given that Sansera pays for its space within the shared truckload, the pre-kilogram cost of goods transported on this route is higher than on any other route. The company is forced to use more individual partial-load trucks per year to transport a given amount of goods that could be transported in far fewer trips in a fully loaded truck if the packaging were stackable.

The logistics coordinator was explicit that the non-stackable nature of Supplier D's packaging is a primary factor limiting truck utilisation. A pallet of busing, the coordinator explained, consists of approximately 5,000 units, which constitutes roughly two weeks of demand at normal consumption rates. Sansera typically holds between one and two pallets per delivery cycle; with a bi-weekly delivery rhythm,each truck must carry enough volume to cover roughly one week of production. Because the boxes cannot be stacked above the floor layer means that additional truck journeys and its associated freight costs are required to move the same total component volume.

The coordinator noted even combining bolts and bushings onto single trucks cannot achieve full loads at this stage, due to relatively low annual demands per each component type. The more effective response, the coordinator suggested, it is better to address the root cause of the problem by making the packaging stackable, if Supplier D bushings could be stacked three high in trailer, Sansera could ship three times more parts per truck per trip without having to adjust the delivery schedule, supply chain relationships or transport provider.

4.5 Transport-Related CO2 Emissions

Sansera measures transport-related emissions by calculating tonnes of CO2 per shipment, based on tonne-kilometres produced using standard conversion factors. Reducing of transport-related CO2 emissions is a priority sustainability initiative, one that already shapes choices Sansera now transports intermodal forge flow using by rail, a mode that produces much less emissions. The dataset from 2025 gives the current emissions performance by flow in full-year terms.

Figure 4.10 visually illustrates the variance in CO_2 emissions intensity between the inbound flows.

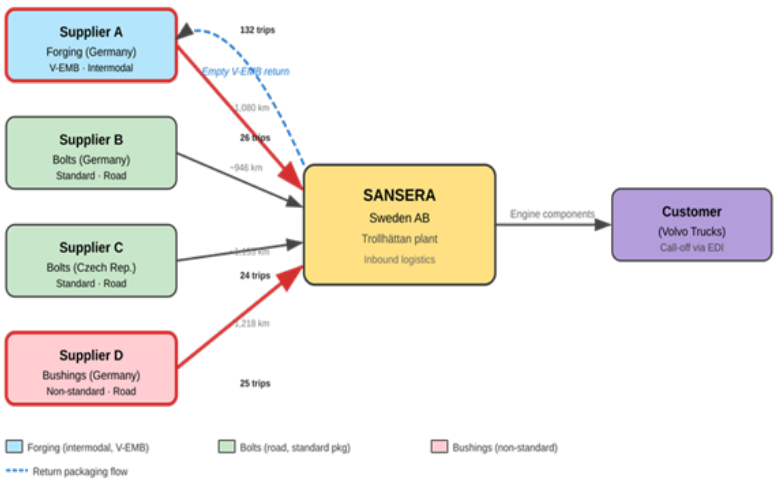

Figure 4.10: Transport-related CO_2 emissions intensity across flows.

The graph highlights a severe four-fold intensity gap between Supplier D's road deliveries and the intermodal forging route.

In 2025, total transport-related CO2 was 177.3 tonnes for all inbound and outbound shipments within the scope of this study. The largest by volume single contributor by volume was the intermodal forging flow, at 129.49 tonnes, corresponding to 132 shipment events at 981 kg of CO2 per trip. It is, however, the least emissions-intensive flow per kilogram of goods: averaging of 27.2 tonnes of material per shipment and 981 kg of CO per trip, it produces roughly 36 grams of CO per kilogram of goods. This is the lowest per-unit transport-related CO of any flow and reflects both the low-carbon nature of rail transport and the uniformly high truck load efficiency (95%).

Supplier D's 24 road trips generated 9.44 tonnes of CO2 in 2025 an average of 393 kg CO2 per trip. however a direct comparison between supplier D and the forging supplier is limited in analytical value, as both flows uses different transport mode with different baseline emission intensities. A more meaning full comparision would be between supplier D and bolt suppliers, all three of which uses the road transport over broadly comparable distances. Normalizing both cargo weight and transport distance by expressing emissions as grams of CO2 per tonne-kilometre reveals the following:

Table 4.2 breaks down the normalized CO_2 emissions specifically for the road-only suppliers in 2025

Table 4.2: Normalised CO_2 emissions by road supplier, 2025

Supplier	Trips	Avg. Load	Avg. Weight	g CO_2/t-km
Supplier B (bolts, Germany)	26	1.58 ldm	1,570 kg	120.3
Supplier C (bolts, Czech Republic)	24	3.57 ldm	5,472 kg	74.5
Supplier D (plain bearings)	24	2.77 ldm	2,473 kg	**130.7**

The metrics show that Supplier D has the highest intensity at 130.7 g CO_2/t-km due to poor load utilization.

Supplier D shows the highest normalized emission intensity of the three road flows at 130.7 g CO2 per t-km. when compared with suppluier c which as around 24 trips per year and achives about 74.5 g co2 per t-km which is about 43 percent lower compared to supplier D. the different reflects in the load efficiency, where supplier c's standard packaging allows it to move an average of 5,472 kg per trip compared to Supplier D's 2,473 kg, which means more goods are being moved per unit transport-realtatated CO2 generated. if Supplier D used stackable packaging allowing three layers per truck, as estimated by the logistics coordinator, the weight transported per trip would increase approximately three times, which would bring emissions down towards the range achieved by Supplier C.

Furthermore, the logistics coordinator's comments on consolidating scrapped forgings in batches to fill the whole truck, in order to "limit impact on the environment," indicate that management is aware of this issue and is acting on it. Had such a practice been combined with the packaging changes enabling Supplier D bushings to fit more efficiently in truckloads, (stackable parts on multiple levels in the trailer), the total yearly emissions benefit from this flow might have been similar.

Monthly emissions in 2025 are generally stable between, roughly 13 and 19 tonnes CO2 per month, with a dip in July to about 5.5 tonnes, mirroring lower factory output during summer vacation weeks. The peak emissions was about 19.2 tonnes in October, showing that the broadly predictable and stable component demand as described by the logistics coordinator held largely consistent across the year.

Table 4.3 provides an aggregated comparison of load efficiency and emissions across all supplier flows.

Table 4.3: Load efficiency and emissions comparison across inbound supplier flows (2025).

Metric	**Forging (Intermodal)**	**Supplier B (Road)**	**Supplier C (Road)**	**Supplier D, Bushings (Road)**
Transport mode	Intermodal (rail + road)	Road, groupage	Road, groupage	Road, groupage
Avg. load per trip (ldm)	13.6 (full trailer)	∼3.2	∼3.2	∼2.3
Avg. weight per trip (kg)	∼27,248	∼1,570	∼5,496	∼2,473
Fill rate estimate	∼95% (interview)	Partial / shared	Partial / shared	∼20% (interview)
Annual trips in 2025	132	26	24	25
Distance to plant (km)	∼1,080	∼946	∼1,135	∼1,218
Avg. CO_2 per trip (kg)	981	178	463	393

This dataset underscores how low fill rates directly correlate with increased transport trips and higher emissions.

4.6 Inventory Storage and Inventory Planning

4.6.1 Warehouse Storage and Space Constraints

Sansera is running out of storage space at its site and must rent external space, which the logistics coordinator considers non-sustainable and does not scale with increasing demands. Sansera negotiated with their landlord to build a new 900-square-metre inbound warehouse directly adjacent to the plant; at the time of the third interview, the signing of the contract was pending. It is intended for inbound materials, with additional space for other uses can be found if capacity permits.

Figure 4.11 displays the localized floor capacity pressures within the facility caused by receiving unstackable materials.

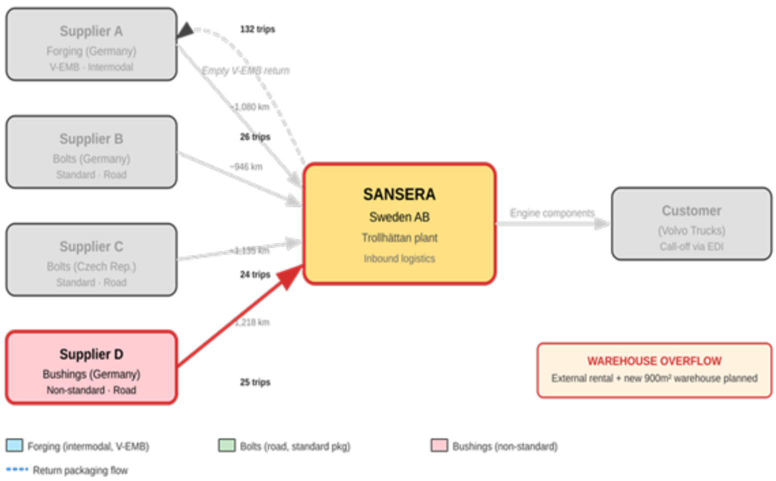

Figure 4.11: Warehouse capacity pressure resulting from non-standard packaging

This model illustrates how single-layer storage creates horizontal bottlenecks, explaining the pending 900-square-metre warehouse expansion.

The V-EMB containers allows this capacity to be fully exploited as multiple levels of stacked containers can be placed within standard pallet racking (Figure 1 and 4), making use of the full vertical space in the warehouse. The standard dimensions and engineered stacking of V-EMB containers supports reliable put-away planning: every container functions in an identical way in the warehouse, which makes it possible to calculate the required storage space in advance.

Supplier D's non-standard boxes, on the other hand, cannot be stacked at all vertically (the sizes are irregular and the soft cardboard walls combined with fabric wrapping provide no stable stacking surfaces). The boxes must therefore be stored one layer per pallet, meaning that where three or four levels of V-EMB containers can be stored per racking bay, only a single layer of Supplier D's boxes can fits. With an external warehouse already rented, this creates a bigger spatial demand for Supplier D's products compared to their component volume, intensifying the need for an external warehouse rental and the construction of a new inbound warehouse.

4.6.2 Inventory Levels and Planning Dynamics

For bushings and bolts, the logistics coordinator stated that the company currently holds roughly one to two weeks of safety stock for each product, occasionally rising to three weeks when the company orders an extra batch of parts in expectation of variability. He considers two weeks of inventory as an appropriate buffer and sees three weeks of inventory as financially manageable but not ideal, as it extends the gap between paying for material and being paid for it by roughly two weeks compared with a one-week buffer. Four weeks or more would be considered too expensive, given how much money would be tied up in working capital.

The strongest argument for having a higher buffer is the bushing supply, because each delivery contains a variable, low-volume of parts from Supplier D (approximately 1 to 13 colli per trip, average around 7). In contrast to the forging flow, where each truck always arrives full with standard packaging and a predictable amount of material to replenish inventory, Supplier D's deliveries provide unpredictable quantities of material per trip. A low delivery volume can therefore deplete the buffer faster than expected and put the operation at risk of stopping if stock is tight and the next delivery arrives much later.

This problem is further amplified when the customer, roughly one every month, raises their demand due to their dual-sourcing policy. If the customer increases its order at short notice, Sansera needs to try to source additional quantity. Whereas the forging supplier is generally able to fulfil additional requests of raw material, the logistics coordinator expressed doubts that additional bushing deliveries can be ordered from Supplier D. Even if Supplier D agrees for additional requests, extra truckloads of its non-standard packaging may not carry enough volume to cover a significant demand increase.

Table 4.4 presents the total annual transport-related CO_2 emissions by supplier flow for 2025.

Table 4.4: Annual CO_2 emissions and intensity by supplier flow (2025).

Supplier / Flow	Mode	2025 Trips	Total CO_2 (kg)	Avg CO_2/trip (kg)	CO_2 intensity (g/kg goods)
Supplier A	Intermodal	132	129,492	981	∼36
Supplier B	Road	26	4,634	178	∼113
Supplier C	Road	24	10,680	464	∼84
Supplier D	Road	25	9,442	393	∼159
empty packaging	Road	22	22,598	1,027	n/a
flows combined	Mixed	229	∼176,846	∼773 (avg.)	n/a

The annual totals confirm that while the intermodal forging lane has the highest overall volume, it maintains the lowest intensity per kilogram.

4.7 Logistics Providers and transport Governance

All inbound transport operations are managed by contracted third party logistics providers at supplier level. According to the contract terms for main inbound transport, suppliers are responsible for arranging and paying for transport, meaning Sansera does not choose carriers or negotiate inbound freight rates. Instead, Sansera specifies its requirements to the suppliers, such as delivery windows and times.

Figure 4.12 maps out the contractual transport governance structure currently governing the inbound lanes.

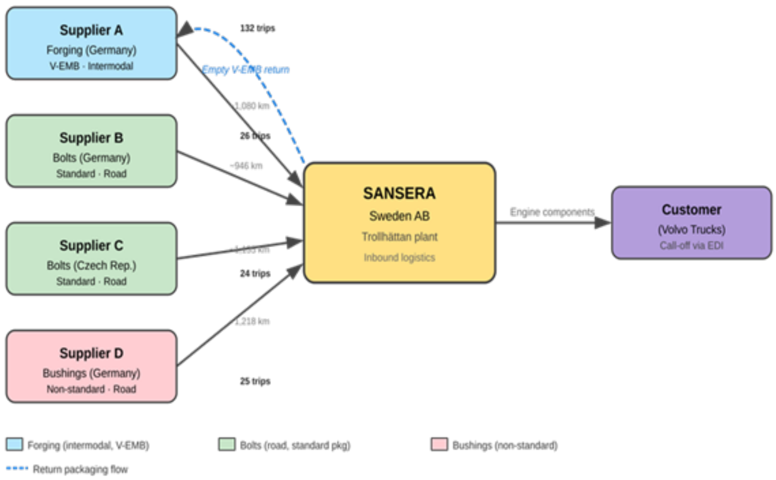

Figure 4.12: Inbound transport governance and supplier-managed lane interfaces.

The diagram confirms that supplier-managed DDP terms limit Sansera's direct control over carrier operations. The transport provider involved in the intermodal forging lane handles both rail and road operations. The 2025 transport data illustrates a well-functioning, stable supply flow where 132 deliveries have consistent shipment sizes of similar weights and volumes. This results from a reliable forging production combined with standardized V-EMB containers that enable efficient loading at Supplier A.

For road-only transport lanes, including Supplier D for bushings, shipments travel on groupage trucks, where Sansera only pays for the truck space that its shipment occupies. Although it can be cost-effective for low volumes that do not justify dedicated truck space, the timing and consolidation of deliveries are governed by the transport provider's freight plan rather than sansera's schedule. This can add more variance to lanes whose volume is already constrained by packaging limits.

To address the non-stackable boxes from Supplier D, the logistics coordinator proposes using standard stackable boxes without requiring Supplier D to acquire their own packaging. Sansera would order the packaging material and supply it to Supplier D via the existing German return truck route that is already running from Trollhättan to Plettenberg for empty V-EMB frames. Because Supplier D would receive the packaging material at no cost, it would be more inclined to adapt to new procedures, and no separate transport lane would be needed. He notes that, while any cost savings could be gained through the greater efficiency, Sansera intends to retain the financial benefit rather than negotiate the component price down with the supplier.

There is no defined governance of packaging for Supplier D's disposables; they are managed as scrap material with every incoming truck. V-EMB packaging is, however, governed under Volvo Logistics (VL), which provides the underlying framework for the closed-loop system. VL is responsible for quality standards, maintaining the packaging pool and managing the return logistics.

Table 4.5 provides a comprehensive summary of the current-state inbound and outbound flow parameters.

Table 4.5: Summary of current-state inbound and outbound flow mapping at Sansera (2025).

Flow	**Supplier**	**Country**	**Mode**	**Dist. (km)**	**2025 Trips**	**Packaging**
Inbound, forging	A	Germany	Intermodal	∼1,080	132	V-EMB (standard)
Inbound, bolts	B	Germany	Road (groupage)	∼946	26	Standard
Inbound, bolts	C	Czech Republic	Road (groupage)	∼1,135	24	Standard
Inbound, bushings	D	Germany	Road (groupage)	∼1,218	25	Non-standard (cardboard)
Outbound, return packaging	A	Germany	Road	∼1,084	22	Collapsed V-EMB frames

This final overview highlights packaging standardization as the most critical internal lever for improving system efficiency.

4.8 Summary of Empirical Findings

The empirical evidence suggests that three of the four supplier lanes in the inbound logistics flow perform acceptably. These are well-supported by the standard,stackable and returnable packaging system, intermodal transport on the largest supplier flow and well-maintained relationships between supplier and client. The fourth lane, consisting of bushing shipments from Supplier D, stands out as the main source of the logistical issues that are the subject of this paper, all tracing back to one common denominator: the use of non-standard, non-stackable, single-use packaging.

Physically,because Supplier D's boxes are non-standard, they cannot be stacked inside a truck. The logistics coordinator estimated that if they could be stacked, three units per truck would fit in the trailer, tripling the components carried per truckload. As it is, supplier D only occupies around 20% (approx. 2.3 linear meters) of the trailer's 13.6 linear meters per trip, whereas the intermodal forging lane uses approximately 95% of the capacity. This difference in packaging causes four distinct but connected problems. First, production stoppages have occurred, reported directly by the logistics coordinator as a consequence of bushings supply issue. This is the only inbound lane with non-standard packaging and the only item with no alternative supplier due to the dual-sourcing mandated by the customer. Second, transport costs per unit delivery is higher, since more trips are required for a given quantity because of sub-optimal load efficiencies per trip. Third, carbon emissions for this road lane are much higher (approx. 159 grams of CO2 per kilogram of delivered goods), which is almost 4.5 times the CO2 intensity compared to the intermodal forging flow, due to the same low fill rate. Fourth, the non-stackable boxes consume unnecessary space in the warehouse that already struggles to maintain storage capacity, to the extent that a new 900-square-metre inbound warehouse is being arranged to help address these issues.

As stated by the logistics coordinator, a potential solution is for Sansera to buy standard, stackable boxes and supply them to Supplier D free of charge via the existing return truck that travels between Trollhättan and Germany, which is currently used to ship empty V-EMB frames back to Supplier A. which is loacted near supplier D, this would move the bushing shipments into stackable packaging, without requiring an extra transport lane and without adding any cost or burden to the supplier.

5 Analysis and Discussion

As discussed in sub-chapter 2.3, packaging and packaging logistics in a supply chain setting has a broader scope than just as a purely technical or protective matter. The following analysis will therefore build on the concepts of industrial packaging, one-way/disposable and reusable/returnable packaging systems, and the packaging characteristics that most directly affect logistics performance. More narrowly, the focus will be especially put on unitisation, stackability, volume efficiency, handleability, and load carrier compatibility. This perspective utilises Pålsson's Packaging Logistics[11] as the theoretical foundation for arguing that packaging should be understood as a broader logistics system whose performance therefore must be assessed holistically across the supply chain, and Kroon and Vrijens' Returnable Containers[8], and Roy et al.'s Cost-effective Pallet Management Strategies[17] for any discussions about open-loop and closed-loop packaging arrangement.

In order to be able to analyse Sansera Sweden AB's inbound packaging situation holistically, their broader inbound-logistics must also then be assessed. For this, the inbound-logistics perspective developed in sub-chapter 2.1 and sub-chapter 2.2, discussing logistics performance in the automotive industry through lean logistics, delivery reliability, and parts availability perspectives in inbound logistics systems. In this context, packaging will be analysed as part of this system perspective.

Using the information gathered at Sansera Sweden AB's factory in Trollhättan, documented throughout chapter 4, this analysis will focus on the contrast between two different packaging logics. First, the V-EMB system represents a standardised, stackable, returnable, and governed packaging arrangement with clear load-carrier properties and an existing return flow. This system is also the most commonly used at the location. Lastly, Supplier D's packaging represents a non-standard, disposable, non-stackable, and weakly governed arrangement outside any managed return system. Sub-chapter 4.2 identified this divergence in packaging, while sub-chapters 4.3-4.6 showed that this divergence coincides with lower truck fill, higher CO_2 intensity, greater storage pressure, and increased exposure to production stoppages.

The purpose of this chapter is not to repeat the findings from chapter 4, but rather to interpret them through the theoretical lens developed in chapter 2. The questions to be answered then are: Why does Supplier D's packaging seem to function as a driving factor of the observed inefficiencies, how does this packaging choice affect transport, storage, supply, reliability, and environmental performance, and why does these effects become especially critical in Sansera Sweden AB's inbound logistic context.

5.1 Supplier D's packaging as a divergent industrial packaging system

The main finding in sub-chapter 4.2 is the differentiated usage of packaging between the standardised V-EMB containers, used by all but one supplier, and Supplier D's palletised plastic wrapped cardboard boxes. These are not individual stylistic choices between the different suppliers, but rather an indication that Supplier D operates with a fundamentally different industrial packaging system. According to Pålsson's concept of industrial packaging[11], packaging used for material supply should primarily protect the goods and facilitate efficient production, material handling, warehousing, and transportation, and that it therefore should be assessed as part of the wider logistics system. Not just as an isolated container choice. Further he argues that packaging should be understood across a primary, secondary, and a tertiary level, where the tertiary packaging level includes the load carrier itself. Interpreted through this framework, the V-EMB container system used for all other inbound flows, excluding Supplier D, works as a coherent packaging system on both a secondary and tertiary level: It has a standardised footprint, structurally stackable, compatible with handling tools like forklifts and racking, collapsible in collapsible when empty, and embedded in a governed return flow managed through Volvo Logistics. In contrast, Supplier D's packaging system, tabulated in Table 1 in sub-chapter 4.2, consists of varying amounts of cardboard boxes that are then palletised and wrapped in plastic. Since they are stacked on top of pallets that are themself standardised, this solution too has a standardised footprint, but the varying amounts within each pallet changes the dimensions of each pallet shipped. The weak load-bearing ability of the cardboard also eliminates the possibility of further stacking on the tertiary level, with each pallet standing alone instead of stacked on top of each other. Lastly they operate outside the managed return flow of the V-EMB with none such of its own. This means that Supplier D is not merely deviating from Sansera's packaging standard, it operates outside the packaging logic that structures the rest of the inbound system.

The difference between the V-EMB and Supplier D systems can also be viewed through theory of one-way and returnable packaging. Kroon and Vrijens[8] define one-way packaging as packaging made in such a way, and of materials that disenables further usage in the supply chain besides delivering the product from the producer to the consumer. Cardboard boxes, being one such packaging solution exemplified, while reusable packaging consists of secondary packaging that can be used several times in the same form and for similar purposes. Pålsson also describes reusable packaging systems as typically sturdier, heavier, and more management intensive systems that require reverse logistics, storage, repair, and administration, but with the result benefit of reducing waste and supporting more efficient materials handling when properly designed and managed. V-EMB belongs to a governed closed-loop reusable packaging system, while Supplier D's cardboard packaging follows an open one-way logic that ends in waste.

Using the perspective developed in sub-chapter 2.3.3, Supplier D's packaging also has a poor performance against core packaging requirements for industrial use. Blomber and Hallams' four-perspective packaging evaluation framework is useful here. According to them, industrial packaging should sufficiently fulfill any requirements for protective, handling efficiency, ergonomic, and information perspectives in their intended use. Based on the empirical findings in chapter 4, Supplier D's packaging appears especially weak from the handling efficiency perspective. The irregular sized shipments combined with the low structural integrity result in the packaging being difficult to integrate into Sansera's standardised handling, storage, and loading routines. The issue doesn't lie in the packaging's ability to contain the bushings, but rather that it doesn't function as an efficient industrial packaging within Sansera's inbound logistic system. The V-EMB logic supports this system by providing a common, predictable packaging interface across much of the inbound flow. Supplier D's packaging does the opposite. It introduces a separate, non-standard packaging regime into a system otherwise built around the standardised V-EMB load carriers and return logistics. This results in a physical and operational integration problem. Supplier D's packaging should therefore best be analysed as a divergent industrial packaging system with misaligned characteristics with the dominant inbound packaging structure used at Sansera's plant in Trollhättan. This distinction will be critical for the remainder of the analysis.

5.2 Packaging characteristics and transport utilisation

One of, and perhaps the most immediate, logistics consequence of Supplier D's divergent packaging is the effect it has on transport utilisation. In sub-chapter 4.4, the average load used Supplier D is shown to be 2.3 linear meters of a standard 13.6 linear metre trailer, corresponding to a fill rate of around 20%. Meanwhile a delivery of forgings using V-EMB packaging instead achieves an approximately 95% utilisation. In the context just established, this difference is not a volume problem in itself, but rather a consequence of the poor packaging performance of deliveries from Supplier D.

A useful starting point is Pålsson's definition of unitisation[11]. Smaller packaging units are grouped into larger and more manageable handling units in order to benefit from emergent improved material handling efficiencies. Similarly, Roy et al. describe pallets as the structural foundation of the unit load, enabling standardised and efficient movement of goods through the supply chain. Combining Pålsson's unitisation[11] and Roy et al.s' unit load theories[17], these concepts clarify that transport efficiency depends not only on how much product is shipped, but on whether the packaging system used allows the goods to be assembled into a stable, stackable, and space-efficient unit load. Applying this to the Sansera case, V-EMB supports this logic with its standardised footprint, stable load carrier base, and known stacking capability. Supplier D's packaging does not. As a result, the transport unit formed by Supplier D's packaging is physically weaker and volumetrically inefficient.

The main form in which this problem expresses itself in the Sansera case is through stackability. Pålsson[11] describes stackability as a key packaging feature affecting both inbound and outbound logistics efficiency. In the theoretical framework on packaging, stackability is described as one of the packaging characteristics that determines whether vertical space in vehicles and warehouses can be used effectively. Using the data gathered at Sansera sub-chapter 4.3 show that Supplier D's pallets can't be stacked safely in the warehouse, and therefore more importantly for this section neither can it inside the trailer of a truck. This means that the useful transport capacity is constrained by the trailer's floor area only rather than by trailer cube. The vertical space above each pallet cannot be further utilised, but the unutilised space must still be paid for for each transport performed, since the contracted transport service company used charges by occupied volume including resulting dead-space above the Supplier D pallets.

The implications of this are economic as well as operational. In chapter 9 of Pålsson's Packaging Logistics[11], he argues that industrial packaging should take into account how packaging size, one-way contra reusability, pallet contra container choice, and degree of load utilisation affect total supply chain CO_2 emissions. Using his framework, the average load used by Supplier D means that Sansera must purchase more transport capacity per delivered unit of bushing than would be necessary under a stackable packaging arrangement. Even if this cost would be shared between the two actors, the packaging still reduces the amount of product that can be moved within each shipment, reducing the transport efficiency per bushing received. According to the logistics coordinator at Sansera's estimate, as reported in sub-chapter 4.3, two or likely three vertical layers should be achievable if the packaging were stackable. This can then be seen as a measure of the lost capacity with each shipment performed, dragging down transport efficiency. It doesn't mean the final efficiency gain multiple of switching to a stackable packaging alternative would be three, but it can still serve as a receipt for the inefficiency currently present in the transport as a result of the packaging choice.

As discussed in sub-chapter 4.4, another avenue to relieve the transport inefficiency was proposed that if it was possible to unite flows from different suppliers with Supplier D included could elevate transport performance. This was not considered a realistic path by the logistics coordinator at Sansera. But even if it was, it would solve the underlying issue of the underperforming packaging solution used by Supplier D, but rather just skew part of those costs onto the better performing supplier's V-EMB packaging solution. Pålsson[11] emphasises that packaging decisions affect the total efficiency of a material-supply process. A packaging system with poor volume utilisation may remain inefficient even if broader transport planning changes are attempted. Supplier D's shipments can therefore not be primarily solved at the carrier-level, but must rather be tackled at the more likely source of its packaging decision.

5.3 Packaging and warehouse performance

In parallel with the issues suffered during transport, the problem of non-stackable packaging has further consequences inside the Trollhättan plant too, once the shipment arrives. Supplier D's packaging performs poorly inside the warehouse for storage purposes. As shown in sub-chapter 4.6.1, Sansera is already operating under storage pressure, renting external warehousing space and further planning a new 900m2 inbound warehouse. Space is therefore at a premium inside Sansera's operation. The difference between V-EMB and Supplier D's packaging becomes significant; the two packaging systems interact very differently with the warehouse's available cubic space. In The Handbook of Logistics and Distribution Management by Rushton, Croucher, and Baker[18] they argue that warehouse operations not only entails the storage of goods, but also to fulfill needs around processing efficiently through reception, reserve storage, picking and dispatch. These tasks must also operate in an environment with efficient exploitation of the available space, due to it often being expensive and more importantly physically limited. One of their proposed methods of preserving space in a warehouse operation is "block stacking" in a palletised storage. It is therefore also theoretically relevant to the situation at Sansera's plant in Trollhättan and applicable to their case. V-EMB packaging is a palletised, stackable, and mechanically compatible storage logic, whereas Supplier D's packaging isn't. This issue can therefore best be understood through the packaging characteristics of stackability, unitisation, and volume efficiency, all of which affect the efficiency of how a packaging system can be integrated into a storage operation.

V-EMB containers are shown in sub-chapter 4.6.1 to be stackable in standard pallet racking and to make use of the warehouse's full vertical height. Their standardised outer dimensions and engineered stackability make planning their storage predictable, due to each unit behaving consistently when acted upon by handling tools, like racking and forklifts. The soft plastic wrapped cardboard, and irregular outer dimensions of Supplier D's pallets mean that they can't act as a reliable stacking surface, and therefore not be stored in layered multiples in the warehouse, sacrificing any vertical space above them. In practice this also lowers the efficiency of the other V-EMB boxes due to that, neither can they be stacked on top of a Supplier D pallet, limiting the flexibility built into the V-EMB palletised block stacking logic.

With this interconnected reasoning surrounding both transport and warehousing, it further reinforces the systems perspective argued by Pålsson[11] that packaging decisions should be assessed holistically due to them affecting several interconnected processes. The same deviating characteristic carries multiple levels of consequences throughout the inbound logistics operation at Sansera. Next we will further analyse the knock-on effects these consequences have on other operations at the plant.

5.4 Packaging, supply reliability, and production risk

The effects of Supplier D's packaging are not limited to their direct operational environment of transport and warehousing. Using the Sansera case, packaging can be shown to also affect supply reliability and thereby impact the risk of production stoppages occurring. This was made clear during the interview with the logistics coordinator at Sansera, documented in sub-chapter 4.3, where they stated that stoppages have occurred and linked them directly to the bushings flow from Supplier D. In sub-chapter 4.6.2 it shows that the Sansera plant in Trollhättan operates with lean inventory buffers and limited ability to absorb variability in its material feeding operations. In conjunction with the theory, it means that the packaging problem would become strategically important due to its interaction and broader knock-on effects in the plant through the inbound logistics conditions under which they operate. The physical constraints of Supplier D's packaging could be generating operational consequences that are then amplified by the structure of the inbound logistics to material feeding relationship.

The theoretical platform that has been used to interpret these issues is the lean context discussed in sub-chapter 2.1.3. Lean philosophy was presented through Avezedo et al.'s[1] interpretation of lean manufacturing and the reduction of muda, explained as non-value-adding activities and waste in production systems. Some common forms of waste identified in lean philosophy include excess transport, waiting, excess inventory, and inefficient space usage. Collectively, these categories are all present in, and therefore relevant to, Supplier D's packaging. More transport is needed in order to move a given quantity, compatibility issues on the warehouse floor increases waiting time between product pick ups, more space is consumed in storage, and the reduced delivery volume per shipment increases the risk that shortages occur on the shop floor as a result of lacking materials if delivery windows are missed. Avezedo et al. argue that lean seeks to minimise waste by reducing excess resources. But in doing so, the system becomes more dependent on reliable material flows. In this case, the material flow reliability can be seen to be made worse by Supplier D's divergent packaging.

As shown in sub-chapter 4.3, the logistics coordinator explained that if the packages were stackable, two and likely three layers of pallets could be stacked on top of each other inside a typical truckbed. This would significantly increase the average component delivered in each shipment. Instead, the current packaging situation of non-stackable pallets limits the available space inside the truckbed to its trailer floor area, which then necessitates more additional small shipments while also being more expensive for each of these shipments, costs that are then passed on to Sansera through higher prices for the components. This fragmentation of shipments also carries a further risk to the production operations at Sansera. The smaller deliveries cover only a portion of weekly or bi-weekly demand. Should any of these deliveries be delayed, or contain fewer components than expected, the current inventory buffer would be fast depleted. The packaging decision of Supplier D is therefore largely responsible for the current risks in the material availability at Sansera.

Na, Sim, and Lee's[10] analysis of returnable transport items in the automotive industry exemplifies this issue well. They argue that packaging is one of the foundations of secure and cost-efficient on-time delivery, and that in automotive supply chains the availability of components and the reliability of their material flows are important due to the high cost incurred from stock-outs. When the delivery system is constrained by the packaging of the products it handles, the consequences are magnified. This further cements the severity of the packaging issue and its effects on the inbound logistics system at Sansera.

One of the easier solutions to a situation like this where the importing company like Sansera lacks governance of the transport process, one might think, would be to switch to another supplier that does use a compatible packaging system. Ideally that would be the case, but Sansera's situation is thus that their customership with Supplier D is mandated by Sansera's customers. This is described in sub-chapter 4.2.2 and later revisited in sub-chapter 4.3. Sansera is therefore left with no alternative supplier to fall back on if the flow fails, and has to manage the situation under the presumption of a sole sourcing setup. Another condition at Sansera that is exacerbating the material availability issue is the demand variability from their customers. In sub-chapter 4.6.2, it shows that customer call-offs can spike unexpectedly when a customer's parallel source has problems, and these spikes occur roughly once a month. The plant is therefore left dependent on each delivery from Supplier D to arrive not only on time, but also in sufficient quantities to cover consumption between scheduled deliveries. If the packaging used prevents this, then the risk created by the sole sourcing and demand variability is exacerbated.

As we have just shown, however, packaging is not alone in creating these issues for Sansera, and it is important to recognise that the exact proportionality of blame isn't as of yet known. But, in conjunction with each other, these issues have been shown to feed off each other into creating a larger problem for the operations at Sansera. Our evidence also suggests that the impact of packaging of Supplier D has a noticeable impact on these issues, and that it is its wide impact on multiple areas of operations in the inbound logistics that warrants this assessment. In summary, packaging is not only a logistics-efficiency issue, it is also a production-risk issue central to the operation of the plant.

5.5 Environmental and waste implications of the packaging choice

Lastly, it is only natural that in a discussion about industrial inefficiency, that the environmental impacts of such inefficiency also be taken into account. Supplier D's packaging choice can be understood through the distinction introduced in section 2 between the direct and indirect environmental effects. In Pålsson's (2018)[13] Chapter Managing the Environmental Impact of Packaging Logistics, he establishes the framework as such: the direct effect relates to the packaging material itself and from packaging waste, while indirect effects relates to how the packaging influences logistics, transport efficiency, and product waste. He also explains that it is these indirect effects that usually are greater than the direct material effect, but are yet often overlooked in practice. Applied on Sansera's case, these distinctions are best explained as follows: the issue of one-way disposable packaging resulting in waste being a direct effect, and the issue of non-stackable packaging and its resulting relative transport efficiency reduction resulting in increased emissions per delivered unit being an indirect effect.

Using the environmental data collected and reported in sub-section 4.4, Supplier D's 25 road shipments generated approximately 9.44 tonnes CO2 in 2025, with a corresponding average emissions intensity of approximately 131g CO2 per kilogram of goods per kilometer traveled. In comparison, the bolts supplier, being of comparable weight per unit shipped, also relying on trucks for their shipments, and originating from comparably equal distances of origin, uses V-EMB packaging for their shipments and has an approximate 75g of CO2 per kilogram per kilometer. This equates to a 43% lower intensity than Supplier D. Though, the exact distribution of this reduction that can be sourced to the packaging choice compared to other potential sources like, the transport providers truck efficiency, driving patterns, distance from origin, product weight etc., cannot for sure be determined with the data collected for this study. But, by using the sources in the theoretical framework as a reference, the significance of the packaging will be assumed to be substantial.

The second environmental issue concerns packaging waste. Supplier D's packaging is a disposable solution that generates waste with every delivery, while the V-EMB is part of a managed returnable system. Pålsson's (2018)[13] discussion on packaging waste characteristics shows that industrial packaging waste that arises within supply chains includes, besides boxes, lids, straps, film, pallets, and other tertiary items. In the Sansera case, Supplier D's packaging consists of cardboard boxes, plastic film wrappings, and wooden pallets. The pallets are reusable and fit within the larger system of Sansera's pallet management, but the cardboard and the plastic film must be handled after use, separately from the reusable system managing the standard V-EMB packaging. This doesn't prove that V-EMB is materially more environmentally friendly. Pålsson (2018)[14] warns the reader of making such assumptions as reusable systems can have large environmental impacts per unit to such a degree that the number of times a unit must be used to recuperate the environmental impact is larger than the expected number of re-uses, effectively making the system less sustainable than a one-way disposable solution.

5.6 Analysis and Discussion Summary

To tie up this analysis and discussion chapter, Supplier D's differing packaging logic is poorly aligned with the V-EMB-based logistics structure at Sansera Sweden AB. Lack of stackability, and the volume inefficieny that stems from it, as well as the one-way disposable logic create consequensens across several parts of the inbound flow.

In transport, the wasted volume above each Supplier D's pallets prevents efficient use of trailer cube and results in higher volume usage, and thus increasing costs per shipment with their 3PL-provider. In warehousing, similarly the inability to stack Supplier D pallets limits the use of vertical space inside Sansera's warehouse. Beyond the inefficeint useage of warehousing space, the lack of stackability interfereces with the ruitine warehousing operations designed to handel V-EMB packaging reducing the flexibility of the standardised handeling routines. These physical constraints also interact with the company's lean inventory conditions, sole-source dependency, and demand variability, meaning that the packaging issues impact goes beyond the analysis of it's efficiency, but also acts as a contributor to production-risk exposure. Lastly, the packaging choice has environmental implications through both direct waste from disposable materials and indirect emissions linked to the lower transport efficiency.

6

Conclusion

In the following chapter, the research questions posed in the first chapter will be answerd based on the findings shown in chapter 4 and the discussion in chapter 5.

R1. What does Sansera Sweden current inbound delivery operations look like?

Sansera's inbound logistics system is organised around four principal suppliers, providing them with forged raw material, bolt and fasteners, and bushings. The forging flow from Germany uses intermodal transport, while the bushings, and the bolts and fasteners use truck transport. Customer demand is communicated to Sansera through call-off signals, which are translated into delivery schedules for the suppliers. Under the current Incoterms DDP arrangement, the suppliers are the ones responsible for organising and financing any transport, leaving Sansera only with influence over delivery timing. Carrier selection, routing, and consolidation lay beyond their jurisdiction. Most of the suppliers use the V-EMB modular container system for their tertiary packaging when it arrives at Sansera. A lone supplier, named Supplier D, operates outside this standard, using a one-way disposable packaging solution instead.

R2. How are Sansera Sweden's inbound logistics operations affected by the current setup, especially in relation to the use of standard and non-standard packaging?

Most of the identified problems with the inbound logistics at Sansera originate from Supplier D. Unlike the other inbound flows, Supplier D delivers their products on pallets in non-standard disposable cardboard boxes. These cardboard boxes then make any stacking of multiple pallets impossible due to their structural weakness and irregular shapes on top of the pallets. In comparison can three V-EMB containers be stacked on top of each other comfortably within a standard truck bed or inside Sansera's warehouse.

The effects of Supplier D's packaging choice extend beyond transport. The inability to stack their pallets reduce warehouse space utilisation when the height above them can't be utilised. This in turn contributes to storage pressure and the need for rented external storage and plans for a new warehouse. The same packaging weakness also affects inventory planning and supply reliability, since Sansera typically holds only around one to two pallets per delivery cycle and each delivery must therefore cover a substantial share of production demand.

How could inbound logistics issues related to non-standard packaging be improved upon?

The wide reaching impact of Supplier D's divergent packaging choice, as shown by this thesis, in itself suggest the solution, change the packaging routines of Supplier D. Ideally such a change would be towards the V-EMB containers system used by the other suppliers, but a change to another design, embodying the characteristics of unitisation, stackability, volume efficiency, and handleability outlined by Pålsson (2018), could also partially solve some of the larger issues found in Sansera's inbound logistics operation. This, however, isn't as easy as that. Under the current DDP Incoterms, Supplier D is the one that is responsible for both packaging and transport. Under such conditions, Sansera lacks leverage over the process and is thus unable to make direct decisions to change the packaging. A precursor to any changes might therefore be to change the governance in this area. How such a change could be executed, however, remains outside the scope of this thesis. Instead we, the authors, encourage further study with the regards to governance by Sansera as a next course of action.

6.1 Future Research

For future research either on the Sansera Sweden Case, or other similar business, should best include Supplier D's, or it's equivalent's, perspective. Since this study soley relies on the perspective and testemonies of the subject, Sansera Sweden AB, many nuances, especialy relating to Supplier D's choice of packaging logic, goes unadressed. Any future work should therefore examine whether the packaging choice is driven by cost, technical constraints, product protection requirements, lack of access to standard packaging, limited incentives, or governance arrangements with the customer.

Another suggestion for future research could be a before-and-after study of a pilot implementation to test the conclusions derived from this study, using systematic measuring of the operational performance before and after the implementation. Measurements that could be interesting in the if such a study were to be undertaken could include: avrage loading meters per shipment, truck fill rate, number of deliveries, warehouse space consumption, handling time, packaging waste, delivery deviations, and emissions intensity. But, this would require the cooperation of Supplier D. Since cooperation between the two actors in this study has been found to be difficult, a study requiring interuptions in both businesses operations like the one suggested above could prove to be unfeasable. An alternative pilot, only including the subject business, Sansera, could also be attempted. Sansera could temporarily implement a repackaging station for Supplier D's deliveries in order to measure the effect on the warehousing operations if the Supplier D products instead were stored with the standardised V-EMB packaging logic. As long as the repackaging station is properly accounted for in the measurements one would likely get a faily accurate simulation of a Supplier D packaging change for the warehousing operations and its knock-on effects.

Lastly, a third area for future research could be to develop a total cost model for the packaging alternatives. This study presents severeal cost-related machanisms, but it doesn't calculate the full economic effect of a packaging transition. Such a cost model would with benifit include cost for packaging procurement, return transport, handeling labour, storage, waste handeling, administration, and potential costs from supply disruptions or production stopages. Further, the allocation of these costs and or costs savings should also clarified under the current DDP arrangement, since the party formally resposible for arranging and paying transport may not be the only actor affected by inefficiencies in the flow.

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A

Appendix 1

The following appendix presents the interview guides used across the three data collection sessions conducted with the logistics coordinator at Sansera Sweden AB. Questions are presented as asked during each session. No answers are included in this appendix; responses are discussed and analysed in the empirical findings chapter.

A.1 Interview Guide: Session 1

Date: 26 January 2026

Company and Supply Chain Overview

1. Can you give us a brief overview of what Sansera Sweden AB produces and who your main customers are?
2. How is the company positioned within the broader automotive supply chain?
3. Who are your main inbound suppliers and what components do they supply?
4. How critical are each of these components to your production process?
5. Are any of your suppliers sole source or customer mandated?

Inbound Logistics Organisation

1. How are your inbound deliveries currently organised and scheduled?
2. Who is responsible for transport planning, Sansera or the suppliers?
3. What transport modes are currently used for inbound deliveries?
4. How many inbound trucks do you typically receive per week?
5. What Incoterms apply to your main inbound flows?

Current Challenges

1. What would you say are the main challenges you face in inbound logistics today?
2. Are there any suppliers or flows where you experience more problems than others?
3. Have there been any production stoppages or supply disruptions recently?
4. Is there anything specific about your packaging or transport setup that you think could be improved?

Data and Research Scope

1. What kind of transport or logistics data does Sansera currently track and record?
2. Would it be possible to access shipment data, CO_2 emissions records, or cost data for this study?
3. Are there any confidentiality constraints we should be aware of when using company data in our thesis?
4. From your perspective, what would a successful outcome of this thesis look like for Sansera?

A.2 Interview Guide: Session 2

Date: 24 February 2026

Transport Load Efficiency

1. On average, do your trucks reach their weight limit or volume limit first?
2. For the forging flow, would you say the trucks are arriving fully loaded?
3. For the other suppliers, bolts and bushings, are those trucks also full or shared with other customers?
4. Do you have an estimate of roughly what the average truck fill rate is for the bushing deliveries?
5. For the non-stackable packaging arriving from one supplier, how much vertical space do you think is being wasted above the boxes in the truck?
6. If the packaging were stackable, how many layers high do you think you could stack the units?
7. If trucks were more fully utilised, do you think that would reduce the number of shipments needed?

Packaging and Supplier Non-Compliance

1. Which supplier is sending goods in non-standard packaging and what does that packaging look like?
2. Why is this supplier not using the V-EMB standard packaging used by the others?
3. Is it possible to influence this supplier to switch to standard stackable packaging?
4. If Sansera were to provide the packaging material directly to this supplier, do you think they would accept it?
5. Could the existing return truck route to Germany be used to deliver packaging to this supplier as well?

Production Stoppages and Supply Reliability

1. Have there been any production line stoppages caused by insufficient inbound material?
2. Which component or supplier flow was responsible for those stoppages?
3. Is the bushing supplier a sole source, meaning you cannot get this component from anyone else?
4. Is this supplier mandated by your customer meaning you cannot change them?
5. How often do unplanned demand spikes from your customer occur and how do you handle them?

Inventory Management

1. How much safety stock do you currently hold for bolts and bushings?
2. What do you consider to be the ideal inventory level for these components?
3. Would maintaining three weeks of safety stock be financially feasible and what would the impact be on working capital?
4. You mentioned renting external warehouse space, is this a long term solution?
5. Is there a plan to build or expand your own storage capacity?

Sustainability and Emissions

1. Does Sansera currently track CO_2 emissions related to transport?
2. Is CO_2 reduction a formal performance target or more of a strategic ambition?
3. You mentioned consolidating scrap forging returns into full loads to reduce environmental impact, is that a standard practice?
4. If the bushing packaging were made stackable and trips reduced, do you see an emissions benefit from that?

General and Closing

1. In your view, is flexibility or efficiency more important in automotive inbound logistics?
2. Are there other inbound logistics issues beyond the packaging problem that you think we should investigate?
3. Is there anything else about the inbound logistics system that you think would be useful for us to understand?

A.3 Interview Guide: Session 3

Date: 16 March 2026

Inbound Logistics Organisation

1. How are inbound deliveries currently organised, is it through direct shipments, milk runs, or a consolidation hub?

2. Who is responsible for transport planning, Sansera, the suppliers, or the 3PL providers?
3. What Incoterms are commonly used and how much operational control does Sansera have over inbound transport decisions?
4. Approximately how many suppliers, shipments per week, and distinct transport lanes are currently involved in inbound logistics?

Data Availability and Quality

1. What quantitative data is available for this study, such as shipment dates, weights, volumes, distances and CO_2 values?
2. What time period can the data cover, is full calendar year 2025 available?
3. Are there known data gaps or quality issues we should account for in our analysis?
4. Are there confidentiality constraints on how supplier names or transport rates can be presented in the thesis?

Operational Constraints

1. What must not be negatively affected by any proposed changes to the inbound logistics setup?
2. Are there any suppliers or component flows that are non-negotiable and must remain unchanged?
3. Are there existing contractual or regulatory constraints that would limit changes to the current transport arrangement?
4. How flexible are suppliers in terms of delivery frequency, could any of them consolidate shipments or change delivery rhythms?

Sustainability

1. Does Sansera formally track transport related CO_2 emissions and if so what calculation method is used?
2. Is CO_2 reduction a formal KPI or more of a qualitative sustainability ambition?
3. Would a comparison between the current emissions profile and a future improved scenario be of value to Sansera?
4. Are there preferred emission calculation standards or tools Sansera uses that we should align with?

Expected Outcomes

1. From Sansera's perspective, what would a successful thesis outcome look like in practical terms?
2. Are concrete recommendations preferred or is a conceptual analysis of improvement scenarios also valuable?
3. Is the primary goal of this thesis to support a future decision or to prepare for near term implementation?

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