Space Utilization in Road Transportation:  
A Case Study of Truck Deliveries

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List of Acronyms

B2B: Business to Business

B2C: Business to Consumer

C2C: Consumer to Consumer

CRM: Customer Relationship Management

EDI: Electronic Data Interchange

FLT: Full Truck Load

GHG: Green House Gas Emissions

HTL: Half Truck Load

JIT: Just in Time

LCA: Life Cycle Assessment

LEP: Limited-Edition Packaging

NST: Standard goods classification for transport statistics

PE: Packaging Engineer

RFID: Radio Frequency Identification Technologies

SCM: Supply Chain Management

SPL: Sustainable Packaging Logistics

SRP: Shelf Ready Packaging
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Abstract

**Aim:** To understand why big logistics companies do not focus their resources on improving space utilization and decreasing the phenomenon of empty running. Moreover, this study aims to present the potential economic and environmental benefits of reduced excess air in packaging and its effect on truck deliveries.

**Method:** This study is a qualitative research, that was conducted using interviews for the collection of primary data, which were semi-structured and provided the participants freedom of expression. For the collection of secondary data, different academic sources were used, and the majority was collected from online platforms such as Google Scholar and Gothenburg’s university internal online database that can facilitate the research in other external databases such as Wiley Online Library and Elsevier.

**Results & Conclusions:** Correct packaging practices and space optimization are strongly dependent on each other. Carrier companies, unfortunately, have not reached yet the level of cooperation to share space and create symmetric goods’ flow. When it comes to the economic and environmental benefits, space optimization and mutual collaboration can lead to decreased emissions, fuel consumption, vehicle amortization and operation costs.

**Contribution of the study:** This study has valuable academic and practical contribution. It provides ideas and solutions that can decrease the number of routes, which is linked to lower traffic congestion and greater effectiveness in road deliveries, mitigation of environmental impact, greater space utilization and lower costs in the supply chain management.

**Suggestion for future research:** Future research can focus on overpacking and its impact on space utilization, as well as different modes of transport apart from truck deliveries. A cross-industry study can take place and the focus can be in packaging practices and its contribution on space optimization.

**Key Words:** Distribution, Emissions, Packaging, Truck deliveries, Space Utilization, Space Optimization.
1. Introduction

With the emergence of the Internet, products and services have easily become accessible to every corner of the world, which in turn has further promoted e-commerce activities (Quelch & Klein, 1996). Therefore, our society has been facing an increased consumption trend, met by global supply chains and large geographical distances, which strive to satisfy the influx of transport demand (Wiedmann & Lenzen, 2018).

Apart from the bright side that e-commerce is becoming stronger, and consumers are investing their money in the market, there is the logistics side, and one needs to consider what happens to trucks after they have successfully arrived at their destination. According to an article in CNBC (Handley, 2022), “more than a fifth of the distance driven by European cargo trucks in 2021 was “deadhead mileage”, where vehicles traveled empty, often on the return leg of a journey”. With this in mind, we aim to investigate why there have been no actions from industry to better utilize the empty space of delivery vehicles in urban freight transportation and how this can be achieved. This topic does not only have high financial cost implications, but furthermore a great environmental impact on emissions, congestion, pollution, waste, and energy consumption.

But what do we actually know about transportation? Apart, of course, from the plethora of routes a driver must take to move from one point to the next, and not only on a small local micro-transportation level, but on a global basis. The frequency of transportation routes is running non-stop, one could even compare it to a living organism. The most striking difference though between transportation and a living organism, is that in a “body” there exists only a limited number of routes, while in transportation there is only expansion, which is complex and vital for global trade and economy.

When thinking of the traditional way of distribution, goods were sold and transported from the manufacturers to wholesalers, later they were sold to retailers and consumers used to purchase their goods in retail shops. Nowadays, with the expansion of e-commerce goods can be directly delivered to the end consumer from the manufacturers themselves. Moreover, e-commerce has significantly increased B2B (Business to Business), B2C (Business to Consumer) and C2C
(Consumer to Consumer). As a result, urban freight transportation is being affected by shippers, freight carriers, and private consumers. (Taniguchi & Kakimoto, 2004)

Goods cannot be transferred without packaging, which in most cases takes up space and occupies resources. But how is packaging related that much to transportation and how can things alter for the better? Often consumers complain about the phenomenon of overpacking (Stuart-Turner, 2018), but packaging is important for preservation purposes, identification, and storage, but also plays a role in brand communication, since it serves as a promotional tool (Agariya et al., 2012).

Packages, and as a result the space they occupy, are important, but what happens to dead mileage? Rarely do we think of what happens after the packages are delivered to their destination, nor do we think of the cost, be that financial or environmental, that the empty trucks create, or the “air” they carry. Of course, there are restrictions from an infrastructure perspective, when it comes to total weight of trucks, packaging instructions of specific products and country specific limitations on road transportation, but what can be improved, is what the writers will try to present in the following chapters.

Although numerous studies focus on multiple supply chain concerns, there is a scarcity of comprehensive research that exclusively addresses the transportation of surplus air generated by unsuitable packaging in current supply chains. This gap in literature linked to space optimization in packaging, especially in truck deliveries, is what we strive to contribute to.

The distribution of goods by road is a crucial element of modern supply chains, with a significant impact on the efficiency and sustainability of the global economy (Tseng et al., 2005). Improving space utilization in the road transport modes, has the potential for decreasing expenses and enhancing competitiveness of the logistics organizations, while also decreasing the carbon footprint caused by the distribution of goods and poor consolidation (Ge, 1996; Granillo-Macías, 2020). This is what makes the subject of space maximization in transportation meaningful in terms of both economic and environmental aspects.

To conclude, the purpose of this paper is to research the potential of space optimization in truck deliveries. To better fulfill this task, we have formulated the following research questions:
1. Why is there no space optimization in truck deliveries, that contributes to excess air, and which factors are influencing it?

2. What are the potential economic and environmental benefits of improving space utilization in road transportation and reducing excess air in packaging for truck deliveries?

1.1 Thesis Contribution

The large geographical distances covered by freight companies have an impact on the environment, traffic, traffic accidents and not only (Wiedmann & Lenzen, 2018), but by trying to make this sector optimal and more sustainable, remain one of the main contributing factors of the present paper. We aim to contribute to the theoretical and practical side of providing information and suggestions on how much is possible to achieve space utilization in road transportation, in both full and empty load routes.

One of the primary contributions of optimizing space maximization in conveyance is the high possibility to decrease the number of transport road modes, which can assist the decline of traffic congestion and improve the motion of commodities (Moeckel & Donnelly, 2016). This can assist in the achievement of greater effectiveness in road deliveries by the growth of the efficiency and the decrease of the delays. Moreover, the mitigation of the environmental impacts caused by the movement of commodities would be helped by the decreased number of conveyance vehicles, through better utilization. This makes the topic of space utilization in deliveries purposeful in terms of sustainability and the transition to more reliable supply chains.

In general, the subject of space utilization in deliveries might contribute to fields such as transportation, supply chain and inventory management and divergent stakeholders, including logistics organizations, policy makers and researchers, might have the interest for further investigation and realization of our suggestions. Optimizing the utilization of the space in transportation can contribute to supply chain management by reducing costs, as the logistics companies will have greater ability to deliver more commodities per mode, decreasing the need for additional modes and fuel (Moeckel & Donnelly, 2016).
Furthermore, it would improve efficiency of the deliveries, since the number of road transport modes would be decreased, which would assist the alleviation of traffic jams and make the flow of commodities better. By improving efficiency and decreasing the expenses, maximizing space utilization can give a high contribution to the competitiveness of the logistics firms. Additional added-value service would be the declining of the carbon footprint caused by the deliveries, which would contribute to the enhanced sustainability of the supply chains.

Finally, all these contributions would be a win-win situation both for companies and customers, as the more reliable and efficient deliveries would increase consumer contentment and loyalty. Through identification and evaluation of potential strategies for the purpose of better optimization and less “air” that is being transported in the packaging, this research can contribute to the development of greater, more sustainable, and effective distribution systems for commodities, with advantages for both the economy and the environment.

1.2 Thesis Delimitations

The delimitation is divided in three main areas, the theoretical analysis, the research approach in methodology and the limited logistics sector of road mode transportation.

The theoretical analysis is mainly focused on concepts from logistics and supply chain with a focus on B2B and B2C. All concepts are general and broad but have been discussed in relation to the context of the present paper.

When it comes to the limitations of the research methodology, we chose qualitative research for the accumulation of our primary data. Further limitations linked to the qualitative choice come from the limited time we had in our disposal and sample size, since we were able to have one or two participants from each occupational background. This occurred due to the unwillingness of the contacted individuals to participate and share inside information.

Last, the study is focused on road truck deliveries as a mode of transportation, since the extended research on other modes of transport would have required more time and other resources which
we did not have. The location of the researchers which is linked to the scope of research can be applicable on a global level, and not limited geographically.

2. Literature Review

In advanced nations, transportation of goods by means of highways is the prevailing method. Consequently, the effectiveness of the highway cargo industry plays a crucial role in determining the overall ecological effect of logistics. Assuming that every journey made by trucks and delivery vans was carrying the maximum capacity, this ecological load would be considerably decreased (McKinnon & Edwards, 2010). Ascertaining the exact scale of this resulting ecological advantage at either a nationwide or worldwide level is challenging as minimal formal information exists regarding the usage of vehicle capacity, particularly with regards to floor area and volume (ibid). Nonetheless, a few of the obtainable data reveal the extent of capacity underutilization. For instance, beyond one-quarter of road transport mode mileage traveled in EU nations is without any consignment, while in Ireland it's ordinarily just about 37 per cent (Eurostat, 2007). The act of traveling without any cargo is commonly referred to as "empty running" and is typically calculated as a percentage of vehicle-kilometers traveled (Rushton, Croucher & Baker, 2014). It is an unavoidable result of the unidirectional nature of cargo movements and the challenge of balancing the motion of goods both in outbound and inbound distribution (McKinnon, 2010a).

Commonly, the last-mile deliveries with multiple stops, or several collections, are being run without any load. As indicated by Eurostat (2007), the frequency of empty running by trucks varies significantly among EU countries and is approximately 27% on average. The proportion of delivering “air” tends to be contrarily corresponding to the length of the trail, as longer voyages provide larger economic encouragement to secure a load and use appropriate packaging. What is worse is that transporting not fully utilized vehicles, as well as empty backload is continuously causing environmental damage.
2.1 Space Utilization and Truck Productivity

The degree of space utilized by a fill rate can be evaluated in three dimensions based on the percentage of occupancy, or in two measurements based on the portion of the ground (or deck) area covered (McKinnon & Edwards, 2010). However, the assessment of space utilization of the vehicles within the road transportation is challenging, as there is a lack of volumetric data. There are several factors that impact the space utilization and productivity of trucks in the road transportation of goods. These include geographical imbalances in traffic flow, the design of casing and handling tools, and road transport mode size and weight restrictions.

The geographical disparity is being seen through the cargo often running in one forward direction, where vehicles are being mostly utilized in the forward logistic but running empty on their way back (McKinnon & Edwards, 2010). To reduce the poor utilization of resources, carriers have turned the method of triangulation into practice, where vehicles increase their productivity by running in more complex environments, having several stop locations, instead of two. This enables them to make use of vehicles in the reverse directions by increasing the average backload through the whole transportation (ibid).

Furthermore, the packaging design and the handling equipment also plays a role in the efficient use of truck occupancy. The form, size, and ability to be stacked on packaging can lead to inefficient use of vehicle utilization. Although decreasing the casing of goods can assist in increasing space maximization, organizations seem to have a greater focus on speed and convenience of managing the deliveries over the efficient use of area capacity in their trucks (McKinnon & Ge, 2006). Thus, the poor truck productivity correlates with the increased air being transported, which results in increased transportation expenses and environmental degradation. Although it is of great importance to intentionally leave space in the backhaul for safety purposes, such as avoiding damage during transit, packaging that is not stackable or is oversized for the product being transported can contribute to this problem (ibid).

Additionally, road carriers may charge customers based on the amount of volume/space occupied by their cargo, rather than the actual weight of the shipment, which can also lead to
inefficiencies in space occupancy. For instance, the rates of the carrier company DHL are based on the volume dimensions for road transportation within Europe (DHL, 2023), while the Swedish and Danish carrier Postnord is charging its customers by weight measurement for road transportation (Postnord, 2023). In the current context, there is a great assessment for green sustainability approach and sharing modes which has leaded the logistics organizations to have the eco-packages as a new preference for the purpose of complying with environmental requirements and reducing packaging expenses (Wang, Peng, Guan, Fan & Liu, 2021).

Moreover, the constraints in terms of the size of the transport mode and the weight, have a great impact over the space utilization and the productivity of the vehicle, as they bring the negative consequences of vehicle underutilization in weight or volume-carrying capacity (McKinnon & Edwards, 2010). Over the past few decades, the law related to weight constraints has changed, enabling carriers to carry more weight than before, while simultaneously there are no drastic changes in the space restrictions of vehicles. In addition, there are great imbalances in vehicle productivity, as heavy goods can be loaded before running out of space and trucks can be filled to the limit of the space before reaching the weight limit. By enlarging the size of the vehicles, greater consolidation can be accomplished. By fully utilizing the trucks, vehicle miles can decrease which would result in reduced emissions. UK is one of the few countries that have 5 meters tunnel and bridge limitations, allowing to increase the height of the trucks by adding a double-deck layer (ibid).

2.2 The Impact Caused by Excess Air in Packaging

The valuable sources used for packaging, waste, as well as the excess occupancy in transportation vehicles (Verghese & Lewis, 2007; Shi et al., 2018; Nguyen et al., 2020; Molina-Besch & Pålsson, 2015), have evoked authorities to react by imposing legislations that would reduce the growing issue of the negative environmental impact caused by packaging (Molina-Besch & Pålsson, 2015 stated by Sjöberg & Eriksson, 2020). While packaging is of great importance for retailers, as it protects the goods from damage during their journey, companies should be precautious in the type of the materials that is being used, as they cause greater damage to the environment, causing greenhouse gas emissions and is responsible for the pollution on land fields (Zhang &
Zhao, 2012; Verghese & Lewis, 2007; Shi et al., 2018). Moreover, excess occupancy generated by large packages filled with redundant air in transportation vehicles contributes to extra miles and hazardous gases. Thus, a potential solution is seen in more sustainable packaging development.

As stated by Sjöberg & Eriksson (2020), packaging has divergent stages, such as the primary, which shows the product information and give primary protection, secondary packaging, for transit and protection of the first layer of packing, tertiary packaging, adaptable for pallets and transit packages, which present the last safety layer during freight mobility. In addition, there is a great number of terms for sustainable packaging, which creates confusion in this research area (Nguyen et al., 2020). With the purpose of maximizing truck fill, green packaging is only sustainable if it is developed with the assistance of neutral sources that can be recycled, able to deteriorate in landfill and water, harmless to the life on the planet, and to initiate sustainability encouragement (Zhang & Zhao, 2012 stated by Sjöberg & Eriksson, 2020). Although the mutual aim when creating green packaging should focus on the recycling and minimization of valuable source utilization (Molina-Besch & Pålsson, 2015), the aspect of properly utilizing the space of a vehicle should be one of the priorities.

The bone marrow of our report for space utilization is to contribute to the potential improvement on maximum fill rate for the purpose of achieving greater optimization of the road transportation. Some suggestions lay in the encouragement towards companies for the need of more detailed data collection for achieving the goal of developing customized protective packages suitable for the handling equipment, while simultaneously completing their main purpose of protecting the goods during their journey. Creating modularized “boxes” with the help of the gathered data by companies, can drastically contribute to maximization of fill rates in boxes, as well as in the vehicles (Grönman et al., 2010). Thus, consuming valuable resources would be down to the minimum, as argued by Grönman et al. (2010). Developing protective boxes with minimum empty occupancy would decrease the general environmental footprint along the supply chain due to the reduced need for transportation modes, as less fuel would be used (Molina-Besch & Pålsson, 2015).
Optimizing packing density is described as using minimal extra weight and size while providing adequate safeguarding to the items (Molina-Besch & Pålsson, 2015). In principle, the superfluous materials and void space resulting in increased weight and volume have unfavorable impacts at every level of the supply chain (Molina-Besch & Pålsson, 2015). If companies increase the quality of their products, their durability will contribute to achieving maximum space utilization due to greater volume optimization, as well as reduced weight (Wever, 2011). Wever (2011) also proposes that weight reduction is among the most crucial aspects of volume enhancement, as transporters have a restriction on the amount of weight they can transport. Consequently, more massive merchandise and packaging have the potential to surpass weight limits without achieving the carrier's maximum packing density. Therefore, it is more convenient to optimize the carrier's shipping volume by employing smaller packaging and products (Wever, 2011).

As aforementioned, fill rates are affected by road carriers who may charge customers based on the amount of volume/space occupied by their cargo, rather than the actual weight of the shipment, as well as the dimensions of the carrier’s requirements and transport planning in terms of frequency (Molina-Besch & Pålsson, 2015). Molina-Besch & Pålsson (2015) support that every package ought to be as lightweight as feasible while maintaining the highest possible packing density within and among each packaging tier to ensure optimal safeguarding and economical as well as environmentally sustainable outcomes throughout the supply chain. In other words, the primary packages should be the ideal size for transportation within the modularized secondary packages (Sjöberg & Eriksson, 2020). If these two packaging levels do not fit flawlessly, the advantages are negated, which leads to increased weight, cost, manufacturing, and waste, thereby exacerbating the environmental issues in the supply chain (Sjöberg & Eriksson, 2020).

Moreover, Molina-Besch & Pålsson's (2015) investigation indicates that maximum packing density also curtails the energy consumption in static logistics facilities as the storage capacity is utilized more efficiently. Currently, there are no regulations pertaining to the utilization of excessively large secondary packages, and there is insufficient awareness among the public and customers concerning this aspect of the supply chain (Sjöberg & Eriksson, 2020). From a stakeholder standpoint, the secondary packaging tier is not a regulated or supervised element of commerce, nor is there any multi-stakeholder pressure (Sjöberg & Eriksson, 2020).
2.3 Overview of the Heterogeneity in Types and Volumes of Goods Being Transported by Road.

Road transportation is a critical component of the global supply chain, allowing goods to be transported quickly and efficiently over short to long distances. However, the types and volumes of goods being transported by road can vary significantly, leading to a high degree of heterogeneity in the transportation industry (Research & Markets, 2020). In terms of types of goods, road transportation is used to transport a wide variety of products, from raw materials and industrial equipment to consumer goods and perishable goods. The transportation of hazardous materials, such as chemicals or explosives, is also common in industry. Each type of product may require specific handling or transportation requirements, which can affect the type of vehicle and equipment used for transportation (Association for Supply Chain Management, n.d.).

The volumes of goods being transported by road can also vary significantly, ranging from small shipments to full truckloads. Some industries, such as retail and e-commerce, rely heavily on small shipments to quickly deliver products to customers, while others, such as construction and manufacturing, often require large quantities of materials to be transported in bulk. The volume of goods being transported can impact the type of vehicle used, as larger shipments may require larger trucks or trailers (Statista, 2022). Simply put, the heterogeneity in the types and volumes of goods being transported by road requires the transportation industry to be flexible and adaptable, with the ability to tailor transportation solutions to meet the specific needs of each customer (Transport Topics, 2021).

Urbanization is much more attractive as statistics have shown that more people in general are living in the cities, where they can consume the demanded goods and services. For that purpose, the need for trade movement on an international level is essential for the population, as well as having an effective way of dealing with the road freight puzzle. As a result of economic growth and the growth of the delivery services, road freight transport has taken a very active part of the demanded logistic activities. Freight is a core activity in the production of goods and services, as
well as in construction in the more advanced and developing countries (Browne, Behrends, Woxenius, Giuliano & Holguín-Veras, 2018). For the countries that are in evolution, freight might be even more significant, as they benefit from agriculture and manufacturing. In Europe, the different types of goods that are being transported by the road network are being classified according to their commodity purpose (Browne et al., 2018). According to Eurostat (2022), the general commodity classification for transport statistics phrased as NST, is a statistical terminology for the carried products by the divergent modes of transport, such as roads, railways, maritime logistics and inland waterways. Goods delivered by the road transportation involve products of agriculture, hunting, and forestry nature, metal ores and other mining and quarrying products, food products, beverages and tobacco, textiles, wood and products of wood and cork, chemicals, and man-made fibers; rubber and plastic products; nuclear fuel, machinery and equipment, mail, parcels and few others. The classification of the types of goods delivered by road freight transport is presented in Figure 1.

![Figure 1: Types of goods being transported by road freight (NST, 2007), EU, 2021 (% portion in tons and tkm).](image)

Note: with exclusion of Malta; ranked based on portion in tons I, Source: Eurostat.
Figure 2 presents the portion of each of the general commodity classifications in the European Union in total, but also includes information of the road freight on national and international level. In the year of 2021, groups such as “01 'agriculture, hunting, forestry, fishing products', 02 'coal and lignite; crude petroleum and natural gas', 03 ‘metal ores, mining and quarrying products’, 04 ‘food, beverages and tobacco’, 07 ‘coke and refined petroleum products’, 09 ‘other non-metallic mineral products’, 14 ‘secondary raw materials; wastes’, 15 ‘mail and parcels’, 16 ‘Equipment/material used in goods transport’ and 17 ‘goods moved in removals; baggage; vehicles moved for repair’ have had a higher portion on national level in terms of road transportation, in comparison to the international degree (Eurostat, 2022). The unmentioned categories carried by road freight have a greater international intensity.

![Figure 2. Types of goods being transported by road freight in total, national and international level (NST 2007), EU, 2021 (% portion in tons and tkm). Note: with exclusion of Malta; ranked based on portion in tons, Source: Eurostat.](image)

Although hazardous substances and materials are also being carried by road transportation, they have drastically smaller proportions. As stated by Eurostat (2022), products carried on pallets,
have represented the predominant form of cargo in many EU countries in the year of 2021. However, remaining cargoes such as liquid and solid bulk goods, large freight containers, preslung goods, as well as remote self-propelled units present the remaining proportion of the cargo that has been delivered by road transport modes in 2021 on European territory.

Generally, road transportation plays a critical role in the movement of goods in the global economy, with its flexibility and adaptability making it a vital component of the supply chain (Association for Supply Chain Management, n.d.). As the types and volumes of goods being transported by road continue to vary significantly, it is essential for the transportation industry to remain flexible and adaptable to meet the ever-changing needs of customers.

2.4 Analysis of Current Delivery Vehicle Types and Their Space Utilization Characteristics

Analyzing the space utilization characteristics of delivery vehicles is crucial for optimizing the use of available space in truck deliveries and reducing the amount of excess air that is shipped with products (Browne et al., 2018). This can help companies reduce transportation expenses, improve efficiency, and minimize their environmental impact. It is of great importance to stress the presence of the multiple different types of delivery vehicles in use today, ranging from small cargo vans to large tractor trailers. Each type of vehicle has its own unique space utilization characteristics, which can impact how much cargo it can carry and how efficiently that cargo can be delivered. We can easily spot the heterogeneity just by noticing the wide range of different vehicles and the different policies made for that below and more than 3,5t in an urban area (Smartload, n.d.).

The heterogeneity of the land transport modes can be seen through the divergent goods moved, which are in need of transport based on the type of the product in accordance with the body shape of the delivery vehicle. Different types of haulage vehicles are used in road transport for the conveyance of goods, in relation to the characteristics of their body shape. Vehicles such as tarpaulin and curtain trucks are adaptable and make loading and unloading easier, whereas box vehicles have an exposed freight area, ideal for carrying construction machinery (Smartload,
Additionally, tipper trucks have the ability to incline for swift unloading of uncontained substances. Furthermore, temperature-controlled trucks feature a cooling system to preserve a stable temperature, while tank trucks are fitted with tanks to transport gases, liquids, or solids (Smartload, n.d.). Food delivery, for instance, needs temperature-controlled transportation, while the construction transport is completely differently organized, using flatbed and box trucks. Containers, however, are mounted onto the integrated section of the vehicle, adaptable for long distances and intermodal transport. Delivery vehicles that are commonly used for local deliveries is the step van or "bread truck". These vehicles are typically box-shaped with a large cargo area in the back, and they are often used for delivering goods to businesses and homes in urban or suburban areas.

According to a study conducted by the National Renewable Energy Laboratory, step vans have a cargo volume of approximately 500 cubic feet, with an average payload capacity of around 3,000 pounds (McMordie-Stoughton & Figueroa, 2017). Another common type of delivery vehicle is the parcel delivery truck, which is used by companies like UPS and FedEx for delivering packages to homes and businesses. These trucks are generally smaller than step vans and are designed to carry individual packages rather than larger cargo. According to UPS, their delivery trucks have a cargo capacity of around 700 cubic feet and can carry up to 10,000 pounds of packages (Ajot, 2018). For larger shipments and long-distance deliveries, tractor-trailers are often used. These vehicles can carry a significant amount of cargo, with some trailers having a capacity of up to 3,000 cubic feet or more. However, the efficiency of these vehicles can be impacted by factors such as road conditions, traffic congestion, and weather (Federal Highway Administration, 2021).

Great focus is aimed at retail chains, as they are significant for the economy and increase the road freight circulation. Less understanding there is for deliveries to small companies or offices, which are responsible for a high level of trips (Browne et al., 2018). In correlation with minimizing the “excess air” in deliveries and increasing the utilization of the vehicles, the interest in managing and creating better un-loading places is growing. Having a back door, the deliveries to supermarkets, for instance, might be much better organized than those to a coffee place or a restaurant, where in most cases, the unloading is done at the front door, or they do not have a lot of space. In many countries in the world, there are different regulations where it is banned to
access an area for some time, for the purpose of enabling a better quality of life for the inhabitants (ibid). For the same reason, organizations and authorities strive towards a livable environment, but not just in terms of providing the requirements for life, rather better infrastructure, design, policies, environmentally more efficient vehicles, and greater awareness (Ajot, 2018).

In addition to these traditional delivery vehicles, there are also newer technologies being developed such as drones and autonomous delivery vehicles. While these technologies are still in their early stages, they have the potential to revolutionize the delivery industry and improve efficiency and speed of delivery (Drone Delivery Canada, n.d.). Drones with their reliability of the components, can potentially be a carrier for the last mile leg, as they could significantly decrease emissions, delivery times, as well energy consumption and it can drastically help the National Health Service in England (E-Drone, 2022). While being suitable for surveillance revolutionized farming, surveillance checking rail track or aerial view of houses, the big question is whether the ‘uncrewed aerial vehicles’ will be used for freight purposes. The idea of fleet logistics is using drones for extremities, rather than using vans which are spending most of their work time on collecting or distributing something in the rural areas (Oakey, Pilko, Cherrett & Scanlan, 2022). There have been different types of drones, such as ‘fixed wing planes’ without pilots and ‘vertical takeoff and landing drones’, which can land on helipads or surgery rooms (Zhu et al., 2023). The extremities suitable for these kinds of deliveries are three layers of packaging tubes of patient diagnostic samples, such as blood samples for cancer patients.

Altogether, the space utilization characteristics of delivery vehicles vary widely depending on the type of vehicle and its intended use. Understanding these characteristics is important for companies that rely on efficient and cost-effective delivery, as it can help them select the most appropriate vehicles for their needs.

2.5 Transport Mode Utilization and Loading Factor

The financial point of view related to appropriate utilization of a transport mode can be seen from the transport operator or an individual or company owning the trucks. It might not be of
great significance for the company that possesses the vehicles, if the modes are partially filled, given that the client is responsible for the cost of shipment. It is a common situation for a fully loaded transport mode to go from one location to another and run empty on the way back. If the consumer funds the carriage in both paths, the actual asset usage would only be 50% at most because the truck is empty on the return trip, while the financial asset usage would be 100% (Hosseini & Shirani, 2011).

When it comes to decreasing overall journeys and, by extension, its adverse impacts like traffic jams, incidents, consumption of gasoline, and atmosphere contamination, the authorities may occasionally be more proactive in accomplishing greater actual asset utilization (Hosseini & Shirani, 2011). As the logistics industry is largely responsible for greenhouse gases and road transportation is typically the most common form of freight mobility, the weight would be significantly lessened if the transit modes were put to use more effectively. According to certain data, 25% of truck kilometers in EU nations are traveled empty, while in the UK, 44-ton trucks with a total load capacity of 29 tons only carry a mean of 17.6 tons when fully loaded and 12.7 tons when empty running is taken into account (McKinnon & Edwards, 2010).

In scientific studies, there are several ways to calculate and assess how well the transport modes are used, using the three variables of capacity, speed, and time (Lumsden, 2007), ranging from straightforward indicators to intricate mathematical computations (Hosseini, & Shirani, 2011). While some metrics can be found under the heading of transport mode utilization, it is demonstrated that there is no agreement among experts in the field and researchers regarding how to measure truck usage. Piecyk (2010) has plainly divided those metrics into fill rate and empty running, unlike McKinnon & Edwards (2010) that have specified them as: ton-kilometers per mode per annum, weight-based fill factor, space utilization/mode fill, and empty running. The ton-kilometer is regarded as a parameter for calculating loading factor in papers produced by the European Environment Agency (2010). Degree of bare operating Weight-based carrying factor, Ton-km loading aspect, Volumetric carrying element, and Deck-area coverage have been presented by McKinnon (2010a) in a separate publication.
Furthermore, it needs to be stated that no business purposefully underused its fleet of engines. If records indicate that mode usage is not to a desirable degree, there may also be other factors, such as inconsistencies, that result in misspent capacity or lorries that are only partially occupied. According to McKinnon & Edwards (2010), there are a few restrictions that affect how companies use the transit modes, and they have been divided into separate groups:

- **Business-related**: These restrictions are affected by the nature of the marketplace and changes in the movement of cargo.
- **Regulatory**: These rules include factors like truck weight and size, timeframe schedules, and protection standards.
- **Inter-operational**: These are limitations brought on by other business units.
- **Infrastructural**: These restrictions concern the actual capacity of the mobility system.
- **Equipment-associated**: They result from improper transport mode, managing equipment, and fill adaptation.

With the general improvement on vehicle optimization, through maximizing space and decreased empty runs, less trucks will be used, which would result in decreased mobility, seen through reduced mode-km. Thus, the level of externalities such as traffic jams, pollution, accidents etc., will be noticeably decreased. Regarding this matter, there are several lawful measures that impact the usage of vehicles (European Commission, 2014). Among these measures is the deregulation of the domestic EU market, which gave rise to intricate movements of freight transportation, culminating in the implementation of cabotage as one of its consequences.

Cabotage is the practice of permitting transporters from a particular nation to collect and deliver products to another. The legislation within the European borders used to specify that transport operators in the destination land may conduct a maximum of three of these activities during a week window following the finalization of distribution. However, this regulation has been adjusted in 2014, as the European authorities have abolished restrictions on cabotage, for the purpose of decreasing the void runs and enhancing the effectiveness of cargo mobility (European Commission, 2014). For transport operators, the loading degree would be a topic of notice.
because it can enhance efficiency, thereby reducing expenses. Figure 3 depicts the various loading pace setting elements conceptually.

![Diagram: Correlation between cargo weight, size, and value](image)

Figure 3. Correlation between cargo weight, size, and value. Source: Hosseini, S. V., & Shirani, M. (2011). Fill rate in road freight transport.

For both carriers and clients, determining the loading capacity is beneficial because price is based on the weight and volume of the shipment and the extent to which it contributes to the transporter vehicle being entirely full. Although there are many elements and variables that affect conveyance prices, the basic concepts apply to all modes (Noonan & Canellis, 2006). There are five factors that determine the cost of conveyance, involving source location, destination, weight, volume, and degree of service and they are used in six equations for determining the cost, such as accountable weight, minimum charge, chargeable weight multiplied by price per pound, half truck load (HTL) price, full truck load (FTL) price, and fuel surcharge, as stated by Hosseini, & Shirani (2011). To prevent bulky cargo from exceeding the volume limitation of the transporter, which is strongly linked to covering cargo and bulky weight in transit costs, optimal density is required (Lumsden, 2009).
2.5.1 Estimating the Loading Factor Capacity

Typically, in road mobility, commodities are conveyed from the manufacturing origin to the final location, resulting in vacant trips during the return journey. This results in a decrease in the efficiency of vehicle utilization and poses a difficult objective for freight transport enterprises to decrease the number of empty trips (McKinnon & Ge, 2006). Hence, another aspect to take into account is that the level of space utilization cannot be evaluated purely by the loading rate, and alternative metrics like vacant trips are commonly employed. On occasions, unoccupied journeys are incorporated into the loading rate calculation, where each way of transportation is taken into account, including the outgoing and backward trips (McKinnon, 1999). In some instances, solely the journey from the initial point to the final location is evaluated when quantifying the fill degree, and the number of vacant trips is factored in to provide a comprehensive analysis of source consumption (McKinnon & Ge, 2006). However, difficulty in estimating vacant runs arises since firms typically determine the unoccupied trips for the truck, leaving out the trailer. As a result, the collected data becomes irrelevant in situations where the trailer is frequently separated (ibid).

An additional aspect to consider is the impact of factoring in the time usage and determining the appropriate beginning and end points. The truck's effectiveness is not solely affected by vacant trips but also by periods of idling, regular upkeep and fixing, as well as filling and emptying, as McKinnon (1999) demonstrated in a study that found an eighteen-wheeler was only operational on the road 35% of the time. It is imperative to establish whether the evaluation should be conducted at a particular instant or over a defined timeframe. Moreover, a predicament that arises when assessing the loading level is the ambiguity regarding the classification of the backward direction (vacant handling tools, such as boards) as either filled cargo or vacant trips, resulting in a loading factor of zero. In terms of measuring loading rate for road freight mobility, several variables can be employed, namely weight, ton-kilometers, deck-area, number of pallets, and volume (Hosseini & Shirani, 2011).
2.5.2 Factors Influencing Loading Factor Capacity

At the organizational level, rates can be impacted by determinations made across various tiers of the enterprise. As shown in Figure 4, Piecyk (2010) divided these determinations into four categories, such as advertising, operational, functional, and commodity associated considerations.

![Figure 4. Classification of factors affecting loading rate. Source: (Piecyk, 2010).](image)

The commerce considerations are related to the businesses' purchasing and transportation plans and practices. The selection of means of conveyance, managing aspect, standard voyage duration, and truck use are likely to be influenced by these selections, which are often taken at the executive level. Buying via the web, returning goods for resale or waste disposal, contracting outsourced operations, and purchasing inventory internationally are a few of these choices. Moreover, operational considerations are choices, which often are taken at the mid-managerial stage, and have an impact on the item circulation timetable. These decisions have an immediate impact on vacant trips and space capacity utilization. Examples of such decisions include the use of the JIT approach, variation among order size, product lead times, and frequency of distribution (Hosseini & Shirani, 2011).
Functional aspects, on the other hand, are associated with the immediate managerial administration of transportation assets and have an impact on truck utilization through the selection of a mode, the haul plan and organization, and the scheduled routing (Hosseini & Shirani, 2011). Some instances of functional elements are the use of telematics, the use of truck routing and scheduling systems, cooperation between businesses in terms of logistics, truck loading, aligning the fleet of transport modes to the quantity needs of conveyance, and integrating manufacturing and delivery (ibid).

Last but not least, product-associated aspects can be seen through vehicle selection and carrying velocity within the scope of logistics and transportation and are influenced by aspects of commodity and casing design. Additionally, they may be the outcome of internal motions or mandates put forth by other supply network participants, as highlighted by Piecyk (2010). Such factors can be noticed in the higher level of utilization of casing, that is space-optimizing, readily prepared item casing for shelves, as well as through adjustments for commodities that are more delicate to supply chain prerequisites.

Providing an exhaustive list of all the aspects that affect the attainable loading capacity degree can be a lengthy task, indicating that capacity utilization can often be complex as it is subject to numerous before-mentioned factors simultaneously. In this regard, Piecyk (2010) surveyed logistics experts from various industries to identify factors that have great impact over the fill rate, and the survey's findings about the affecting variables were as follows consolidation/collaboration, JIT (just-in-time) distribution, packaging/pallet stacking, loads restricted by volume, and increase in maximum weight of trucks.

Furthermore, Knight et al. (2008) found that LHV s, which are longer and/or heavier than HGVs, achieve a higher fill rate because they are typically operated on routes with favorable loading opportunities in both outbound and inbound mobility. As specified by Hosseini & Shirani (2011), better inter-functional coordination, backloading, centralization, and adjustments in truck design are aspects that can positively impact loading factor rate, while service specifications, decentralization of retailers, multi-drop processes, and fuel prices can have negative effects.
Moreover, utilizing adequately sized transportation means and establishing transport charging at the foundation level of truck stacking can enhance the space capacity utilization.

2.6 Analysis of Current Supply Chain Practices and their Impact on Space Utilization in Road Transportation

Enterprises across various industries and magnitudes are confronting the task of becoming more liable and answerable to the ecosystem and community. To accomplish durability, supply networks require closer regulation and attention (Singh & Trivedi, 2016). Efficient implementation of supply chain procedures and exchange of information intensifies the existing environment of supply chain administration (Zhou & Benton, 2007).

Several years ago, there were enterprises that had vertical integration and owned, to some degree, some of their providers or customers (Zhou & Benton, 2007). However, that is not the circumstance nowadays, where due to the high expenses and complexity of management, companies have multiple suppliers and customers, and are working towards improving their relations. Relationships with the divergent stakeholders within the supply chain are maintained, as well, since coordination can be the best way to remain successful on the market and is a key point of supply chain management. In today’s industry the competition between companies is based on their supply chains (Sorooshian, Jambulingam & Dodangeh, 2013). The complexity of a supply chain becomes evident when one considers the multitude of suppliers a manufacturer has, along with the suppliers of those suppliers. In addition, almost always companies go towards careful selection of trustworthy suppliers to build long term B2B relations, instead of one-time purchase, while they exchange data between them in terms of supply chain transactions and information.

To explain what supply chain management is, we need to consider a simple example of how a supply chain works. Organizations extract raw materials such as soil, minerals, water, and wood, which are then sold to suppliers that transform them into processed materials (Sorooshian, 2022). Manufacturers use these processed materials to create final products, which retailers sell to end-customers. Supply chains involve information, material, and monetary flows, and may also
include reverse logistics. Larger supply chains may have direct and indirect suppliers, such as divergent agencies and information systems providers. That is why complex supply chains with their flows of information, material and money are being seen as supply networks (Sorooshian, 2022).

In addition, companies also need to think of doing these tasks while applying environmentally more efficient ways for satisfying sustainable purposes. A supply chain manager needs to have the ability to do all these tasks and give closer attention to the origin of the materials and the ways that they are made and transported, to meet demand requirements for a reasonable price, while still managing the making of profit. Bigger firms aim for successful supply chain management to improve collaboration with partners, better resource utilization, quality, and lower procurement expenses, resulting in larger returns on investment. They also need to identify customer satisfaction/dissatisfaction to maintain operations and improve business.

Additional tool that has helped or encouraged the effective proactive working of the supply chain and their coordination, are the enterprise resource planning systems, which makes the communication between companies easier, by sharing their demand forecasts, procuring and manufacturing plans, strategies, or basically anything that would impact the flow of the chain network (Shaul & Tauber, 2013). The increased usage of the internet, EDI (electronic data interchange) systems, as well as the radio frequency identification technologies (RFID) have assisted partnered companies to share information not just between them, but also with their third-party logistic providers (Wisner, Tan & Leong, 2014). Taking into consideration the improving technological changes, it is challenging for firms to produce products, find trustworthy providers and gain competitive advantages. Consequently, there is a broader range of new job opportunities in the area of logistics, procurement, operations and supply chain management (Wisner et al., 2014). On the other hand, a lack of coordination and collaboration, where partnered companies do not know their plans, can contribute to creating a bullwhip effect, which is caused due unpredictable demand fluctuations. The importance of collaboration between departments and employees within operations, is also valuable for the company’s micro supply chain within the company internally.
When it comes to supplier management, one of the tasks of supply management is to do supplier evaluation and ensure that the supplier has met specified requirements, controlled by certification. Organizations have also recognized the advantages of having relationships with their customers (CRM) for the purpose of decreasing or increasing their safety stock level. Over the past five decades, intensified rivalry among firms, particularly producers and manufacturers, has been a crucial concern (Mackelprang and Nair, 2009). To remain competitive and optimize profits, companies may adopt various approaches (Altitude Advisory, n.d.). Typical targets of these strategies include reducing costs and enhancing efficacy (Mitrefinch, 2014).

2.6.1 JIT as a Current Supply Chain Practice

The effective implementation of selected optimal strategies, such as supply chain planning, just-in-time production, and delivery practices, is considered to constitute a group of efficient supply chain practices (Zhou & Benton, 2007). To enhance their supply chain, businesses must concentrate on both proficient supply chain maneuvers and the sharing of information with associates, as these two methods are mutually reliant and necessitate simultaneous attention (Zhou & Benton, 2007).

Numerous merchandisers are embracing a rapid response inventory mechanism, recognized as JIT inventory systems, that feature more frequent, smaller shipments from makers, leading to lower inventory investment, enhanced availability, and reduced lead time (Levy, Weitz & Grewal, 2019). The five techniques encompassed in JIT production are pull system, reduction in cycle time, cellular manufacturing, agile manufacturing strategy, and bottleneck removal (Flynn et al., 1995; Powell, 1995; MacDuffie et al., 1996). The pull approach operates on the principle of customer need driving production, with the aim of fulfilling the customer's requirements accurately and punctually. Decreases in cycle period enable the production of minor quantities, thereby enhancing the quality and punctuality of feedback. Cellular manufacturing identifies similar processes or products and groups them together, which can decrease throughput time, while the agile production approach enables its systems to cope with sudden changes in consumer's needs, thereby fostering efficient management of the supply chain. (Zhou & Benton, 2007).
The utilization of the JIT strategy allows companies to maintain lower inventory levels by ordering goods only when demand arises. JIT delivery systems are known to improve delivery times and product quality, leading to decreased reliance on safety stock levels (Wisner, Tan & Leong, 2017:17). However, over-reliance on JIT practices brings about difficulties and risks. Supply chain risks are defined as "the likelihood of a disruption that would impact the ability of the company to continuously supply products/services" (Jacobs & Chase, 2018:31).

One challenge associated with JIT delivery is the time and cost involved during implementation (Wisner et al., 2017). Reordering poses another challenge due to the low inventory levels and short delivery times (Kesavan, n.d.). The environmental impact of JIT delivery is also a concern, as frequent deliveries increase the number of vehicles on the road, resulting in lower fill rates if not planned correctly (McKinnon, Browne, Piecyk & Whiteing, 2016). Another challenge with JIT practices is the risk of disruption, as low inventory levels may result in companies running out of stock, which is detrimental to their business (Planet Together, 2021). Additionally, low inventory levels increase the dependency of manufacturers on suppliers, making coordination between them crucial. This dependency brings about the risk of a lack of coordination and communication, complicating processes and resulting in an inefficient chain and a bullwhip effect affecting actors earlier in the chain (Yew Wong & Johansen, 2005).

2.6.2 Lean Approach as a Practice

Reducing costs can be achieved through decreasing unnecessary inventories, which can be accomplished by having the lean approach as a supply chain practice (Hicks, 2007). The Lean method focuses on removing waste in terms of unnecessary processing motion, or surplus stock (Hicks, 2007). In general, the logic is that if a move does not contribute to creating value, it should be eliminated from the operation, which is why supply chain is sometimes correlated with the phrase "value chain" (Wisner et al., 2014). Since customer value refers to the willingness to pay for the desired thing, the production of the desired object should sustain value-added processes. That is why waste such as overproduction, excess inventory, unnecessary waiting, and product defects are seen as non-value-adding both in manufacturing and in service processes. Unlike services, manufacturing is more controllable as demand is slightly less uncertain. Production processes and tools can be adjusted and controlled to cope with the demand, while cutting costs.
In the context of supply chain management, Lean principles have been applied to improve the flow of goods and services across the supply chain, from raw materials to finished products. (Womack & Jones, 2003). One of the purposes of the Lean approach is to maintain constant development through the recognition and elimination of disorganization and wastefulness in the supply network. Thus, this can result in refinement in the space utilization for mobility on the roads, as this approach can assist in the optimization of available space and decrease waste in the transit of goods. For instance, by adopting Lean practices such as just-in-time delivery, organizations can reduce the amount of inventory that needs to be transported, which can lead to more efficient use of space in trucks and other transportation vehicles (Ohno, 1988).

An alternative way for the Lean attitude to positively affect the optimization of the delivery vehicles is through the use of value stream mapping to pinpoint domains of waste in the transit procedures. By charting the movement of products and services from providers to end-users, enterprises can recognize regions where space is being underutilized or where inefficiencies are happening and implement measures to tackle these problems (Bicheno, 2004). For instance, by decreasing the distance traveled between suppliers and consumers, organizations can decrease the quantity of space required for transit, which can result in expense savings and improved efficiency (Rother & Shook, 2003).

2.6.3 Supply Chain Planning as a Practice

Supply chain planning is a critical practice in the supply chain that can significantly impact space utilization in road transportation. According to Boukherroub, Ruiz, Guinet & Fondrevelle (2015), supply chain planning is a crucial practice in supply chain management (SCM) that involves making decisions at three levels: strategic, tactical, and operational. While traditionally, SC planning has mainly focused on expanse minimization, the increasing awareness of consumers for environmental and social issues, has resulted in, incorporating sustainability concerns into SC planning decisions, as well as tightening of legislation in this regard (Boukherroub et al., 2015). Efficient planning has the potential to enhance the distribution of resources, including capacity, and decrease inefficiencies in the movement procedures of goods (Wan, He & Chen, 2018).
Models that take into account greenhouse gas (GHG) emissions can encourage road delivery companies to reduce their carbon emissions, which can be achieved through measures such as optimizing delivery routes, using fuel-efficient vehicles, and reducing idle time (Boukherroub et al., 2015). These actions can decrease the capacity required for distributing goods, thus improving space efficiency, and minimizing the demand for extra vehicles. Additionally, models that consider social criteria, such as the maximization of local employment, can encourage companies to locate their facilities closer to urban areas, which can reduce the distance and time required to transport goods, as well as the associated space requirements (Boukherroub et al., 2015). Using advanced analytics and optimization tools, organizations can forecast demand, plan routes, and optimize delivery schedules, enabling more efficient use of available space and reducing the number of partially filled or empty trucks on the road (Gunasekaran et al., 2017). Furthermore, by promoting cooperation and coordination among supply chain allies, supply chain planning can further influence space utilization in road transportation. By sharing information on demand, inventory levels, and delivery schedules, organizations can work together to plan and optimize transportation routes, reducing the number of trucks on the road and improving space utilization (Christopher, 2016).

2.6.4 Delivery Practice as a Practice

Sjöberg & Eriksson (2020) discuss the three core packaging levels in the packaging system: primary, secondary, and tertiary. The primary packaging, i.e., the main enclosure is fashioned for its appeal on the display racks and is utilized for B2C connections. It encompasses details about the product, directives, and serves social purposes. On the other hand, the secondary packaging is the distribution unit and is often used to protect the primary packaging during transportation, while it can also be the package customers encounter on the shelves (Sjöberg & Eriksson, 2020). It is primarily employed in B2C online sales delivery, frequently without compartmentalization up to the primary packaging tier. Finally, the tertiary packaging is the loading unit designed to carry several secondary packages on pallets, mainly used in B2B transportation (Bramklev, 2007; Bertoluci, Leroy and Olsson, 2013). The primary objective of packaging is to provide enough
protection of the commodities during their movement and storage, as well as providing required information and promoting the brand for the purpose of sales growth.

Dörnyei (2020) provides an in-depth exploration of the objectives of limited-edition packaging (LEP), where the included brand-related objectives are the most frequent, and they encompass a wide range of objectives, such as communicating heritage and history, brand identity, values, and associations, premium and globalizing the brand, reaching a specific segment, engaging (loyal) consumers, and communicating country-of-origin. In addition, sales-related objectives focus on creating urgency and scarcity, generating incremental sales, and accelerating product distribution, while product-related objectives include enhancing product attributes and differentiation, improving product trial and repeat purchase, and creating excitement and buzz around the product, as identified by Dörnyei (2020). Nonetheless, packaging additionally conveys product characteristics such as directions and particulars concerning the substance, and in promotional context, the primary aim is to heighten customer anticipation and enhance the desirability and commercial appeal of the merchandise and label. Sjöberg & Eriksson (2020) emphasize the importance of keeping the fit between the primary and secondary packaging as slim as possible to create maximum protection and reduce the amount of air, but this can create issues in B2C e-commerce packaging where excess air is a major issue.

2.6.5 Demand Forecasting as a Practice

Demand forecasting as a practice in the supply chain can have an impact on space utilization in road transportation and the excess air in packaging, as proper forecasting can lead to greater optimization of the supply chains and thus properly used space, as well as appropriate used packaging in terms of size and shape (Jenkins, 2021). Demand management is not just about predicting the future demand with the help of forecasting, but integrating the demand (marketing, sales and downstream partnered stakeholders) with the supply (sourcing, operations, and logistics), which would contribute to improved coordination and the flows in the supply chain (Rodney, 2018). The great divide referring to the lack of communication between these two important aspects can be eliminated by their integration, by the assistance of S&OP, where capacity and demand forecasting is aimed to be done. These forecasting methods help
determine how much inventory should be procured for the purpose of accomplishing consumer desires.

From decades ago, people were trying to foresee the future and ancient forecasters were making predictions based on the animal movement or change in their behavior, for instance, discovering that they have a certain ability to sense the weather conditions, something that people were not capable of at that time. Today, essential for demand management and every business for making quality decisions for planning and control are the forecasts (Jenkins, 2021). Forecasting is of great assistance in the area of finance and accounting, in marketing, since the procurement department can order the optimal quantity of goods, plan sales employees schedule, as well as in production, where suppliers and type of processes are being picked, the organization of operations is done, the plan for the production and right capacity is determined, and the goods are delivered in a correct capacity order, based on the forecasts made. Demand forecasting is a crucial practice in the supply chain as it helps businesses optimize their inventory levels and avoid stock outs or overstocks, which can have significant financial implications (Jenkins, 2021).

Lack of collaboration in terms of information sharing can be the reason for inaccurate forecasts which would negatively influence the planning of demand and supply. On the other hand, more accurate forecasting leads to advantages such as lower inventories, decreased expenses, improved meeting in customer demands and efficient planning. Accurate demand forecasting enables companies to have the right quantities of products to meet both current and future needs, and this process takes into account historical sales, sales forecasts, seasonality, and promotions (Jenkins, 2021). Lack of coordination and collaboration, where partnered companies do not know their future plans made based on forecasting, can contribute to creating a bullwhip effect, which is caused due unpredictable demand fluctuations. When choosing a forecasting method, organizations need to focus on their purpose, or what is the question that they want answered by forecasts. For instance, if the company wants to know what the expected demand for several products is over the next two years, it might use strategic forecasts, which are concentrated on medium- and long-term decisions regarding factors, which the overall strategy is based on, such as sourcing, capacity, operations and sales planning, design of the production process and service process and so on (Chase & Jacobs, 2018). For daily, weekly, or monthly basis,
tactical forecasting is used for consumer expectations in terms of time and availability of the goods/services. Customer demands are correlated with the inventory levels of the companies. If the forecasts present more accurate demand over a shorter period, the inventory level would be easily and correctly regulated. If companies have difficulty determining the demand prognosis, then they would need to increase their stock level. The same would be important both for goods and services. Since there are not perfect forecasts, it is suggestable for companies to use more methods and analyze them from different perspectives.

In order to satisfy consumers’ demand, companies need to distribute commodities from one location to another, and road movement is often used for this objective. Since space utilization in road carriage refers to the amount of space that is used while moving goods, accurate demand forecasting can react proactively and terminate actions such as overloading or underutilization of products. Both of those actions can lead to missed opportunities to improve the utilization of the vehicles and reduce emissions. Forecasting demand can have a vital impact on enhancing the usage of space in road vehicles by supporting organizations in the improvement of their transportation operations planning and management (McKinnon & Edwards, 2010). Through precise forecasting of demand for particular routes and delivery schedules, companies can improve the loading and routing of their trucks, which can result in a reduction of empty runs, and the enhancement of the efficiency of their transportation networks. This can help to address the issue of geographical imbalances in traffic flow, as well as the variable truck fills that are common in international road transportation (McKinnon & Edwards, 2010). Moreover, demand prediction can assist organizations in aligning their packing and handling equipment with the distinct requirements of their clients, thus allowing them to curtail the volume of unutilized space in their vehicles.

By understanding the size, weight, and other characteristics of the goods they are transporting, organizations can design packaging and handling equipment that maximizes space utilization while still ensuring the safety and security of the cargo (McKinnon & Edwards, 2010). Demand forecasting can help divergent enterprises to optimize packaging for conveyance by predicting demand for particular routes and delivery schedules. This enables organizations to align packaging with consumer needs, avoiding the mobility of excess air and addressing poor vehicle...
utilization. When demand is accurately foreseen, packaging can be optimized to the appropriate size and shape, reducing the amount of excess air during conveyance. This leads to a decrease in material usage, as well as a reduction in transportation expenses since lighter boxes require less fuel to be distributed. Additionally, it can also result in waste depletion generated from excess packaging material, which is better for the environment (McKinnon & Edwards, 2010). In summary, accurate demand forecasting can lead to more efficient use of transportation space and reduced excess packaging, which can help decrease expenses, minimize environmental impact, and improve overall supply chain sustainability.

Simply put, supply chain management is present both in managing the production, transportation, organization of the processes of providing a product or a service. Some of the challenges that supply chain management faces today are related to supply chain analytics, which helps the making of better decisions, as predictions are made as a result of the chain data studies. Another challenging aspect that is of great importance is the supply chain visibility of the location of the products, at any time, since it can be very beneficial for improving the utilization of space in the vehicles. And last, sustainability as a challenge, which would be the ability of the stakeholders to do everything they can to meet the needs, while at the same time, decrease their carbon footprint in every single process of their operations and eliminate the potential threats of jeopardizing future generation needs.

2.7 Evaluation of Existing Packaging and Palletizing Practices and Their Impact on Space Utilization

In international markets that are progressively more viable, tumultuous, corporations and, more broadly, the networks of suppliers to which they pertain, are obligated to encourage endeavors that advance productivity and ecological awareness, particularly with regards to logistics and conveyance. Effective management of goods mobility has emerged as a crucial concern for the public and private bodies. It is not only beneficial in terms of expanse reduction and enhanced service, but also plays a vital role in lowering resource consumption, greenhouse gasses, and traffic jams, as highlighted by various sources (McKinnon & Ge, 2004; European Commission,
One of the major components in this regard that may actively add to supply network enhancement and greater environmental viability of logistical procedures and operations is packaging layout (Saghir, 2002; Klevas, 2005; Hellström, 2006). Packaging should support the growth of environmentally friendly practices in each one of its elements (financial, ecological, and ethical), in addition to the vital and unquestionable safeguarding it offers the commodity (García-Arca, Prado-Prado & González-Portela Garrido, 2017). The ability of specific (physical and conceptual) commodity attributes to stand out from the competition is a key component of the financial element of sustainability (Krishnaa, Cianb & Aydinoğlu, 2017; Sohrabpour, Oghazi & Olsson, 2016). Simultaneously, packaging innovation can help the entire supply chain cut expenses in general including those related to managing, storing, and notably transfer logistics (Hellström & Saghir, 2006; García-Arca & Prado-Prado, 2008; Sohrabpour, Oghazi & Olsson, 2016; Dickner, 2012).

Regarding the ecological aspect, the design of packaging also influences the quantity of resources that are utilized (Azzi, Battini, Persona & Sgarbossa 2012; Grönman et al., 2013; Molina-Besch, 2016; Svanes, Vold, Møller, Pettersen, Larsen & Hanssen, 2010; Albrecht, Brandstetter, Beck, Fullana-Palmer, Grönman, Baitz & Fischer, 2013), as this utilization encompasses not only the materials required for the wrapping, but also other supplies consumed in the supply network such as gasoline used for commodity movement. The aesthetics of packages also affect the ecosystem by increasing or decreasing the generation of waste or degradation. Lastly, an element of environmentally friendly practices in packing design that has not typically been explored by researchers is the ethical element.

The encouragement of initiatives to recycle, the provision of truthful, clear details, the secure use of items, and modification of the item's consumption, ergonomics, or quantity to the requirements of consumers including seniors or individuals who have special needs are concerns related to package layout's social effect (Azzi et al., 2012; Vernuccio, Cozzolino & Michelin, 2010; Nordin & Selke, 2010). Considering the information previously provided regarding environmental responsibility, it is clear that the influence of design criteria is complex. These specifications, which are found at multiple tiers and address various demands (security and safety, marketing, ethical, environmentally more efficient, etc.), must be met for suitable casing design. Even if they
are significant, it is also necessary to grasp the framework of casing as a system, thus, it is not sufficient to just comprehend the many style criteria placed on wrapping. Generally, according to Saghir (2002) the structure is divided into three layers:

- "Primary packing", which is also known as the "inner container," "first container," or "consumer package" and serves as the product's initial point of contact;
- "Secondary packing" made to safeguard and make it simpler to manage many principal packages of identical or distinct goods during shipping and selling, and it is referred to as "exterior casing" or "retail wrapping"; and
- "Tertiary packing" ("unit cargo" or "transport pack"), which is the last level, typically connected to a number of secondary casing units that are bundled together, for example, on a board or sway container, to make managing, safeguarding, and mobility easier.

The rationale behind the inclusion of one or multiple products in both second and third-level packaging is associated with modifications made to fulfill the requirements of orders from a company, retailer, or final consumer (García-Arca, Comesaña-Benavides, González-Portela Garrido & Prado-Prado, 2020). Employing multi-item assortments typically involves deviating from the original casing plan devised by the packaging company, which necessitates extra touch and can impact the environmentally more efficient structures of the entire supply network. The tiers of the packaging system should interact in a way that is consistent with the design guidelines to which each of them is committed. Therefore, each stage of adaptability should not be reviewed separately instead in a collaborative coordinated approach with the other tiers considering the significant reliance between them in order to verify that design criteria are satisfied. In addition, a certain amount of outside and within cooperation in the design phase is required due to the range of needs.

The significance attributed to every design prerequisite varies according to the specific location, division, or company involved in scrutinizing it within the supply network. Furthermore, the distribution of style, shape and material specifications is not uniform across the various tiers of the casing system, nor is it uniform across every phase, operation, and duty throughout the supply network (Kievas, 2005; García-Arca & Prado-Prado, 2008; Lee & Lye, 2003; Chan, Chan &
Choy, 2006; Olander-Roese & Nilsson, 2009; Sohrabpour, Hellström & Jahre, 2012). Hence, all the choices regarding the design would revolve around several interrelated elements that complement each other: the choice of components and types, selection of innovations linked to casing procedures (starting from the elementary packing of the item to safekeeping and conveyance in the distribution center, along with identification techniques such as universal item codes or RFID mark), the visual style of the casing (which includes its form, shade, signs, writings, figures, etc.), the casings three-tiered framework, as well as the measurements chosen for each tier. The arrangement of casing design choices within an organization must be harmonized and consolidated with decisions related to the item’s style, form, and shape, and associated with the supply network, so it can fulfill sustainable purposes.

Sustainable Packaging Logistics (SPL) is a process that integrates packing, goods, and supply network systems for efficient and effective handling, mobility, distribution, safeguarding, retailing, purchasing, recovery, reuse, or disposal, with a view to maximizing social and consumer value, sales, and profit from a sustainable perspective, as stated by García-Arca et al. (2020). The "best" casing should have an appealing design that is also functional, a low total expense, and a minimal ecological footprint. Despite this, the majority of businesses believe that expanse savings is an alluring enough justification to encourage modifications to their wrapping creations, materials and processes. The contrasting structure, however, is not as straightforward when the "excellence" of an individual casing substitute is determined from factors beyond expenses, and, in numerous instances, it is challenging to convey the variation in solely financial values. Thus, the LCA (Life Cycle Assessment) technique is frequently utilized for assessing the ecological effect over nature (ISO, 2006), but because of its intricate structure, adjusted systems that are easier to use have appeared (Molina-Besch & Pålsson, 2020).

2.7.1 Palletization

The growth and adoption of pallet-supported equipment, particularly in the latter portion of the twentieth century, was one outstanding discovery that advertised effectiveness in logistics internationally. (García-Arca et al., 2020). For the purpose of promoting effective pallet usage, progress has been made to regulate box measurements according to a common standard. ISO
3394:2012 stipulates “a range of measurements for firm rectangular distribution packaging, utilizing the standardized design measurements (module) of 600 mm × 400 mm, 600 mm × 500 mm, and 550 mm × 366 mm, and it defines the layout measurements of four series (1,219 mm × 1,016 mm, 1,200 mm × 1,000 mm, 1,200 mm × 800 mm, 1,100 mm × 1,100 mm)” (ISO, 2012). The most popular ISO pallets can be utilized effectively thanks to this specification. To maximize productivity and estimate package heights depending on the number of sections, it is crucial to define vertical standards for stacked pallets. Naturally, the suggested height for stacked pallets ought to be in proportion to the beneficial inner vertical size of the conveyance means. As a rule, one item in a palletized load should not have a total height (involving pallet) greater than 2.6 m (when pallets are arranged in a stack, the highest allowed height is 1.3 m) (Comesaña-Benavides et al., 2020), but could be less varying on the balance, safety, and features of the goods (ECR Europe, 1997; AECOC, 2012). This criterion is established upon maximizing the utilization of trailer trucks and the measurements of their freight space.

2.7.2 Intermodal Container

An additional remarkable invention that has advanced logistics productivity is the creation and expansion of the intermodal container. Similarly, to the adoption of palletizing, the uniformity of the container model has played a crucial role in the growth and establishment of container conveyance. At present, the 6,10 meters (20 foot) and 12,19 (40 foot) meters containers are the most frequently encountered and acknowledged according to the ISO guidelines (ISO, 1999). Moreover, besides the regular criteria, exist other measurements with varying volumetric capability, such as the 45-foot extended container or the "Tall Cube," which utilizes the 40-foot foundation, but has an increased height of 9.6 feet."), according to García-Arca et al. (2020). In order to facilitate the emptying and filling process of containers by gantry cranes, it is recommended that deep well cars remain without a top cover and be specially designed to handle high-cube 40-foot containers, which will ensure a smoother and quicker transfer of goods from the container to the deep well car and vice versa (Haferkorn, 2020). Regrettably, the harmonization of these measurements has been carried out without any correlation to the regulated uniformity of pallets.
In reality, some of the baffling features of logistics regulation, has been the inadequate or missing synchronization between container and pallet lawful merits, founded on a commutable idea. It has resulted in the inability to load typical European pallets, as well as those with American origin effectively into any of the previously mentioned containers, leading to poor utilization of space. Consequently, it is frequent for containers to transport boxed cargo rather than stacked pallets. This final aspect implies that one must manipulate the spatial spectrum of the boxes (along with their corresponding capacity) to discern the options that optimize container usage (maximizing fill capacity). Often, provided that it does not compromise goods safety, the packages can be pivoted within the container to enhance utilization of the accessible area. Additionally, European short-sea routes have seen the development of ‘pallet-wide’ containers in recent years, which are 2.4 inches wider than standard containers, providing the same internal width as a road trailer (2.44 m), and thus having the ability to accommodate the same number of pallets (Ballis & Golias, 2002 stated by Monios & Wilmsmeier, 2014). The internal capacity of this innovation has been developed in a way, to maximize the palletization of all the space. Sadly, not all docks or pathways offer these containers, and chartering them is also far more costly.

2.7.3 Parcel Packaging

One of the trends associated with the current logistic transition is the growth of e-commerce, which is continuously changing the retail scope in terms of the traditional shopping behavior of the customers (Cherrett, 2022). As a consequence of the e-commerce growth, the dynamic market has increased the demand for home deliveries, which has led to increased challenges to the last mile leg, both on the forward and reverse logistics. The pandemic has also changed the traditional high shopping streets, leaving huge stores no choice but to change their format into smaller size stores (Wang & Hu, 2016). The trends such as free next and same day deliveries are just increasing the negative impact on society in terms of congestion, emissions, and other externalities. The key issues with the last mile deliveries do not lie in the weight of the packages, rather the volumes, the size of the parcels and their variety that make last mile logistics difficult (Cherrett, 2022). Furthermore, there are additional challenges with accessing the curbside, which as quite significant freight loading/unloading space is the reason behind the thousands of dollars
for parking fines yearly worldwide. As the operations of the last mile delivery have been and are in high density, it has stressed the question of how those can be done differently. In respect to the changes in the last mile services, as from being parcel deliveries only, they have become the so-called extreme instant deliveries (Wang & Hu, 2016). Although it has fundamentally altered international mobility, it still competes with the other retail channels such as the actual shops. The unexpected rise and progress of this new channel has brought about fresh issues and logistics approaches, requiring the reorganization of numerous procedures, specifically those relating to safeguarding, distribution, managing, and reverse logistics.

The majority of the "e-commerce" movement is handled by parcel delivery providers, which have quite divergent challenges than the packaging in the industries previously discussed. To assure prompt distribution and navigate past logistical issues, express cases are frequently used in online retail for bringing commodities to consumers. According to Wang & Hu (2016), express packaging is composed of outer packing, internal fillers, and an express waybill, and is characterized by miniaturization and lightweight design, as well as a destructive casing style to prevent damage and theft. These authors expressed their opinion about the main issues related to express wrapping. Some of the concerns include excessive packaging, non-green supplies, non-recyclable casing, low uniformity, as well as exceeding actual needs, leading to resource waste and ecological issues (Wang & Hu, 2016). The packaging system employed for products sold both in physical shops and online can differ, with specific packaging usually necessary for online sales (Pålsson, Pettersson, & Winslott Hiselius, 2017). As found by Van Loon, Deketele, Dewaele, McKinnon & Rutherford (2015), e-commerce's ability to cause climate change was greatly influenced by the quantity and kind of casing utilized. Pålsson (2018) describes the types of packaging used in retailing, both in e-commerce and in actual stores (see Figure 5):

| Primary packaging, consumer and sales packaging |
| Casing which is in contact with the item, and the one that consumers usually bring home |

<p>| Secondary packaging - involves a particular number of primary packages |</p>
<table>
<thead>
<tr>
<th><strong>Tertiary packaging</strong> - Involves a number of secondary packages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transport packaging</strong>, industrial, distribution, bulk casing</td>
</tr>
<tr>
<td>Packaging that facilitates handling, transport, safeguarding of a number of primary packages in order to provide efficient production and distribution, as well as to prevent physical handling and damage during distribution</td>
</tr>
<tr>
<td><strong>Group packaging</strong> – created to facilitate protection, display, handling, and/or transportation of a number of primary packages</td>
</tr>
<tr>
<td><strong>Display packaging</strong> - Same as group packaging, often with an emphasis on display features</td>
</tr>
<tr>
<td><strong>Shelf-ready packaging</strong> - as group packaging with special emphasis on the design to fit in retail stores</td>
</tr>
<tr>
<td><strong>Used packaging</strong> - packaging or packaging material remaining after the removal of the product it contained</td>
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The various terms used in recent research and common usage are outlined in Figure 5. While distribution casing concentrates on organization performance, sales casing prioritizes upon the advertisement and purchaser-associated legal constraints. Shelf-ready packaging (SRP), which should be simple to identify, open, regenerate, dispose of, and purchase, can be put on stands without needing to be reprocessed and is handed over to merchants in a prepared-to-sell item (Pålsson, 2018). Additionally, it must have readily accessible signs, straightforward details, and uncomplicated directions for use. Once being opened, the box's look and level of craftsmanship
should not alter. Moreover, the main casing should be simple to select without having an adverse effect on the SRP or the main casing after selecting it.

From a safekeeping perspective, associated to the secondary tier, once an item is taken from its initial casing and put into a divergent one intended for the last mile delivery, it declines its safeguarding given by the initial packing. The lack of safety means that filling or stuffing must be added to provide extra shielding, which obviously increases the volume (and weight) of the new boxes (García-Arca et al., 2020). This has also affected the transition within distribution centers. Due to the need to organize various core wrapping kinds inside a new package while minimizing space and weight, the selection procedure in storage facilities has grown increasingly complicated. The necessity to group various goods kinds also occurs when utilizing pallets or containers, even if the range of categories for express deliveries is larger and must be completed more rapidly.

From the standpoint of the environment, the realization that more massive compartments are going through processes, and that a disproportionately large portion of their size and weight is used for padding and safeguarding indicate that both the assets they use and the waste they generate are rising (García-Arca et al., 2020). The growth of e-commerce has caused the market to become increasingly volatile, which has raised demand for home deliveries and exacerbated obstacles for the last mile segment of reverse logistics.

An appropriate packaging (usually and ideally the initial one) is needed since the return processes for electronic retail frequently begin at the consumer's residence to safeguard the goods as they are being delivered back (Pålsson, 2018). It would be suitable to have a variety of cartons accessible for selection in this technological environment, allowing for rapid, flexible, and environmentally more effective adaptation to suit the demands of the various requests (in terms of resources, trash, and transit). Nevertheless, this study has mainly focused on increasing the awareness of the potential benefits that can be gotten from modifying the packaging shape and kind in order to make it more effective and environmentally more efficient (Pålsson, 2018). When the three tiers of packaging's structural changes are minimal, such a method is typically adequate. What emerges, though, when that formation's secondary casing needs to
comprehensively adapt with every order? Moreover, having a wide range of package designs readily accessible might make it difficult to take advantage of economies of scale. Unifying the types of packages available can therefore increase sales, but it may have the opposite impact when conveyance or the natural world are considered since it does not make the most of the capacity of the package used for gathering of all ordered items and thus, must be filled with stuffing. However, unified shapes in terms of standard assist when digitizing certain logistics procedures such as collection and handling (Comesaña-Benavides et al., 2020). Therefore, a proper expanse evaluation ought to decide whether it is more efficient to use a variety of box kinds that maximize volume while requiring a small batch order when purchased, or to use fewer kinds that are more common and have better batch orders when purchased but perform worse in regard to distribution and ecology (Comesaña-Benavides et al., 2020).

Delivery rates in carrier firms that provide package delivery are usually calculated in categories based on weight boundaries, travel times, and the quantity of packages (Pålsson, 2018). However, both the volumetric weight and the actual mass of the package must be identified so as to correctly calculate freight tariffs, where volumetric weight refers to the "extra space" that the products occupy in a vehicle or aircraft, and it seeks to account for transports in which the volume of the packaging is proportionally bigger than the actual weight (García-Arca et al., 2020).

2.8 Recommendations for Maximizing Space Utilization in Road Transportation and Approaches for Raising the Loading Rates

There is a big difference between the private and the public perception of the freight regulations in road transportation. The increase of the e-commerce trend has drastically changed customer behavior in terms of expected availability and fast and instant deliveries, which have a high impact over whole supply chains (Browne et al., 2018). Due to the attractiveness of the urban areas, where the customers consume increasingly the demanded goods and services, freight is a core activity, as well as in construction in the more advanced and the developing countries (Browne et al., 2018). The shippers are funding the carrier’s services, and in return expect that the carrier will meet his demand, in terms of quality and time. The transport providers are aiming
to meet the demands of both shipper and the receiver, by handling the distribution. The carrier’s perspective is reasonable because they do everything in their power to meet the demands. The space utilization in road transportation is highly associated with the last mile delivery, as the picking, loading and emptying points are of great importance for the retail companies, transport operators and carriers (ibid). Even if there is a ban on private cars in some areas, the freight in the last leg will always be there, due to all economic activities, such as restaurants, business offices, store retailers and so on.

The carrier’s efforts to meet demands involve struggling with the inconvenient infrastructure, the lack of collection/unloading areas, low level of security, bad working conditions, delivering parcels on multi-floored buildings and so on. Some commercial districts have loading zones or underground parking, unlike the residential areas that are not designed even nearly for the freight activities or the increased home deliveries (Sanchez, 2022). The high commercial activity does not depend only on the high number of establishments, but also the type of merchandise that gets delivered. Also, the regulations for access to a low emission area in terms of vehicle type and time are not making the deliveries easier, as many carriers coming to a greener area are also not well informed of these zones (ibid).

The biggest challenge for the carriers is the lack of the delivery and collection space, which is the reason for causing the thousands of parking tickets yearly, which carrier companies are willing to pay, thinking that meeting customer demand would justify the costs (Dablanc, 2008). This influences the way carriers are utilizing the space capacity within the delivery vehicles, as not having proper loading, and unloading areas increases the lack of efficiency and poor utilization. Possibly having a back door, the deliveries to supermarkets, for instance, might be much better organized than those to a coffee place or a restaurant, where in most cases, the unloading is done at the front door, or they do not have a lot of space (Yannis, Golias & Antoniou, 2006). Complying with the restrictions of the private sector probably seems pointless for the carriers, as it seems that the public sector has forgotten to include the freight in their planning (Dablanc, 2008). While the carriers are blamed, greater thought should be given to the main driver, which is the whole system, including us as customers.
On the other hand, since few decades ago, governments and researchers are discussing the ways on how to regulate the freight transport, solving the negative external social and environmental cost that lays in the complexity of different actors in the society, such as visual intrusion, safety, air pollution and noise (Dablanc, 2008; European Commission, 2006; Yannis, Golias & Antoniou, 2006). In many cities in the world, there are different regulations where it is banned to access an area between some periods, for the purpose of enabling better quality of life for the inhabitants. Thus, this would establish higher optimization of the available space in terms of space within the road infrastructure and the internal space capacity of the delivery vehicles (Dablanc, 2008). Policies are one of the solutions, according to the authorities, which limits the logistics operations in terms of time restrictions, vehicle characteristics, weight regulations, and environmental zones. The solutions can be found in the technical aspect, where new environmentally more efficient innovations and loading/unloading equipment can be implemented.

Associated with these findings, some solutions for maximizing vehicle utilization are found in the amount of fill percentage growth. According to the findings of the survey carried out by McKinnon, Ge, & Leuchars (2003), there exists potential for additional enhancement in the use of resources, which would increase the productive use of the transport mode capacity. In respect to this, McKinnon et al. (2003) proposed the following:

- Stockpiles can be improved by changing casing and pallet-packaging technologies, boosting cargo consolidation, and adjusting the shape and size of handling tools.
- Use double-deck transportation with two sets of pallets or roll cages more frequently.
- Lower the transport mode's conveyance capacity to correspond with the usual dimensions of the loads it conveys. Along with improving the truck's aerodynamics and fuel efficiency, lowering the transport mode height is beneficial in this sense.

According to Baumgartner, Leonardi, & Krusch (2008), digital navigation, planning, and telematics for transport modes give a significant opportunity to increase carrying components, which will subsequently improve the sustainability of freight deliveries. In addition to these, McKinnon (2010b) identified two additional strategies for increasing mode stacking: "the widespread use of greater mobility-efficient request phases", which enables buyers to select a purchasing
sequence and distribution schedule that aids in this sense and "the importance of businesses to cooperate in order to maximize transport mode capacity by sharing the space". Additionally, Pan, Ballot, & Fontane (2009), studied the impact of combining different stakeholders within the supply network for the purpose of decreasing negative environmental externalities. Finally, Jordan (2011) provides some guidelines for maximizing the loading velocity, including:

- Make the most of all the available square feet of space by loading the transport mode so that more cargo may be hauled on each journey. The heaviness that is moved might be enhanced if the truck had been filled, beginning with the biggest parts and moving down to the lightest. If no passengers are being carried, it even recommends using the chauffeur's cabin.

- The amount of room can be optimized by adjusting how the freight is enclosed or stacked. As a result, unnecessary packaging supplies should be removed to enhance the amount of cargo that can be accommodated inside the truck. Naturally, protection concerns ought to be accounted for.

- Rearranging timetables for transit will allow for as few deliveries as feasible, allowing each transport mode to haul more weight while decreasing waste from underutilized space (Jordan, 2011).

In accordance with the findings in the study by Hosseini & Shirani (2011), the strategies mentioned in their paper can help transport companies to increase their loading factor or fill rate. To accomplish greater quantities of occupancy percentage, the research specifically highlights the significance of gathering quick and precise details, streamlining deliveries, adapting resources according to needs, and taking supply use for the goods and casing design into consideration. While pointing out the potential drawbacks of Forwarder's 1 decentralization method and close partnerships with transport operators, it also gives examples of how Forwarder r2 has put some of these approaches into practice, such as designating an accountable individual in terminals for the purpose of ensuring maximum fill rate and purchasing double-deckers. The authors argue that in order to increase efficiency, Forwarder 1 might profit from centralizing some decision-making, while emphasizing the significance of information sharing for the goal of increasing the fill rate (Hosseini & Shirani, 2011).
3. Research Methodology

3.1 Illustration of the Research Steps

Figure 3.1 “Research Steps” provides an illustration of the research journey that we undertook from beginning to end. It describes the line of work that will be presented in the following chapters.

Figure 5: Research Steps, Source: Own, 2023.
3.2 Thesis Breakdown

The thesis journey started with the preliminary research that helped us define the desired purpose of the thesis. The purpose itself was expressed in the form of the problem definition, which later resulted in the formulation of the research question. Therefore, we structure our work in two different ways. First, we began with the informal pre-study, where we raised questions and searched for potential sources of research material. In the meantime, we met stakeholders from the Logistics, Transportation, Retail and Supply Chain industry, who participated in discussions and answered questions that contributed to narrowing down the scope of research and finally, making it possible to focus only on our research questions.

Second, we used all the information from the pre-study as the foundation of the main study. The main study was developed by accumulating the theories around the desired topic and placed in a controlled environment where we saw how in line were the theories with the reality that the logistics industry is phasing.

3.2.1 Pre-study

If one were to think of the structure of a preliminary study, one can easily associate it with the design of an exploratory research (De Vaus, 2001). Explanatory research inquiries generally commence with "how" or "why," with the purpose of clarifying how or why a formerly analyzed phenomenon occurs. Moreover, this type of approach delves into research inquiries that have not been extensively explored, and the initial findings typically establish the basis for subsequent examination.

It is quite a different thing to be able to develop explanations about the phenomenon you try to study and contribute to defining the research design (De Vaus, 2001). The main starting point is the lack of past data and in most cases is informal and without a defined structure. In the present paper the pre-study serves the purpose of an exploratory study, where we went through literature research, internet, observations, and discussions. The literature research consists of various theories around transportation, logistics and regulations of loading capacity both on Local
and Global level. The observations were made by choosing different freight forwarders and carriers, by gathering information on how they construct their work and routes. Last but not least, we went through theories and regulations about road construction, vehicle weight limitations and trucks’ weight load.

3.2.2 Main Study

The main study was structured in a different way from the pre-study and was treated as descriptive research. Descriptive research refers to a research method that involves describing and summarizing the attitudes and characteristics of a phenomenon, with the purpose of creating a profile of a given situation (De Vaus, 2001). It is frequently utilized to acquire essential comprehension of a given subject and develop assumptions for more intensive examination (De Vaus, 2001). One of the main reasons for choosing descriptive research is because it can provide answers to questions like “who”, “what”, “when”, and “how”.

For us to be able to create a holistic view of the investigated topic and gain an in-depth understanding, we chose as our main research methodology to focus on qualitative research. By focusing on qualitative research, we avoided the need to analyze a vast amount of statistical data, but rather focused on interviews.

3.3 Qualitative Research

Qualitative research is defined as an interpretive and naturalistic approach (Denzin & Lincoln, 2011). Bell, Bryman & Harley (2022) found that qualitative research is highly suitable for comprehensively exploring and comprehending attitudes and experiences through data collection modes, including observations and interviews. Therefore, this method is effective in identifying patterns and trends, leading to ground-breaking insights. One of the main advantages of qualitative data is the fact that they are normally temporal and understood only within the context that they are associated with and usually those findings come with a high degree of validity (Collis & Hussey, 2021: 130).
One of the main advantages of conducting a qualitative approach is its less standardized and more flexible manner (Potter & Hepburn, 2005) that allows for a more naturalistic observation of the subjects in their natural environment (Flick, 2022). This can help to provide a more authentic representation of their experiences and perspectives, as it allows participants to speak more freely and express themselves in their own unique way. By conducting research in this manner, researchers can gain a deeper understanding of the complex and multifaceted nature of human experiences, which may be difficult to capture through more standardized methods (Bryman & Bell, 2011). Additionally, this approach can help to build rapport between the researcher and the participants, which can facilitate more open and honest communication, leading to richer and more meaningful data (Flick, 2022).

3.4 Data Collection & Analysis

3.4.1 Primary Data

Since we have decided on conducting our research based on a quantitative approach, the most common method of collecting qualitative data is by interviewing a number of participants. To get a better workflow we strived to build a rapport between the researcher and the participants as an important aspect of qualitative research. By establishing trust and developing a positive working relationship with the participants, researchers can create a safe and supportive environment in which participants feel comfortable sharing their thoughts, feelings, and experiences (Bryman & Bell, 2011). This, in turn, can facilitate more open and honest communication, leading to more detailed and nuanced data that can provide a deeper understanding of the phenomena being studied (Packer, 2010). Additionally, building rapport can also help to minimize the influence of potential biases and power dynamics on the research process, as participants will be more likely to share their perspectives freely, without fear of judgment or repercussion (Bell et al., 2022).

The number of participants is limited due to time, access, budget, and sample size constraints.

The researchers interviewed:
● Packaging engineer, from the automotive industry, who specializes in packaging design and regulations.
● Inbound logistics specialist, from the automotive industry, who specializes in shipment of products.
● Operation manager, from the retail industry, who manages the packaging and shipment of items on a daily basis.
● Freight Forwarder specialist.
● Regional Transport buyer, who specializes in carrier contracts for shipments on a global level.
● Road Construction engineer, who provided us with insight about the vehicles’ weight limitations, by region.
● Social media retailer, who sends packages on a frequent basis.
● Employee at Retail store.
● Employee at PostNord.

The interviews were semi-structured to provide the participants with the freedom to express their opinions and experiences (Bell et al., 2022). As a result of the tight schedule, the researchers interviewed the participants through separate online sessions using Microsoft Teams and Zoom, or in person for those participants who could meet in a live setting. There were different sets of questions for the participants, as they came from different departments and industries. The reason behind it was to capture in detail the differences or similarities between the space utilization in truck deliveries.

3.4.2 Secondary Data

For successful research a properly formulated theoretical framework is needed. In the present paper there has been used a plethora of secondary data, which according to Bryman (2016) secondary data are data collected previously and published either in a book or an article. The collection of secondary data was made through the use of online platforms such as Google Scholar and Gothenburg’s university internal online database that can facilitate the research in other external databases such as Wiley Online Library and Elsevier. Moreover, the physical library
of the university was used for acquiring physical books and other publications that were possible to be found in printed format.

3.4.3 Data Analysis

For the analysis of the acquired qualitative data, we used Microsoft Excel to group and categorize the information into two main groups; those related to packaging dimensions, specification and expansive space inside them and transportation. After we grouped the data, we coded them so they can fit in theoretical frameworks and create the foundation of the following chapter “Empirical Findings & Discussion”.

3.4.4 Reliability and Validity

The concepts of reliability and validity have been embedded in empirical research since the early days of scientific practice (McDonald, Schoenebeck, & Forte 2019:4). Reliability describes the consistency and extent to which results can be reproduced and be consistent, while validity is the part that focuses more on the level of accuracy of the method used (Fitzner, 2007). In other words, when we refer to validity each time, we assess a phenomenon the study gives the same result. After all, fluctuations and inconsistent results can undermine the strength of the findings (ibid).

Generating credible and trustworthy findings, with practical applications in a study, can be ensured by strong reliability and validity, which are essential factors that warrant valid and reliable results (Bryman & Bell, 2011). On the other hand, though, the two concepts of internal and external validity are fundamental to developing a trustworthy research design, since research should be both internally and externally valid (De Vaus, 2001). Internal validity is important for demonstrating that the observed relationship between variables is the result of the involved parameters and excludes alternative explanations. While external validity refers to the extent to which results from a study can be generalized beyond the particular study (De Vaus, 2001: 27-28). Therefore, in this paper we will focus on external validity, which implies the degree
to which the results can be generalized to be applicable to other settings and groups (Fitzner, 2007).

3.5 Study Limitations

The study limitations are connected to the sample size, since our interviewed participants were only eight people. The mode of transport was limited to road transportation via trucks, while a better understanding of how empty space could be utilized better could have been gained if other modes of transportation were included. The region of activity is limited to participants located in the area of Gothenburg and Swedish contractual agreement experiences. Time constraints are connected to limited time for data collection and data analysis, that under different conditions might impact the accuracy of the results. The study setting was restricted to real-world conditions from either the Retail or Automotive industry. The sampling bias is connected to the participants' background and the potential of them not representing the larger population (mode of transport vs. industry). Lastly, as a data collection instrument we used a semi-structured questionnaire that provides the participants with the freedom to express their ideas and feelings but can be perceived time consuming from the participant’s point of view and difficult to analyze and code the responses, since the data are qualitative.

3.6 Ethical Considerations

One of the most important aspects of the present report was the ethical considerations (Bouma, & Ling 2004) that we kept in mind during the gathering of data, their process and presentation.

The report aims to present what is actually happening in the transportation field in relation to space utilization in urban freight shipments and if possible, to find ways to maximize that space by making sure that no harm would involve those who willingly participated in our interviews, nor any violation of their rights was indicated.

All information was obtained with the verbal consent of the participants, by protecting their confidentiality and avoiding any harm or discomfort to the interview participants. Any unethical
behavior was avoided because that type of display by the researcher can compromise the validity and trustworthiness of data that is collected (Cacciattolo, 2015).

Moreover, Cacciattolo (2015) supports that research that is conducted in settings where participants are non-native speakers of English can involve additional ethical reflections for researchers, as a result of cultural boundaries, translation issues, perceptions of power and authority. In the present study, in order to avoid any issues of this nature, we transcripted the interviews and asked from the participants together with a native English speaker to go through the interviews and provide us with feedback, in case they agreed with the answers they provided us with. As a result, we avoided cases of deception, privacy and confidentiality breach.
4. Empirical Findings & Discussion

Before jumping to the presentation of our empirical findings, it is important to name our participants in order for the comprehension of the narrative. To respect their animosity the names are just for reference and not their real names.

Pernilla - Packaging engineer, from the automotive industry, who specializes in packaging design and regulations.
Nathan - Inbound logistics specialist, from the automotive industry, who specializes in shipment of products.
Maria - Operation manager, from the retail industry, who manages the packaging and shipment of items on a daily basis.
Tomas - Freight Forwarder specialist.
Oscar - Regional Transport buyer, who specializes in carrier contracts for shipments on a global level.
Nicholas - Road Construction engineer, who provided us with insight about the vehicles’ weight limitations, by region.
Anna - Social media retailer, who ships packages on a frequent basis.
Eleni – Employee at Retail company.
Olof – Employee at PostNord.

Since the whole concept of this study was inspired by road transportation, it was natural for us to start our exploration from the first interview with Nicholas, who is a civil engineer specialized in road construction and maintenance. He told us that while planning a city the authorities need to have in place regulations concerning the maximum weight constructions can carry. If there were no limits, then highways and local streets would have been damaged all the time. The reason behind it is not only linked to higher costs of reparations but to minimizing the accidents that might occur. This of course is in line with the weight constraints mentioned by McKinnon & Edwards (2010), regarding geographical imbalances in traffic flow, that in turn mitigate the risk to the public infrastructure.
As a second topic of the data collection, was the packages themselves, which contribute to the way trucks are loaded. Furthermore, we got feedback from employees working in the Retail industry but also a PostNord employee, which is the Swedish post office. Maria, who is an Operations manager at Inditex, together with Eleni and Olof, were the ones who participated in this second round of interviews. Stores with an online presence in the current market have the option of home deliveries. When Monika and Eleni were asked about the difference sizes of packages, they both explained that there are box packages of different sizes, three to five types, depending on the store and their articles, and envelope packages. For example, at Eleni’s work environment they use small, medium and large, while at Maria’s they have five types of box packaging and one package option that resembles an envelope. While there are no strict regulations on how items should be packed, the employees try to fill the boxes up to their maximum. As argued by Grönman et al. (2010) the creation of modularized boxes can drastically contribute to the optimization of the fill rate in trucks. On the other side, having a wide range of package dimensions makes it difficult to take advantage of economies of scale (Comesaña-Benavides et al., 2020).

However, there are cases where packaging of a specific size is not in stock, and the employees are obligated to use another size of packaging, which in most of the cases is bigger and this contributes to the excessive quantity of air transported between the store and the final consumer. Of course, this is only one of the examples where the human element together with bad planning, leads to higher expenses for a business unit. By not having regulations in place or a way to monitor business interactions, then the impact of overpacking into the environment, as mentioned by Zhang & Zhao (2012) and Shi et al. (2018), is seen as land field waste, depletion of resources and increased pollution.

What was mentioned by a few of the participants is customer satisfaction, which comes with faster deliveries, and this can be seen when freight forwarders are booking vehicles when they have not reached their full capacity. This information came from Maria and Eleni, who work in the Retail sector and trucks are being loaded once per day and it does not matter if there are not enough packages to be shipped. Since pickups are arranged, they should be respected. Browne et al. (2018) raised the concern that the increased e-commerce trend has drastically changed
customer behavior in terms of expected availability and fast and instant deliveries, which have a high impact over whole supply chain.

Moving to the interviews from the automotive industry, the situation remains the same. In one of his answers, Oscar stated that carrier companies are booked based on frequency of shipments. That frequency though can affect retroactive potential customers, since cargo couriers might decide to change their customer base and that can impact the fill rate (Molina-Besch & Pålsson, 2015). For example, plants have a specific schedule on shipping parts. While the volumes and quantities of items needed may vary, the shipping frequency remains the same. In other words, the truck is booked and will transfer the items from point A to B, regardless of if it will be a full load or not.

Another set of questions that Oscar participated in were related to payment terms. While booking for a shipment, carrier companies are using their software to calculate the available space, routes, and prices charged. What is interesting to mention is the fact that if the carrier company has the ability to book a return journey, when the charged price is lower, rather than in the cases where they do not have a confirmed booking, and the vehicles are running empty. This occurs as a result of the lack of collaboration between the different carrier companies. Which in turn, shows that carrier companies always have their expenses covered.

Continuing on the topic of packages, we had an interview with a packaging engineer (PE). Pernilla explained to us how packages are made. According to Sjöberg & Eriksson (2020), packaging is comprised of various stages, including primary packaging, which displays product information and provides initial protection, secondary packaging for transit and protection of the first layer of packing, and tertiary packaging, which is adaptable for pallets and transit packages, presenting the final safety layer during freight mobility. Each industry has its own specifications and needs. Some examples include the food industry where the materials should be selected carefully and be toxic free. In the pharmaceutical industry the size of the packaging depends on the medication itself and how it should be preserved. In the automotive industry it depends on the sensitivity of the product, the size and the distance carried. In some cases, they create single packaging for spare parts, or they create durable packaging that is expected to be used on a regular basis. In
the retail industry the packaging is focused on appearance and the sizes are custom made, but with few alternatives. According to Pernilla the Pes do not have any power over orders they get, but what they can do is try to find new material and solutions when it comes to packages level of recycled material, but that is a factor that needs to be approved by those who place the orders, since they are the ones who will cover the cost of production.

Last, we had the interview with Nathan and Tomas. In this daily routine Nathan has to coordinate shipments of a category of products (i.e., car seats) and needs to respect a timetable defined by the manufacturing plants and their assembly lines. Since different car models have different car seats, the suppliers who produce them are located in different areas globally and that is why they have ongoing contracts with carrier companies or freight forwarders.

Tomas, who is a freight forwarder, has a responsibility to transport goods of any nature, in a fast and safe manner. In order for him to do so, he uses a software that analyzes and calculates the costs, available space and route for a better service. When Tomas was asked about the frequent phenomenon of empty running, he explained that is something that they cannot avoid. If their main focus is customer satisfaction, they need to choose speed over trucks full capacity. This is something noticed on a global level, where the main focus of carriers is to do everything in their power to meet the demands of both shipper and receiver (Sanchez, 2022) by creating empty runnings and maintaining them.

Moreover, companies get paid, so it is not an issue of a financial loss for them, rather for the customer. There are also cases where the customers do not wish to share the space of a truck, due to their product's sensitivity and they carry the cost for a full truck. But if there were different guidelines in place, where the goods safety would have not been compromised (Jordan, 2011), then loading rates would increase and charging prices for customers would have been lower. On the other hand, for Tomas to be successful, their logistics network needs to be competitive but, in the meantime, they do not have collaborations with their competitors, and that is something that he hopes to be altered in the future.
5. Conclusions

In today's society where consumers are used to having their orders shipped in a short time, it is necessary to see under which conditions those deliveries are carried out and specifically what is actually being carried out in truck deliveries. Even though there is statistical data of empty runnings it is vital to understand where those are coming from. That is why in this chapter answers will be provided to the two research questions.

The first question was “Why is there no space optimization in truck deliveries, that contributes to excess air, and which factors are influencing it?” and a simple answer would have been that carrier companies do not like to collaborate with each other and that would have been true. But is that the only reason? Unfortunately, the factors that contribute to empty running trucks and lack of space optimization are closely related to asymmetric flow of goods, packaging, packaging dimensions and the human factor. There are no regulations on how packages should be, which parameters should comply to or how much empty space they should have. Even though the tendency is to have small packages, we saw that is not always the case.

On the other hand, when trucks are booked by one customer who is willing to pay for a FTL while the vehicle is not full, carrier companies are obligated to respect the contract they have signed. We should keep in mind that carrier and freight forwarder companies offer their services with the intention of profit. Therefore, it is not as easy as it may seem. Fortunately, there are solutions here as well, but collaboration on a greater level is needed from the carrier companies. How and if this will be achieved is a scenario to be expected, since there have been small steps towards this direction by DHL and DB Schenker as logistics partners.

Moving to the second question, “What are the potential economic and environmental benefits of improving space utilization in road transportation and reducing excess air in packaging for truck deliveries?” It can easily be stated that the benefits are close to unlimited, but we want to be realistic therefore, by starting from the economic aspect, both parties can benefit by space optimization. As a result, the charged prices can be less for those who choose to use carrier companies for their goods transportation, as well as for the carriers themselves, who can have
savings by minimizing the number of routes for vehicle, vehicle amortization, and fuel consumption.

On the other hand, there are the environmental benefits that automatically will follow as a result of fewer vehicles in the streets, that will be accompanied by lower emissions and greenhouse gasses, congestion, noise pollution, and lower energy consumption. Moreover, if packages were to be improved both from a design and sustainability aspect then the environmental benefits will be improved even more, since the removal of overpacking in some industries can lead to increased free space in vehicles.

To conclude, the transportation industry is booming and continuing to increase in km traveled, which has led to increased empty runnings. To be able to see positive changes, then all involved stakeholders need to reflect on and be willing to collaborate for a more sustainable and profitable workflow. Even though the idea of collaboration among competitors seems not feasible, without taking a step towards the right direction, it will never be possible to explore the potential possibilities.
6. Future Research

From the beginning of this paper, it was clear that academic literature has not been paying much attention to space optimization, empty running or even packaging and its major role in space utilization. Even though we are putting the first stone in the right direction, we hope to see more engagement in the future. Not only from an academic point of view, but from a business optimization practice.

In an era where the pace of deliveries is increasing rapidly, being efficient is of vital importance, but speed should not be the only major factor. As was shown, speed with a pinch of collaboration can go a long way. That is why we recommend that future research should focus on developing a common platform where different carrier companies can share their logistics networks together with the demands for distance. Furthermore, one can focus on another mode of transportation and on different regions.

Apart from the perspective of space optimization, there is the excessive air in packaging together with overpacking, which is most frequently seen in the retail industry. Even though each industry has its own needs and specifications when it comes to creating packages, academia has paid little attention to how overpacking is playing a major role in truck space optimization and how we can improve that.

To sum up, there are plenty of ideas for further research, but what is more important is the reflection and actions that need to be taken by the involved stakeholders. Sometimes we focus on optimization as such, but the findings need to be accompanied by actions.
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