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MSc Degree in Production and Technological
Innovation Engineering



Future logistics solutions estimation through
LCV market trends analysis and urban freight
transport investigation

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RINGRAZIAMENTI

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TABLE OF CONTENTS

INTRODUCTION	6
ORIGIN AND MOTIVATION.....	6
OBJECTIVE AND PURPOSE.....	6
STRUCTURE	7
1 INTRODUCTION TO LCV	9
1.1 HISTORY OF LCV	9
1.2 LCV MARKET	12
1.3 LCV SEGMENTATION	14
2 URBAN GOODS TRANSPORT INVESTIGATION	22
2.1 OVERVIEW OF URBAN GOODS TRANSPORT	22
2.2 MARKET AND STAKEHOLDERS	24
2.3 DRIVERS OF CHANGE.....	29
2.3.1 Urbanization.....	29
2.3.2 E-commerce	33
2.4 PROBLEMS CAUSED BY GOODS TRANSPORT OPERATIONS	41
2.4.1 Environmental issues	41
2.4.2 Safety issues	42
2.4.3 Noise.....	44
2.5 IMPACT OF GOODS TRANSPORT ACROSS SECTORS.....	45
2.6 NEW LOGISTICS SOLUTIONS	47
2.6.1 Analysis of the solutions	48
2.6.1.1 <i>Urban consolidation centers</i>	48
2.6.1.2 <i>Electric vehicles</i>	50
2.6.1.3 <i>Load pooling</i>	52
2.6.1.4 <i>Combination of passenger and parcel delivery</i>	55
2.6.1.5 <i>Night delivery</i>	57
2.6.1.6 <i>Autonomous light commercial vehicles</i>	58
2.6.1.7 <i>Parcel lockers</i>	59
2.6.1.8 <i>Bike delivery</i>	62
2.6.2 Choice of the best solutions.....	64
2.7 LOGISTICS SOLUTION SCORECARD.....	67

3	LCV MARKET TRENDS ANALYSIS	68
3.1	METHODOLOGY AND TOOLS	68
3.1.1	Data sources.....	68
3.1.2	Methodology.....	70
3.2	LARGE VAN SEGMENT ANALYSIS.....	72
3.2.1	Vehicle body type.....	73
3.2.2	Gross Vehicle Weight	74
3.2.3	Horsepower.....	75
3.2.4	Transmission	76
3.2.5	Driven wheels.....	78
3.2.6	Vehicle length.....	79
3.3	VAN ANALYSIS	81
3.3.1	Gross Vehicle Weight	82
3.3.2	Horsepower.....	84
3.3.3	Transmission	86
3.3.4	Driven wheels.....	88
3.3.5	Vehicle length.....	90
3.3.6	Electric vehicles	92
3.3.7	Characteristics of the travel	95
3.4	LOGISTICS SOLUTION SCORECARD.....	98
4	CONCLUSIONS	99
4.1	FUTURE LOGISTICS ESTIMATION.....	99
4.2	FIAT DUCATO.....	104
4.2.1	Present	104
4.2.2	Future.....	107
4.3	FINAL CONSIDERATION	110
4.4	RESULTS.....	112
	REFERENCES	113

LIST OF FIGURES

Figure 1 - Fiat 29HP, source [9]	9
Figure 2 - Fiat 505F Van, source [9].....	10
Figure 3 - Fiat 127 Fiorino, source [9]	11
Figure 4 - Fiat Ducato x2/12 Van, source [9].....	11
Figure 5 - Fiat Panda Van	14
Figure 6 - Fiat Fiorino	15
Figure 7 - Fiat Doblò.....	15
Figure 8 - Fiat Talento	15
Figure 9 - Fiat Ducato	16
Figure 10 - Fiat Fullback	16
Figure 11 - Internal/External Length Ratio, source [23].....	105

LIST OF CHARTS

Chart 1 - European LCV Market from 1988 to 2018, source [23]	12
Chart 2 - European LCV market segmentation, 2018, source [23]	17
Chart 3 - Large Van segmentation by mission, source [23]	21
Chart 4 - Percentage of European population living in urban areas, source [21].....	30
Chart 5 - Internet use and online purchase in Europe, source [22].....	34
Chart 6 - Large Van Industry from 2013 to 2018, source [23]	72
Chart 7 - Large Van Industry, Body Mix, source [23], [24]	73
Chart 8 - Large Van Industry, GVW Mix, source [23], [24].....	75
Chart 9 - Large Van Industry, HP Mix, source [23], [24].....	76
Chart 10 - Large Van Industry, Transmission Mix, source [23], [24].....	77
Chart 11 - Large Van Industry, Driven wheels Mix, source [23], [24]	79
Chart 12 - Large Van Industry, Length Mix, source [23], [24]	80
Chart 13 - Large Van Industry, Body Mix, source [23], [24]	81
Chart 14 - Van Industry, GVW Mix, source [23], [24].....	82
Chart 15 - Van Industry, HP Mix, source [23], [24]	85
Chart 16 - Van Industry, Transmission Mix, source [23], [24].....	86
Chart 17 - Van Industry, Driven wheels Mix, source [23], [24]	89
Chart 18 - Van Industry, Length Mix, source [23], [24]	91
Chart 19 - Average daily distance covered by traveling LCV, source [23].....	95
Chart 20 - Frequency distribution of LCV travel duration, source [23].....	96

LIST OF TABLES

Table 1 - Scorecard of logistics solution based on characteristics of cities and regulations	67
Table 2 - Scorecard of logistics solution based on characteristics of future LCV.....	98
Table 3 - Logistics solutions: final scorecard.....	101
Table 4 - Logistics solutions: final ranking.....	101
Table 5 - Comparison Internal/External Length Ratio, Ducato vs Sprinter, source [23].....	105
Table 6 - Comparison loading bay width, Ducato vs Sprinter, source [23].....	106

INTRODUCTION

ORIGIN AND MOTIVATION

Thanks to my internship at FCA, I had the opportunity to work for the Fiat Professional brand. During the time I spent there, I was able to learn more about the market of commercial vehicles, their characteristics and their usages. In particular, I worked on segmentation and market analysis projects, with a particular focus on goods transport vehicles.

Moreover, during my studies and previous internship, I had the chance to explore topics related to logistics, finding them very interesting. I have learned more about logistics systems and processes, about the importance of having an efficient logistics system and how its efficiency is reflected both in the organization and in the customers' satisfaction.

I wanted to include both logistics issues and commercial vehicles analysis in this paper and, for this reason, I chose to discuss and focus on urban goods transport. In fact, this topic allows me to analyze some logistics processes, with particular focus on the transport phase, and it allows supplementing this investigation with commercial vehicles market insights to carry out a more detailed and more meaningful analysis.

OBJECTIVE AND PURPOSE

Considering that this paper discusses both logistics and commercial vehicles, it has two main objectives.

The first one concerns logistics. The purpose of this paper is to analyze urban goods transport in order to propose alternative logistics solutions that may improve the efficiency of transport while reducing its negative impacts. These solutions will be examined and they will be ranked according to their probability of implementation in the next few years.

The second objective concerns commercial vehicles used for goods transport operations. The purpose of this paper is to analyze their market to identify the main

trends, in order to define the main characteristics of future vehicles. Based on the result of this analysis, it will be possible to suggest how Ducato could improve future vehicles to keep being competitive in a market that is changing.

STRUCTURE

This paper is divided into four chapters.

The first chapter is useful to introduce commercial vehicles. It explains what commercial vehicles are and how they are divided into light commercial vehicles and heavy commercial vehicles. Afterward, it focuses exclusively on light commercial vehicles and it briefly analyzes their market, introducing the reasons behind its changes. Lastly, this chapter illustrates the light commercial vehicles segmentation, explaining their classification and the characteristics of each segment.

The second chapter focuses exclusively on urban goods transport. It begins highlighting the importance and influence that urban goods transport has over inhabitants of cities. Afterward, this chapter provides an overview of goods transport: it examines how the market is changing, how these changes are reflected in goods transport operations and which are its main stakeholders. After this overview, this chapter analyzes the forces that are pushing towards an evolution of the goods transport sector. In fact, it follows examining the main drivers of change (urbanization and e-commerce) and the consequent problems provoked by goods transport operations. Afterward, it examines the impact this evolution has across other sectors, as the public and the automotive ones. Lastly, based on the previous considerations, this chapter proposes potential future logistics solutions and it analyzes each one of them: after a brief description of the solution and of the problems it helps to solve, this chapter follows examining its main benefits, its costs, its main stakeholders and its disadvantages.

The third chapter is fully dedicated to the analysis of available data, and it begins explaining the methodology and tools that will be applied. Afterward, the chapter analyzes a segment of the light commercial vehicles market, the one called Large Van segment. This analysis is essential to introduce the vehicles and their characteristics that

will be examined in depth in the following analysis. In fact, the second analysis is focused only on the vehicles of the Large Van segment that are exclusively used for the transport of goods in urban areas. After having analyzed the trends for each one of the characteristics previously introduced, this chapter concludes making considerations about the relationship between each characteristic and the logistics solutions examined in the second chapter.

The fourth chapter is the last one and it draws conclusions from previous analyses. In fact, it begins combining the results of the analysis of new logistics solutions and the results of the analysis of commercial vehicles to develop a semi-quantitative method to rank logistics solutions according to the probability of their future implementation. Afterward, it focuses on suggesting how Ducato could improve its future vehicles to follow the trends that came up in previous analysis. In fact, it examines current Ducato models to identify their main characteristics, it compares them with the foreseen characteristics of future vehicles and it provides consequent suggestions for improvement. Lastly, this chapter concludes presenting the results achieved thanks to this paper.

1 INTRODUCTION TO LCV

Commercial vehicles are motor vehicles used for the carriage of goods or passengers for hire. They are different from passenger cars, which do not transport persons for hire. Commercial vehicles are further classified by their gross vehicle weight in light commercial vehicles or heavy commercial vehicles. Light commercial vehicles (LCV) are commercial carrier vehicles with gross vehicle weight no more than 3,5 tons, while heavy commercial vehicles have a gross vehicle weight between 3,5 and 7 tons.

Because this paper will analyze urban freight transport, it is important to consider only LCV for further analyses: passenger cars are not used for goods transport, and heavy commercial vehicles are not used for goods transport in urban roads, but mainly in extra-urban roads.

1.1 HISTORY OF LCV

The transport of goods and people has always been one important element to improve the quality of life and services in cities and towns. Moreover, the possibility to move easily every kind of object and passengers allows easier connections among cities, thereby promoting their development. For this reason, commercial vehicles have had an important role, and they evolved together with the technical and technological development. In fact, commercial vehicles changed during the years to be in step with the times and to be adaptable for all users. In the following pages there is a brief presentation of the most important event in the evolution and history of commercial vehicles.

They have more than 100 years of history: in fact, one of the first commercial vehicles was the 24 Horse Power, produced in 1903. It was the first light commercial vehicles produced by Fiat, and it took its name from its engine power, which was measured in steam horsepower. It

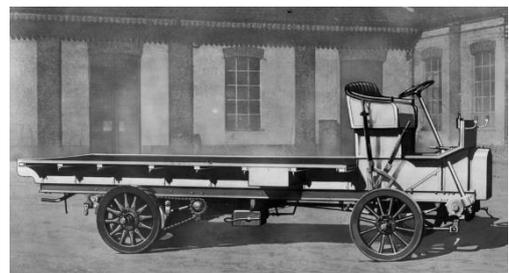


Figure 1 - Fiat 29HP, source [9]

was quite small and was able to carry up to 4000kg of goods. This vehicle was new for those times, and it was produced on a small scale, while its successor, the 18-24 Horse Power was already produced on a bigger scale.

The production of LCV had major increase between 1910 and 1920, mainly caused by the World War I: armies required new kind of vehicles, able to carry both troops and supplies, therefore greatly increasing the demand for such vehicles. In fact, during these years armies were the main customers for producers of LCV. For example, the British Royal Navy in 1910 used a military version of the model 2F (2Furgone), one of the first vehicles with a van body.



Figure 2 - Fiat 505F Van, source [9]

Commercial vehicles become to be so common that during the first years of the 1920s Italy renewed its roads, building near Milan the first road with a special lane for commercial vehicles. Another relevant year in the history of LCV was 1925 when the production of

LCV had another boost similar to the one of the WWI, when producers of commercial vehicles widened their range, offering models with different size, payload or engine capacity to satisfy different needs. In fact, during these years, companies began the production of special purpose vehicles (like ambulances, post office vehicles, fire brigade vehicles), investing more money for the production and the promotion of sales of commercial vehicles.

During the 1930s the production of LCV kept growing and models kept improving: in 1932 Fiat produced the first truck with a diesel engine, specifically designed for goods transport. During these years, LCV were able to travel on average at a maximum speed of 75 km/h and able to carry more than 350 kg.

The production of LCV had a significant drop during the first half of the 1940s, caused by World War II. In fact, during the war, some Italian cities were bombed, including Turin. As a result, a lot of ammunition factories and Fiat plants were severely damaged,

consequently slowing the production of vehicles in Italy. After WWII the production of LCV growth once again more focused on the needs of individual owners or small enterprises, more than large industries. Vehicles improved more and more, in fact during the 1960s the average maximum speed had risen to 105 km/h.



Figure 3 - Fiat 127 Fiorino, source [9]

During the 1970s producers of cars and commercial vehicles started to divide both productions, clearly separating the production of industrial vehicles from that of cars. In fact, considering the case of Fiat, the Fiat Light Commercial Vehicles brand was born in 1975.

These years were important also because they saw a growing demand for small vans for town deliveries and intercity links, both in Italy and in Europe. Important to mention the Fiat Fiorino: it was the response to these new demands, but above all, it was the first small van produced in Italy.

The market kept growing until the 1990s without any particular innovation or event. Having joined the Fiat Ducato team in my internship, I must report the year 1981, in which the first Ducato was born, which later was successful throughout Europe.



Figure 4 - Fiat Ducato x2/12 Van, source [9]

During the 1990s there was the birth of a new kind of vehicle, a more compact van with a good load capacity but a car-like driving style.

Since then, thanks to technologic improvements, vehicles have been more and more performing, becoming able to adapt even more to customers' needs. In fact, it is now possible to change the characteristics of every vehicle, as volume or length and it is even possible to change the structure of vehicles in case of particular needs, creating for example vehicles able to transport refrigerated goods.

1.2 LCV MARKET

It is necessary to consider LCV sales to be able to proceed with the analysis of the LCV market. In particular, sales that have been considered are the ones of the last 30 years (from 1988 to 2018) and referred only to the European area (all 28 countries members of the European Union).

The results of this analysis are shown in *Chart 1*.

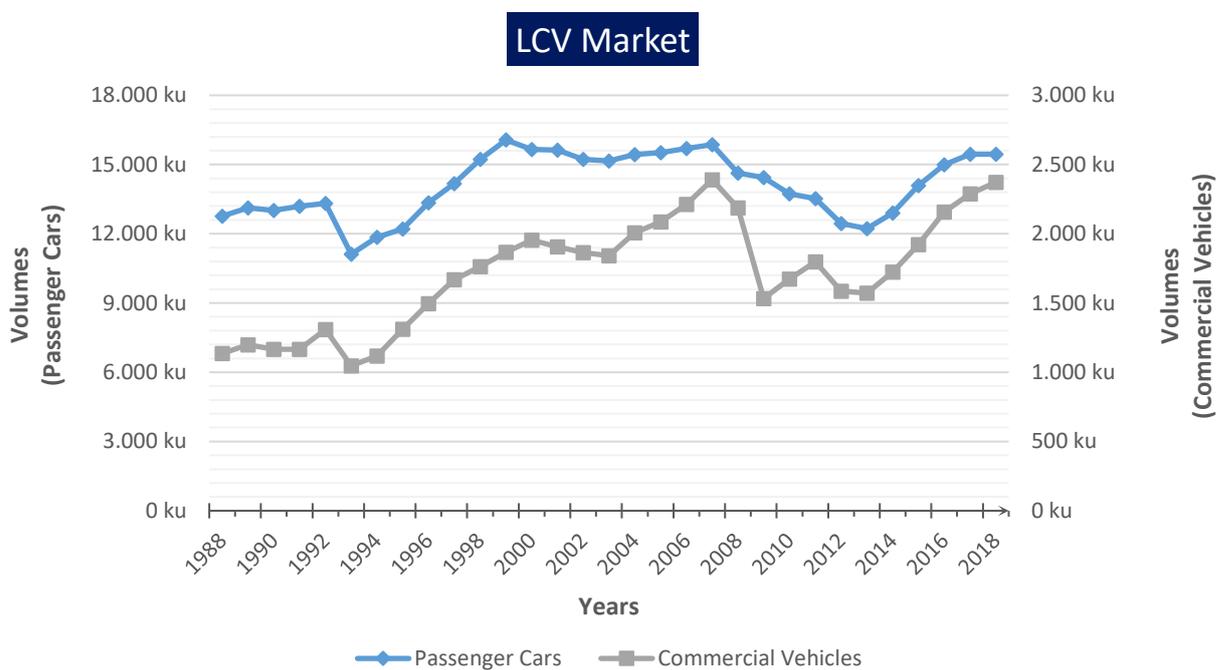


Chart 1 - European LCV Market from 1988 to 2018, source [23]

As shown in *Chart 1*, the LCV market has clearly maintained a positive growth trend.

Since 1988, the European LCV market has had high growth in the number of vehicles sold, and consequently of vehicles produced. In particular, the number of sold units has more than doubled from 1988 to 2007. There is a significant and unpredictable decrease in sales in 2008 and 2009, but this is the effect of the financial crisis of 2008. In fact, after 2009 the market has generally kept growing, maintaining its trend of growth. It is interesting to notice that LCV market had a faster recovery than the one of passenger

cars: this is explained by the fact that LCV are used for professional purposes, and therefore they are more needed than passenger cars, even in times of crisis. In fact, LCV market kept growing, reaching pre-crisis level in 2018.

The main causes of this positive trend are briefly presented below:

- Urbanization: more and more people are living in cities, requiring more vehicles intended for the carriage of passengers or goods;
- E-commerce: it causes an increase in the number of vehicles intended for the carriage of freight, considering there is the necessity to deliver all products to their buyers;
- Increase of expectation of people: people now expect better service levels, requiring sellers of goods and services to adapt using new management principles, for example arranging smaller but more frequent deliveries, therefore needing more vehicles;

The consequences of these causes on urban goods transport operation will be deeply analysed in the second chapter.

In conclusion, considering the causes of the growth of the LCV market and the cause of its anomalous decrease, it is reasonable to think the market will maintain this positive trend of growth for future years.

1.3 LCV SEGMENTATION

It is possible to divide the market into sub-groups according to different classifications to conduct more accurate analysis. These groups are called segments.

One classification of the LCV market is the one according to the dimension and type (car, van or pickup) of the vehicles. According to this classification, LCV are divided into five segments:

- Car Derived Van, which includes commercial cars derived from city cars;
- Compact-size Van, which includes commercial vehicles with small dimensions. It is further divided into Small and Large;
- Mid-size Van, which includes commercial vehicles with large dimensions;
- Large-size Van, which includes commercial vehicles with large dimensions;
- Pick-up, which includes commercial vehicles with an enclosed cab but an open cargo area;

For a better understanding of this segmentation, there will be a brief presentation of Fiat Professional vehicles, associating them to their respective segment:

Fiat Panda Van: it belongs to the Car Derived segment. It is a vehicle designed from Panda car. In fact, from the outside it looks like the size of a car, but on the inside of the vehicle it has the same functionality of a van: it does not have rear seat belts and rear seats, making space for a payload area with floor panel in the rear of the vehicle.



Figure 5 - Fiat Panda Van

Fiat Fiorino: it belongs to the Compact-size segment. It is the smallest commercial vehicle of the Fiat Professional product portfolio. It is produced thanks to the collaboration between Fiat Group and PSA Group of 2015, aimed at the reduction of



Figure 6 - Fiat Fiorino

investment costs and production costs. The project is Italian and made by Fiat, while the vehicle is manufactured in the Tofas plant, a Turkish plant owned by Fiat. This LCV is placed on the market following the same strategy of all vehicles produced by the joint venture Sevel (between FCA and PSA), which means it has Fiat, Peugeot or Citroen brand (Fiat Fiorino, Peugeot Bipper or Citroen Nemo).

Fiat Doblò: it belongs to the Compact-size (Large) segment. It is a medium-sized minivan produced by Fiat in Turkey. It has been launched into the market for the first time in 2000, while the second generation has been launched in 2009. Another important year for Fiat Doblò history is 2014 when its new aesthetic restyling has been presented at Hanover Fairground. The vehicle has a spacious interior and can be equipped to transport either passengers or goods.



Figure 7 - Fiat Doblò



Figure 8 - Fiat Talento

Fiat Talento: it belongs to the Mid-size segment. This vehicle is born in 2014, thanks to an agreement between Fiat and Renault. It was the substitute of previous Fiat Scudo, which was manufactured by the joint venture Sevel (between FCA and PSA) along with Peugeot Expert and Citroen Jumpy. It is a rebrand of the model Renault Trafic made by Fiat Professional, which is also sold as Opel Vivaro and Nissan NV300.

Fiat Ducato: it belongs to the Large-size segment. It is the largest LCV vehicle of the Fiat Professional product portfolio. The first launch of Fiat Ducato was in 1981, and this vehicle is manufactured by the joint venture Sevel (between FCA and PSA). The first generation of vehicles was sold also as Citroen C25, Peugeot J5, Alfa Romeo AR6 and Talbot Express. The second and third-generation vehicles are sold as Fiat Ducato, Citroen Jumper and Peugeot Boxer in Europe, while in Canada and the USA it is sold as Ram ProMaster since 2013.



Figure 9 - Fiat Ducato



Figure 10 - Fiat Fullback

Fiat Fullback: it belongs to the Pick-up segment. It is a medium to large size pick-up, produced thanks to an agreement of 2014 between Fiat and Mitsubishi. It is a rebranding of the fifth generation of Mitsubishi L200, and it has been manufactured by Mitsubishi Motors Thailand since 2016.

These five segments cover the whole LCV market, but they have not the same percentage of coverage. The following chart shows the division of the market in these segments in 2018.

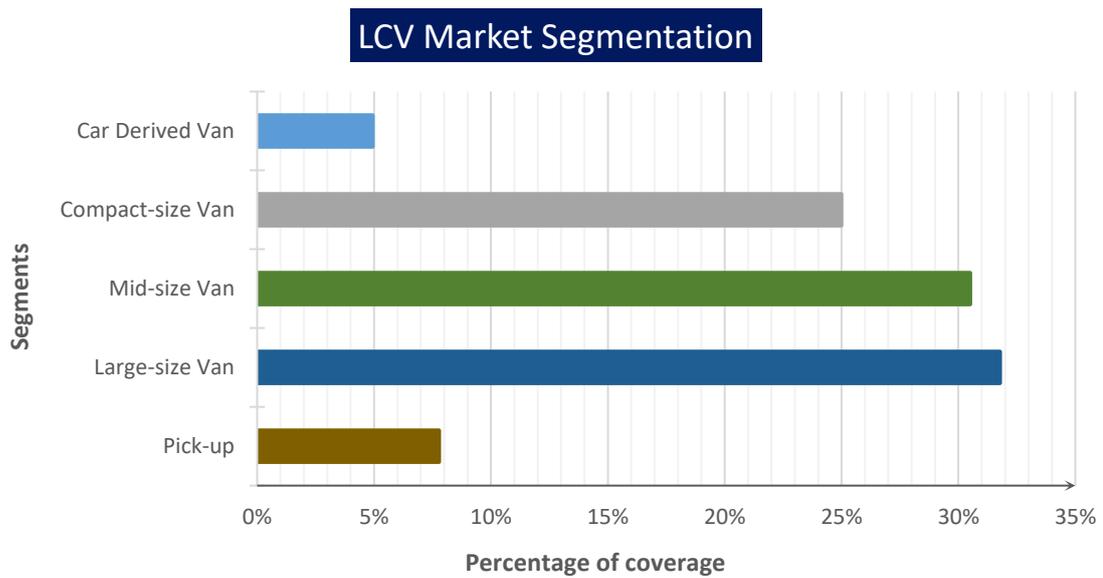


Chart 2 - European LCV market segmentation, 2018, source [23]

It is clear the market is not equally shared among these segments, because Pick-up and Car Derived van segments together cover only the 12,7% of the market, while Large-size van is the most important covering almost the 32% of the market, followed by Mid-size van and Compact-size van segments.

Being the Large-size segment the most important in the whole LCV market, all subsequent analysis will be focused only on this segment.

One important division of this segment is the one that considers the use the customer makes of the vehicle, called mission. In particular, it is possible to divide vehicles into two main classes:

- Goods transport;
- People mover;

These classes can be furtherly been divided into six subclasses:

- General haul: individuals or small enterprises use vehicles for the transport of goods and tools. In this particular case, transport activity does not represent their core business;

- Delivery: vehicles used for professional freight logistics or short-term rental;
- Construction: vehicles used for the transport of construction materials and equipment logistics to and from job sites;
- Special equipment: this category includes emergency vehicles or vehicles used by maintenance or special publics;
- Collective transport: vehicles used for passenger transport, either public or private services, and either city or intercity routes;
- Recreational: vehicles used for leisure applications, such as camping or vacation;

Going more into details, these subclasses can be furtherly divided into eighteen different main missions. General haul subclass is divided into five missions in the following way:

- Craftsmen: this mission includes workers providing little services or works, like small construction or agriculture works. Generally, these vehicles are used to reach the workplace, as in the case of plumbers, or to deliver final products to clients, as in the case of carpenters. There is a wide range of possible uses of vehicles of this mission, and generally different from each other;
- Retail and merchants: this mission includes retailers, wholesalers and sellers of finished products. Generally, workers included in this mission own a few vehicles (less than 5) or a small-size fleet (between 5 and 20 vehicles) used for freight transport in urban or suburban areas. Workers can also use these vehicles for little deliveries, even if the delivery services do not represent their core business;
- Short-term rental: this mission includes rental companies that have large motor pools with more than 100 vehicles. Different types of users use these vehicles according to their needs, and usually they rent them for short-term (days or weeks);
- Utilities (service): this mission includes workers that offer assistance or repair services, mostly at customers' houses. They can have small to medium size

motor pools. Workers use these vehicles to transport specific equipment necessary for their job;

- Utilities (municipalities): this mission includes workers that offer assistance or repair services, mostly at customers' houses. They generally have large motor pools. Workers use these vehicles to transport specific equipment necessary for their job;

Delivery subclass is divided into five missions in the following way:

- Parcel delivery: this mission includes all companies whose core business is constituted by the transport of goods. Companies have medium to large size fleets (from 20 to more than 100 vehicles) and usually they use their vehicles mostly in extra-urban areas, while urban travel represents only a little percentage of their total travel;
- Urban delivery: this mission includes all companies whose core business is constituted by the transport of goods. They generally deliver goods bought through e-commerce platforms. Unlike parcel deliveries, these companies use their vehicles mostly in urban areas;
- Food and beverage: this mission includes companies related to restaurant, catering and hotel business. Fleets of these companies have small to medium size and the vehicles are used to deliver at home only packaged foods;
- E-foods: this mission includes companies that deliver at home products (foods and beverages) bought online through the websites of supermarkets;
- Thermocontrolled and refrigerated: this mission includes companies transporting products that need controlled temperature, as fresh products. These vehicles are used to supply restaurants, bars, sellers of frozen food products, bakeries and pharmacies;

Construction subclass is divided into two missions in the following way:

- Aerial: this mission includes workers that use specific vehicles, characterized by the installation of an electro-mechanical arm in the rear part of the vehicle;

- Road maintenance: this mission includes workers that use their vehicles for road maintenance works. These vehicles must be able to transport technical equipment. Generally, workers of this mission have small to medium size fleet;

Special equipment subclass is divided into three missions in the following way:

- Waste collection: this mission includes workers whose job is the cleaning of urban centers. They use vehicles properly equipped for waste collection in urban areas. They have medium size fleets. Another important characteristic of vehicles belonging to this mission is they do not work only during the day, but they work also at night;
- Car recovery: this mission includes companies that help vehicles when they have any problem. Vehicles of this mission are used to recovery other vehicles in emergencies or vehicles that need repairing on road;
- Ambulance: this mission includes hospitals. They use vehicles to provide first aid but also for the transport of patients to and from the hospital;

Collective transport subclass is divided into two missions in the following way:

- Shuttle bus: vehicles belonging to this mission are vehicles used for the transport of people, generally for the transport of passengers between two fixed points;
- Downtown mobility: vehicles belonging to this mission are vehicles used for the transport of people, generally in city centers. One difference with shuttle buses is they have multiple stops and do not transport passengers between two fixed points;

Recreational subclass is divided into one mission in the following way:

- Camping car: this mission includes vehicles used for recreational purposes. One important characteristic of these vehicles is that they are used for less time than all vehicles belonging to other missions, but they are used more intensively;

The next chart will sum up the previously explained segmentation by mission.

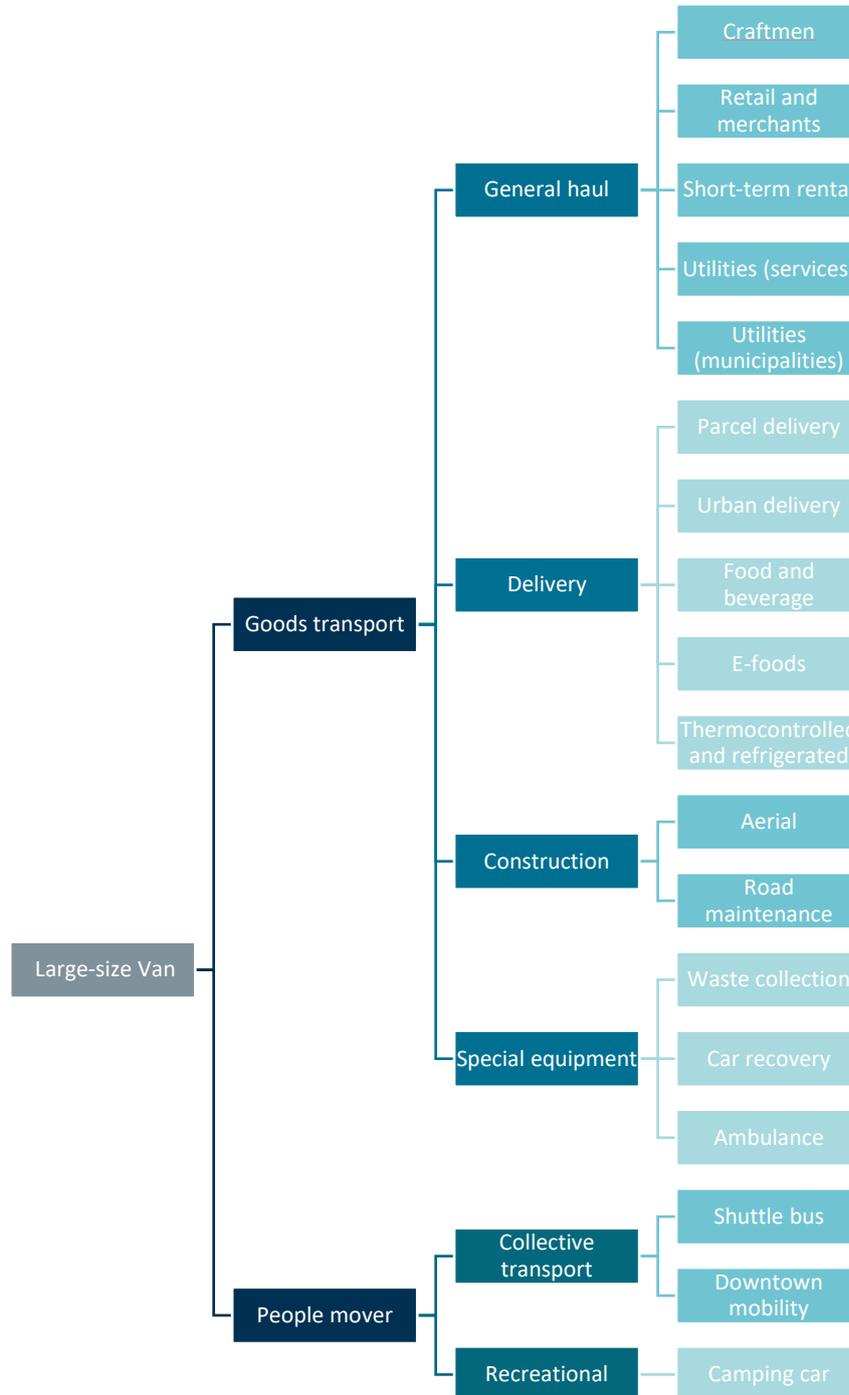


Chart 3 - Large Van segmentation by mission, source [23]

2 URBAN GOODS TRANSPORT INVESTIGATION

2.1 OVERVIEW OF URBAN GOODS TRANSPORT

Transport of goods plays a significant role in everyday life because it allows people to have an easy access to goods, like food, electronic products, furniture or clothes, coming from all over the world.

People are used to taking urban goods transport for granted, but it has a considerable impact on the definition of the quality of life, accessibility or attractiveness of the local community and it is fundamental for cities to maintain their social and economic functions.

It allows citizens to receive products directly to their house or workplace, it enables supermarkets or shops to get supplies, ensuring the availability of the products people are looking for and it permits goods to be easily moved where they are needed, enabling citizens to have access to products whenever and wherever they require.

There is growing pressure on logistics operations, as the society is changing going towards e-commerce and just-in-time manufacturing, with more and more people living in big cities and demanding quick responses from retailers. This leads to more frequent freight movements and to a rise in the number of vehicles used for urban goods transportation, with a major amount of vehicles along urban roads in order to meet more needs.

Similar to goods transport vehicles, the number of passenger vehicles is rising as well, and these trends of growth have led to a competition between both means of passenger transport and goods transport: their number keeps growing, causing them to compete among each other for the same limited space available in urban areas. There are also other problems caused by the greater number of vehicles circulating in urban roads that make this growth not sustainable in the long term, as for example congestion and pollution.

Due to the fact that both compete for the same space, people tend to prefer the means of passenger transport, because they have a direct influence on citizens daily life, unlike goods transport that has an indirect impact and therefore it is often seen from a negative point of view. There is a lack of knowledge and awareness of the fundamental role of goods transport among the general public, causing people to focus mostly on its problems rather than its benefits, like noise and traffic.

Both people and goods transportation are fundamental to define the level of the services offered in urban areas, but it is a fact that the importance of goods transportation keeps growing. It is interesting to analyze the current market and its trend to identify how it is evolving and changing, to still be able to meet new needs and respond to the growing demand.

2.2 MARKET AND STAKEHOLDERS

Before making any considerations about how the goods transport world is changing, knowing its current framework is fundamental. To have a better understanding of the problems that affect urban freight transport and the needs it meets, it is crucial the analysis of the challenges it is facing and the identification of the main stakeholders.

It is a fact that the market has evolved and changed, and the homogeneous mass market that existed years ago is not present anymore: people are now used to higher service levels and a wider offer, two factors that make customers increasingly more exigent. In fact, it is not advisable anymore planning to produce one kind of product and sell it in all markets with few modifications. Nowadays, customers are becoming more demanding: they expect and require high customization of products, with products focused on their needs and an extremely flexible delivery system. Moreover, they are used to always have access to products they want, and they have very little tolerance when they are not able to have a product for any reason, for example because it runs out of stock or, in case of an on-line purchase, because it is delivered too late. An example of this rise of expectation could be the fact the definition of “late delivery” for e-commerce sales has changed: in 2016 most of people considered as very good a delivery time within 5 days, while in 2019 most people consider only as acceptable a delivery time of 3 days. Another example is the fact there is a wider choice of products in supermarkets, and consumers are now expecting to find there exactly the products they want: they do not choose anymore on the spot what to buy, picking from the available products the supermarket has in stock, but they go there already expecting to purchase a specific product.

This rise of people expectations has led to important changes in the goods transport sector: it has evolved, passing from a “Push” market-oriented approach, in which costumers have to choose among the available products, to a “Pull” market-oriented approach with customers fully integrated into the supply chain, in which customers choose any product they want and it is logistics duty to make sure they receive them.

The foretold rise of people expectation has a huge impact on the goods transport system, but it is not only limited to this sector because it affects any firm, regardless of its industry, size or role in the value chain. In particular, it leads to further fragmentation of current markets (every consumer wants something different), which will require a continuous flow of goods to be able to satisfy the needs of every person. With more goods to be moved, freight transport has an increased importance, which puts a higher pressure on supply chain professionals and logistics operators because they are asked to deliver goods considering four new main constraints:

- Cost effectiveness;
- Speed;
- Customization;
- Transparency and visibility;

These factors are the most important ones for customers or firms, and having a balance among them is fundamental to be able to meet the requirement of both customers and firms:

- Even if cost is an important factor for consumers, it is more for sellers: to keep being profitable, they have to reduce costs whenever possible. The problem is last-mile delivery often causes a loss for the majority of retailers, because it has a much higher cost per unit: if in extra-urban transports goods may be pooled and moved all together with a low cost per unit, in urban transports this is not possible anymore and they have to be delivered in small groups or even individually, with a significant increase in costs;
- Because of the fact that goods are continuously moving and expectations have increased, fast delivery is necessary to supply shops with missing goods as quickly as possible and also to deliver the products bought through e-commerce in a short time. For the latter case, fast delivery has the double effect to please both the customer, who probably will rely again on the same e-commerce platform, and the seller, because a fast delivery could bring an additional income. According to a study [4], 25% of people will expect same-day delivery in 2025,

but for now 24h delivery is something people are still willing to pay for (around 30% of people are willing to pay a significant premium for same-day delivery, while 70% would choose the cheapest option). With an efficient delivery system, the premium for guaranteeing fast deliveries could be a huge part of income;

- Customization of deliveries is a factor more important for e-commerce customers because it allows them to receive goods wherever and whenever they want. In fact, goods transport operators are asked to have flexible delivery systems to give customers the possibility to customize the delivery, choosing where they want to receive the products and when they are available for the receipt;
- A more recent need is the one, for both customers and sellers, to track their goods and being able to know at any moment their location. This is why visibility and transparency are required for goods transport operators, because they allow customers to know the status of their orders and they allow sellers to easily track their goods in case of problems or changes in the delivery route;

Once understood the main new needs and requests goods transport must satisfy, another important analysis that has to be done is the one regarding those who are involved or have an impact on urban goods transport. In particular, urban freight transport has four key stakeholders:

- Shippers;
- Carriers;
- Residents;
- Regulators and planners;

Each of them has its own objective and needs, and it is important to notice each stakeholder tends to behave in a particular way to promote its interest. The root cause of the majority of the problems related to urban goods transport is the fact each stakeholder has needs that do not directly relate to freight transport, causing conflicts among them:

- Shippers can be considered as those who have goods to be delivered (as retailers, manufacturers, wholesalers...) for any reason, for example in case of an e-commerce sale, for the supply of a shop, for the storage in a warehouse or else. These stakeholders are generating the demand for freight transport because they are the ones who need to move some products. They have a direct interest in urban goods transport because it constitutes a fundamental part of their business: they need a fast and reliable freight transport to be able to deliver the correct products in the correct place at the correct time;
- Carriers are those who manage the freight transport: they are the ones who are responsible for the effective handling of the goods. They obviously have a direct and major interest in urban goods transport because their whole business is based on freight deliveries: they are strongly affected by changes in goods transport regulations because these changes could require them to rethink their whole business and operation system;
- Residents and consumers are the people living in cities, who will need and use goods. The problem is they are the indirect cause for freight movement (shippers generate freight demand to meet their needs) but they have little interest in goods transport because they do not perceive its importance. Not only they see it negatively, but they also expect to have always access to products they need, without even considering the problems the carriers have to overcome;
- Regulators and planners are the ones who try to regulate and set rules to the freight transport sector. They can exist at different levels, from city to country, and they have an indirect interest in goods transport because even if it does not satisfy their needs, their job is to assure a smooth movement for both people and goods;

Each group has relations with the others, and all of them play a relevant role for urban goods transport: the generation of freight demand comes from the shippers to satisfy customers' needs, and carriers operate to satisfy this demand within a framework set by planners' rules. The balance among all the stakeholders is delicate because they have different consideration of urban goods transport and a little change could strongly affect the balance. For example, if regulations result in higher advantages for carriers,

residents could complain because they could perceive this as an obstacle or a limitation for people transport. On the other hand, if rules for carriers are too strict, this could provoke delays in the deliveries of goods, leading to other complaints and to an increase in operating costs for carriers.

Freight transport is a difficult issue, because it has to operate in a complex environment, which is the result of conflicting forces, and it has to satisfy needs of multiple parts, sometimes in opposition to one another (flexibility of delivery is one example, because while customers require it, carriers would prefer a fixed delivery route in which they are able to delivery when they prefer optimizing costs, and not adapting to the needs of customers).

2.3 DRIVERS OF CHANGE

Urban goods transport is becoming more and more important, allowing people to have access to a wide range of products that was inconceivable until a few years ago. Goods transport must be able to adapt to satisfy the growing demand and to meet new needs, being able to operate in an environment that is constantly evolving and changing.

There are a lot of changes goods transport has to face nowadays, in particular over the recent years, and the most important ones are the growing urbanization and the growth in e-commerce. The latter has the major influence, and while the influence of urbanization is lower compared to the e-commerce one, urbanization is still very relevant, considering the fact that cities represent the working environment for goods transport vehicles. Another relevant factor is the foretold rise of expectation of people, but it will not be analyzed singularly: it is more interesting to analyze it in relation to both urbanization and e-commerce in the respective chapters, to have a better understanding of its effects and consequences.

2.3.1 Urbanization

Urbanization is meant as the growing number of people living in cities, due to the shift from rural areas to urban areas, consequently rising the proportion of people living in urban areas over the total population.

Urbanization is a phenomenon started in ancient times, but in the last century it has increased its intensity, passing from 7% of people living in cities in 1900 to more than 30% of people living in cities at the end of the century. 52% of the global population lived in urban areas in 2010, and according to studies this trend towards urbanization is about to continue, with more than 60% of people living in urban areas by 2030.

This shift of people from rural to urban areas is in part explained by the fact that cities can serve needs that are not served otherwise, and therefore they tend to attract more people, who can decide to establish there for a short or long period of time.

Urbanization, with more and more people living in the same metropolitan area, can lead to the development of multipolar metropolitan areas, in which there are multiple centers close to each other with almost the same importance, or centralized metropolitan areas, opposite to the multipolar metropolitan areas, in which there is only one center with greater importance. In this way, urban areas are becoming bigger, leading to a growth in traffic movements that causes multiple transport problems. In fact, it has been observed that the increase in traffic congestion is more noticeable in bigger cities than smaller cities: one example is London, in which studies show vehicles spend almost half of their time stuck in traffic jams. As more and more people are living in urban areas, these kind of traffic problems are going to be more common, and this is the reason why countries are trying to find solutions that allow to keep increasing the benefits of cities not at the expense of liveability and environmental sustainability.

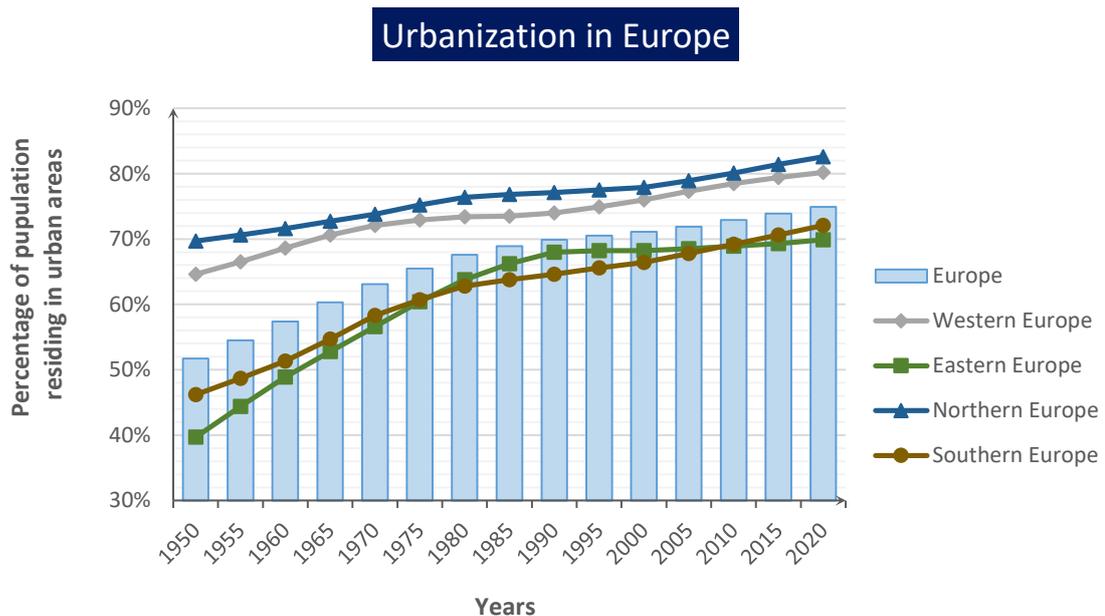


Chart 4 - Percentage of European population living in urban areas, source [21]

People living in a city have higher expectations, and considering the fact competition among logistics operators has increased the service level, customers are becoming more demanding, requiring flexible or just-in-time goods delivery: this does not offer a wide mode choice, limiting almost all urban freights to road transport. Alternative routes, for

example water transport or rail, do still exist, but they are not suitable anymore for urban goods transport if the company wants to be competitive: they do not offer enough flexibility to meet the needs required by customers. For example, service and retail establishments have complex delivery patterns possible to satisfy only with road transport.

The densification of demand in urban areas and the limitation of deliveries to road transport should lead to bigger and heavier vehicles, like tractor-trailers, to make goods deliveries in cities to optimize resources as the number of drivers or energy. The issue is that this solution is not suitable in the practical case, because this kind of vehicles would significantly increase noise, congestion and pollution, and people are having a very little tolerance with interferences with mobility caused by goods transport vehicles. Therefore, it is necessary to use smaller vehicles for limited and more frequent deliveries, to accommodate both the increased volume of freights and the expectations of people. This second solution is the one currently adopted but it has some weak points, despite being more acceptable than the first one, because it causes more traffic as a consequence of the higher number of vehicles along urban roads. To reduce traffic it is essential to make changes in last-mile distribution.

Excluding the problems already taken into consideration of the densification of demand and the rise of people expectations, urbanization has also the problem of not having enough physical space available: with ever more people than before living in the same area, cities are running out of space. The importance of this issue keeps growing, as not having enough space to accommodate people or goods could greatly affect the success of commercial activities, therefore both retail and real estate sectors take this subject very much into account. Referring to available space, one simple example is the parking space because it concerns not only goods transport but also personal mobility. In particular, due to the importance of having parking space for potential customers in shopping areas, one version of the marketing product mix considers 4+1 "P", adding a "P" for Parking to the already known 4 "P" (Product, Price, Place and Promotion). The shortage of parking space has important effects not only for citizens, because it creates discomfort at the time of leaving their cars, but also for goods transport because drivers

are not able to find a place to stop for deliveries. There is a lack of parking space reserved for freight vehicles, both on-road and off-road, and in the cases such places exist, other vehicles often occupy them: the problem, as said before, is that there is a negative consideration of goods transport vehicles, leading to poor consideration and low enforcement of regulations that protect their interests. This has consequences not only for goods transport, but also for passenger transport because if freight vehicles can not find a free space, they are forced to double park on roads when they stop for loading or unloading, causing firstly safety problems, but also disruption of traffic and mobility issues.

The problem of the lack of space in urban areas could be also intended as the missing opportunity for commercial activities to have a warehouse: especially in city centers, a common problem for shops is not having the possibility to have a storage area due to insufficient urban space. The difficulty of finding available space, also considering the fact that there are new trends of mass customization and just-in-time logistics, is pushing some stores to give up the idea of having a storage area. One example is Barcelona, where almost 70% of retail outlets do not have a warehouse. This fact is bringing new problems and adding complexity to the urban delivery system, greatly increasing the number of travels necessary to replenish the stores. For example, a medium-size supermarket would need between 30 and 35 deliveries per week, the same number of deliveries required for a big supermarket with a huge storage area.

Another problem is the one related to accessibility because it is a very common fact that cities do not have proper systems that allow many goods transport vehicles to circulate safely and fast within urban limits. One example is the lack of parking spots for freight vehicles, which has already been discussed, but another example is the imposition of access restrictions to some parts of the cities on goods transport. Delivering goods to city centers is fundamental to maintain and increase both social and economic functions of cities, but there are regulations aimed to restrict the movement of freight vehicles in city centers according to their size, weight or time, to maintain a good living environment and as an attempt to reduce pollution. Consequently, operators of goods transport are forced to change their original route to adjust their logistics systems to

available time windows in which they are allowed to enter to city centers to deliver goods. Setting time windows has the positive effect that freight vehicles are not involved with congestions for most of the day, as they are not allowed to access city centers. On the other hand, in the strict time windows in which they are allowed to access city centers, the congestion could be much worse because there are a lot of vehicles doing deliveries, considering that this solution concentrates all deliveries in a few hours, in which the number of freight vehicles on the road is greatly increased, more than distributing deliveries during the whole day.

2.3.2 E-commerce

The second main trend that greatly affects the world of urban goods transport is the rise of e-commerce.

It had an explosive growth when the Internet became more accessible and common to all: the diffusion of the Internet and the technological progress has changed the way people do shopping and it has renewed the whole retail sector. Thanks to e-commerce, people are now used to have the possibility to buy products whenever they want, it allows them to make purchases 24 hours a day, 7 days a week. People are able to shop at any time of the day, without being limited to shops opening hours. In addition to the possibility to make purchases without time constraints, another benefit of e-commerce is that it links people from distant parts of the world. This has positive effects both for customers and for sellers. Under the customers' point of view, this connection is positive because it put them in contact with almost every online seller in the world, allowing them to buy products not available in their geographical area and having access to a wider set of products. It increases the offer because customers can finally have the opportunity to choose and compare products from all available sellers and they are not bound anymore to local vendors. From the sellers' point of view, this connection has both positive and negative effects. The main one is positive because sellers are now able to reach more people, they can get in contact with potential customers they never would have reached otherwise, regardless of their locations. While this connection has only positive effects for customers, for sellers it comes with a little side effect, which is

that with the increased offer vendors lose their power related to the proximity with the clients: with e-commerce, the distance does not exist anymore, and the main drivers to choose a product from a seller over another are its cost and the delivery time.

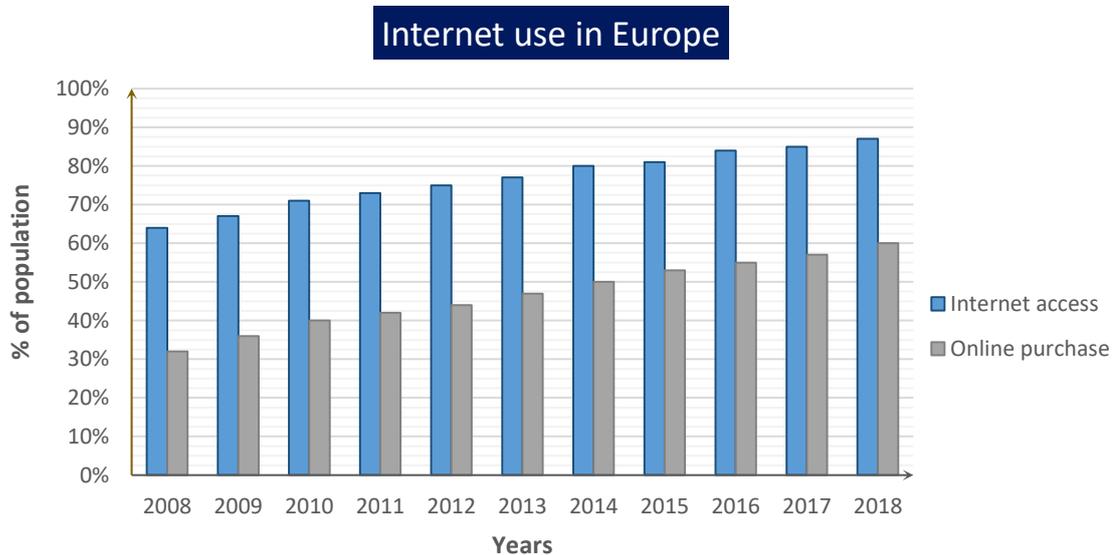


Chart 5 - Internet use and online purchase in Europe, source [22]

Another advantage of e-commerce is that people can not only buy products online, but also they can receive the products they have bought directly to their houses, and this is possibly the one considered as the main benefit. It is a clear benefit for customers because they can receive the products in total comfort, but it could cause problems for sellers because they have to arrange the delivery of the products, on their own or with an external logistics operator.

For this reason, e-commerce could be related to the traditional mail-order system: in both cases, goods are delivered directly to a specific destination, whether they are goods or mails, even if in one case people order using Internet services while in the other one they use mail or phone. This analogy is correct, but what makes a great difference between mail-order system and e-commerce is the way operations of the deliveries are carried out. In the past, in the traditional mail-order system, mail order services mostly used their facilities and personnel to do the entire administrative job, the storage, the

product selection and the delivery. With e-commerce, and its consequent strong increase in the demand, retailers are not able to arrange the delivery on their own anymore, and they tend to outsource their administrative and logistic activities to express carriers, not being fully equipped to deal with e-commerce businesses. One example is Amazon, which offers vendors the possibility to sell, deliver or even store goods for their part.

The fast diffusion of the Internet and the rapid growth of e-commerce have led to some changes in customers' behavior: having such a wide offer, customers are not satisfied if they just find a good product because they want a product that perfectly fits their needs. For this reason, there are changes in the market, which has evolved going toward mass customization and focused integration.

The role of customers has grown enormously, and due to the fact that the market is requiring more and more customization, designing the products considering the voice of the customer is something necessary and not just advisable anymore. It is possible to apply the same logic to the supply chain: to achieve the reduction in the delivery time required by the consumers and to be prepared to organize quicker processes and faster deliveries, the integration of the customers in the supply chain is fundamental. If the customers are more involved in the supply chain, a company can be more competitive: the knowledge of the consumers' behavior is something very useful, because it allows companies to make a prevision about future needs, anticipating not only which products consumers are more likely to purchase, but also predicting when they will buy and where they will need them. This is an important help in planning logistics activities because it allows logistics operators to be better organized and to anticipate their work. For example, they can already move the products that are more likely to being bough closer to the customers, so that at the moment of a purchase there will be a lower delivery time, being the products already close to the customers.

The main purpose of having the consumers integrated into the supply chain is that it helps logistics operations, allowing an effective movement of goods even before a real sale, reducing the lead-time and obtaining a competitive advantage.

An important consequence of the diffusion of e-commerce and the integration of customers in the supply chain is that the flow of the supply chain has become more time-sensitive, requiring faster and reliable goods transport and delivery in order to respond quickly to varied and variable customer demand. This is the reason to explain why the industry of Logistics is the one that has had the biggest impact from the rise of the Internet and e-commerce.

To illustrate this, one example could be the number of supply chain transactions generated by one of the major e-tailers in December 2016, during the Cyber Monday.

“In 1 day, a reported 426 orders per second were generated from the website throughout the day. That equates to over 36 million order transactions, an estimated 250 million picking lines at the distribution centers (DC), 40 million DC package loading scans, 40 million inbound sortation hub scans, 40 million outbound sortation hub scans, 40 million inbound regional sortation facility scans and 40 million outbound delivery truck scans. Assuming 200 stops per parcel delivery truck and 300 packages per truck, there were about 122,000 delivery trucks involved that made 24.5 million stops generating 24.5 million proof of delivery transactions and 24.5 million shipment confirmation messages.”[5]

These numbers highlight how big the impact of e-commerce on the goods transport sector is, considering that more than 100.000 trucks have been necessary to deliver the goods people have bought in just one day in just one e-commerce platform.

An important consideration to make is this impact is not equally shared between extra-urban or urban goods transport, but it is far greater for the latter. As discussed before, there are more people living in cities, who needs goods and to whom the goods have to be delivered, and this situation makes the urban delivery system more complex because it adds a lot of variability to the delivery pattern, even without considering what it has already been addressed before (citizens' complaints, regulations, infrastructure...). The situation is different for extra-urban goods transport because, even if it is true that a higher number of vehicles is required, extra-urban transport does not have all the

problems and complexity of urban transport, being much easier and having the big advantage being more standardized and subjected to less variability.

With focus on urban goods transport, it is possible to identify four main effects caused by the growth of the Internet and e-commerce.

In fact, there are four principal effects e-commerce has over urban goods transport, that are:

- An increase in both goods and services demand;
- A higher level of demand for freight transports;
- A better utilization with improved productivity of freight transport vehicles;
- A reduced number of supply chain delays;

These four effects are caused by several reasons. It is possible to analyze each effect to identify its main causes.

- The first one is the effect of the combination of a few causes. One is the wider choice of products consequent to the fact, as explained before, that e-commerce allows people to get in contact with almost every seller in the world. Another cause is the decrease in administration and business transaction costs because sellers have a reduced number of expenses due to the fact that they no longer incur in some additional costs, such as the management costs of a public shop;
- The second one is caused indirectly by the increased sales of products. Thanks to e-commerce, sellers are now able to reach more markets but they have to arrange the deliveries of sold products. This increased volume of sales, and consequently of deliveries, has led to the birth of many logistics companies, that compete among each other offering their services at a lower cost and increasing the offer for such services, due to the fact that there is growing demand;
- The third one is the consequence of better routing software and improved scheduling of deliveries. In particular, the unit cost for goods delivered can reduce, thanks to the combined effect of the improvements mentioned above such as the lower cost for transport services and better loading of vehicles (which

with the increased number of goods to be delivered can be fully loaded more easily);

- The fourth one is caused by the possibility to have better management of the whole supply chain, obtaining more reliable and more frequent data useful to evaluate its performance;

The influence of e-commerce on urban mobility is not only limited to these four main factors, but it has also side effects. In fact, e-commerce has provoked a renewed interest in reverse logistics. Forward logistics means the operations to move the goods through the supply chain, from the producer to their destination, generally customers or distributors. Reverse logistics is meant as the opposite process, in which a product is moving from its typical final destination going steps back in the supply chain.

This increased role of reverse logistics has a huge impact on the single carriers, on the management of the inventory and, indirectly, on urban mobility itself.

This renewed interest for reverse logistics has been a consequence of one of the three principal pain points e-commerce have had according to customer experience:

- Safety of payments;
- Order tracking;
- Reliability and characteristics of products;

All of them have already been relieved:

- The initial little confidence towards online transactions and e-commerce platform has been overtaken by more regulations and safer payment procedures. Anyway, this pain point has no impact on logistics, so it will not be examined in greater depth;
- Customers get anxious if after having made an online purchase they have no further notice about the status of their order. They want to know its expected delivery time and its location at any time. This has been solved requiring operations to be more transparent and visible. This has a huge impact on logistics, but it has already been discussed before;

- An important problem for e-commerce customers is the one they can not see the products for themselves and this could provoke missed sales. For example, they could decide not to buy shoes or clothes because of the impossibility to try them on and check how they fit, or they are not sure about the size or other characteristics of the product. In fact, without seeing an item for themselves, people can decide not to buy anything because they have not checked it and they are not sure about the convenience of the purchase. This pain point has been relieved offering customers the possibility to effortlessly give back the purchase and easily get a refund: in this way people buy even if they are not sure and then decide how to proceed, and the unavailability to check products is no longer blocking sales;

The last solution causes the problem of devolutions management, which creates the necessity to have an efficient reverse logistics system.

With a high number of devolutions, carriers' work has changed: if before they had a simpler job, now their tasks are more complex. In the past, their delivery-cycle was generally more standardized: they started the cycle loading their vehicles recollecting products from fixed locations, they continued delivering the goods to various destination and they ended the cycle with empty vehicles, ready to recollect goods for other deliveries. Now it is different, because they have to constantly load and unload their vehicles, and there is not a clear difference between the two phases anymore: they have to deliver goods while at the same time they are recollecting the devolutions. With this method, they end up having an empty vehicle on a few occasions, because with this continuous flow of goods delivery moments are mixed with recollecting moments. This brings more limits and complexity at the time of setting the travel route because it has to be planned considering the different type of stops (deliver or devolution) and also considering the loading volume of vehicles is limited and has to be shared between products to be delivered and products that have been returned.

Another consequence of the rise in reverse logistics operations is the fact there is an increased flow of goods: in addition to the moving goods that have to be delivered to

customers (with forward logistics), there is a consistent number of moving goods that have been returned (with reverse logistics). The reverse logistics role is more important than one could believe, because it has been estimated that people return more than 30% of the products bought online, generating significant traffic (for the brick-and-mortar sector, the percentage of devolutions is lower, around 8,9%) [11]. Due to the fact people are now able to buy online any product they want and can return the ones they do not like without any relevant consequences, the number of goods that are moving in cities has greatly increased, even if the effective number of sold goods is lower.

2.4 PROBLEMS CAUSED BY GOODS TRANSPORT OPERATIONS

As discussed before, freight transport has to face new needs and try to manage the problems caused by a more demanding class of customers, improving their operations. While these problems can be solved internally with more efficient processes and good planning, there is another class of problems, the ones caused by goods transport operations with policy implications at a national and international level, more difficult to resolve.

In particular, these problems are:

- Accessibility and congestion, which have already been examined in *Chapter 2.3.1*;
- Environmental issues;
- Safety issues;
- Noise;

These problems can seriously hinder freight transport, so it is crucial to keep considering them in the definition of new transport solutions and in the planning of operations.

2.4.1 Environmental issues

In recent years, there has been a new interest in environmental problems, such as emissions and air pollution. This has led to the search for new technologies aimed at the reduction of pollution generated by vehicles: this improvement is more visible for passenger vehicles, which now use environment-friendly fuels, but it less visible for goods transport vehicles. The fact is that many freight vehicles are old and they still use older technologies, like diesel engines, causing them to be more prominent as an environmental problem.

The main air pollutions are carbon monoxide and dioxide, nitrogen oxides, sulfur oxides, suspended particulate matter, and volatile organic compounds.

While freight transport vehicles are a little part if compared to people transport vehicles, the problem is that they have a major contribution to total transport emissions. For example, the contribution of freight transport to total transport sulphur oxides is 43% in London and 32% in Marseille. The situation is worst for suspended particulate matter, because the contribution of freight transport is 61% in London and 32% in Marseille. Regarding nitrogen oxides, freight transport vehicles contribute for 28% in London and 42% in Marseille [1]. Therefore, reducing emission for goods transport is an important matter.

Another important issue is that urban goods transport is contributing to critical global sustainability and environmental problems:

- Climate changes, because they are strongly influenced by carbon dioxide and greenhouse gasses (as nitrogen oxides and sulfur dioxide) emitted from goods transport vehicles among others, as shown above;
- The overexploitation of natural resources;
- The dumping of waste materials, for example oil and tires;

Another fact is the huge contribution of freight transport to carbon dioxide emissions is made worse by the fact that emissions from transport activities have increased, while emissions from other human activities have decreased.

These are the reason why improving sustainability and reducing emission for freight transport are objectives of every government, because the current situation is no longer sustainable, even considering the number of freight vehicles is rising. That has a huge impact on freight transport because governments expect it to reduce its environmental negative impact.

2.4.2 Safety issues

Accessibility problems and a lack of interest in policymaking for urban goods transport can be the indirect causes of safety problems. For example, as already examined, the lack of parking space for freight vehicles can lead to the loading and unloading of double-

parked vehicles, increasing the danger for operators and the risk of an accident because other circulating vehicles do not expect to find an unforeseen obstacle on the road.

Freight vehicles sometimes tend to use transit residential streets to avoid congested roads, but in this way they circulate on streets in which they are not supposed to, greatly increasing the risk of accidents: roads can be narrow and there would be a lot more pedestrians compared to truck roads. There is evidence that the accident rate for freight vehicles in urban areas is double than that of non-urban areas.

Other dangerous situations are provoked because people are more demanding and expect fast deliveries: delivery deadlines tend to be shorter and stricter, causing freight vehicle drivers to drive more aggressively and consequently being a danger for other people. A similar situation happens even when drivers are paid according to the number of successful deliveries they are able to accomplish, causing them not only to drive faster but even to unload carelessly from double-parked vehicles, greatly increasing the risk of an accident.

A consequence of accidents involving freight vehicles is that often it ends with shedding of loads, which requires time to recollect and then it requires road cleaning. Clearly, in case of a vehicle transporting packages there are generally fewer consequences, but if the accident involves a vehicle transporting foods or beverages the time required to clean the road and to make it safe again would be longer, leading to longer traffic jams. Accidents can be also caused because of vehicles with high height range that pass under elevated structures for which they are too high, colliding with them.

A fully loaded freight vehicle has not the same agility and maneuverability of a small passenger vehicle, and this inability to stop or change direction quickly can be another safety problem because it could be more difficult for them to drive within cities at rush hours, in which drivers tend to be less cautious.

The last cause of safety problems that will be examined is the one regarding dangerous goods. In particular, there are restrictions and laws aimed at the limitation of vehicles transporting dangerous goods, that have to follow particular routes, not being allowed

to travel along certain roads. The purpose of these laws is to reduce the risk of accidents for this kind of vehicles because such accidents can have serious consequences.

2.4.3 Noise

The problem of too noisy freight vehicles is very important for urban goods transport. The issue is that delivering goods is a noisy job, because there are noises caused by tires, engines, and exhausts of traveling vehicles, but even noises caused by doors, body rattle of vehicles or resulting from other freight equipment, for example forklifts. These kinds of problems are more evident for example when vehicles are delivering goods to shops near residential buildings because, as said before, operations of loading and unloading are quite loud.

These problems are aggravated at night when residents sleep and generally are more sensitive to noises caused by moving vehicles. Moreover, goods transport vehicles are also a cause of noise in early morning hours because drivers tend to park overnight freight vehicles in front of their houses, and when their engines are started at the beginning of drivers' workday they generate a lot of noise.

This problem is very important for municipalities, because noise is one of the many indicators of the quality of life. For this reason, various cities have established decibel indicators for acceptable noise levels.

With people becoming more demanding, their tolerance for noise caused by goods transport vehicles is reducing, creating important complications for logistic operators.

2.5 IMPACT OF GOODS TRANSPORT ACROSS SECTORS

The rise in goods transport and the need for new logistics schemes have effects on many sectors, and not only on urban mobility, which has been analyzed previously.

The first sector is the public one. Governments are greatly affected by the rise in goods transport because they are asked to make freight movement sustainable and more efficient. That is the reason why governments have an important role, because they are the responsible ones to set the framework for goods transport, set its rules, establish good regulations and planning: they must create infrastructures and set incentives in order to make freight transport safer, at the same time improving the viability and air quality. Cities have to study urban planning able to accommodate transport solutions: for example, having more parking spots for goods transport vehicle, as examined before, would reduce congestion and safety risks. As another example, cities can reduce congestion if they have information over the number of commercial vehicles within their limits. This information can be acquired if cities favor initiatives as the application of smart infrastructures that obtain data when vehicles enter cities. One example is the city of New York: with more than 8 million inhabitants, the city needs lots of goods, and trucks deliver 90% of them. To reduce its problems related to this high number of trucks entering the city, New York has created the Smart Truck Management Plan, thanks to which it is possible to have data about the vehicles, knowing when and where trucks are entering the city, and rerouting the traffic accordingly with the purpose of reducing congestion. Another action cities have done to promote the use of “clean” transport is limiting the access to high emission vehicles, generating low emission zones. For example, Athens, Madrid and Paris among others have started plans aimed at the ban of diesel vehicles from their cities. It is clear governments have a fundamental role and influence over the future of goods transport.

Regulations set by governments have a huge effect on the automotive sector because they have to produce new vehicles according to the law. For example, following what said about the ban of diesel vehicles promoted by many cities, producers of commercial vehicles have to adapt, designing new electric vehicles and planning their production to

be still competitive in a market subjected to strict regulations. A positive consequence for the automotive sector of the growth of freight transport is the associated growth of the demand for commercial vehicles. The rise of e-commerce is requiring more goods transports and deliveries, which cause an increase in freight volume and consequently in the number of vehicles produced: typically, the number of commercial vehicles manufactured change accordingly to the number of freight deliveries. Another example is the fact, as said before, that cities want to track commercial vehicles traveling within their limits: consequently, this leads to the demand for manufacturers to produce new vehicles able to send their location in real-time and able to connect to each other.

Focusing only on the diesel ban and on electric vehicles as an option to keep traveling in cities, this has an important effect also on the energy sector. One positive consequence is that this could lead to an increase in profit for electric companies because the growth of electric vehicles will consequently induce an increase in electricity demand: electric companies could take advantage of the opportunity to provide charging to a high number of electric commercial vehicles. On the other hand, this increase of electric vehicles can provoke inconveniences for electric providers, causing peaks in energy demand difficult to handle and which require investments to improve local grids.

The growth of goods transport affects also the logistics sector: with the foretold increase in freight deliveries, there is a consequent increase in the demand for services offered by logistics companies. This brings new players in the market, increasing the competition. To be more cost-effective and competitive, logistics companies have to manage their assets well, to have a better organization and utilization of their vehicles. To do so, they should invest to improve their digitization: in this way, information can circulate rapidly and data can be analyzed to predict future demand, allowing companies to plan deliveries accordingly.

2.6 NEW LOGISTICS SOLUTIONS

Goods transport is a fast and challenging world because its components have to cooperate and to act rapidly, always under the push of different forces. As already examined, the methods used in the past for deliveries of goods are no longer effective. It is necessary not only to plan the routes trying to optimize utilization of vehicles but even reimagine new logistics schemes and procedures.

There are many potential solutions able to reduce drastically some of the problems related to freight transport. The most important ones are:

- Urban consolidation centers;
- Electric vehicles;
- Load pooling;
- Combination of passenger and parcel delivery;
- Night delivery;
- Autonomous light commercial vehicles;
- Parcel lockers;
- Bike delivery;

Each one of them enhances the operations of companies and it can solve at least one of the issues raised by goods transport.

It is important to notice these solutions are the ones with the highest benefit for all stakeholders and the most feasible for all kinds of businesses: they do not lower the service level of companies and are not limited to specific kinds of goods transport.

In order to make these solutions effective it is essential for a company to be able to operate in “normal” situations: it means the company has already reached a high level of organization and digitization, it is able to efficiently plan delivery routes, it has good warehouse logistics and it is able to operate reducing reverse logistics at the minimum. Applying one of the solutions proposed above in companies that do not reach these requirements could do more harm than good. For example, doing load pooling could even be counterproductive if practiced by companies that still do not have the ability to

efficiently define routes and are still not able to track their goods because it can lead to loss of freight or late deliveries.

2.6.1 Analysis of the solutions

All the solutions mentioned above will be analyzed and examined in the following pages to identify their main strengths and weaknesses.

2.6.1.1 *Urban consolidation centers*

Description: Urban consolidation centers are cross-docking locations outside city centers, but generally close to them, to which both suppliers and retailers ship their orders to be delivered in urban areas. In this way, with all the goods gathered in one place, goods can be consolidated into fewer deliveries and sent to their final destination. The best place to set an urban consolidation center is near city centers but also close to highways or other forms of transit: they should be easily accessible by vehicles but sufficiently close to the end recipients to reduce distances.

Problems solved: Urban consolidation centers reduce the problems caused by the high number of freight transport vehicles circulating within city limits, like the problem of congestion or pollution.

Benefits: Urban consolidation centers allow a full load of trucks: all goods to be delivered in the city center are gathered in one place and therefore is easier to load them on vehicles, by making use of their maximum capacity. In the current situation, most vehicles entering cities are not fully loaded and they still have room for more cargo. Improving the utilization of vehicles with this system leads to a lower number of vehicles required to transport all the goods and therefore leads to a lower number of vehicles entering city centers. Thanks to the lower number of vehicles required, it is

possible to deliver goods even in cities that limits the number of truck allowed to enter or that impose congestion charges (like London and Stockholm).

Costs: The costs to promote this solution are high because it is necessary to create the basic structures, with new buildings and improved accessibility to such places. It is necessary to build warehouses large enough to accommodate all goods, plus making them easily accessible, considering there will be a high number of vehicles that need to stop there to deliver their freight. Set up costs can be reduced by adapting already existing buildings, as abandoned supermarkets, in urban consolidation centers, with the advantage that they are already well connected and close to city centers. On the other hand, after the initial high capital cost, costs will be lower because there will not be the need for continuous investments.

Main stakeholders: This solution does not affect directly people buying goods online because they keep receiving them with the same lead time, but positively affects people living in cities because there will be less congestion allowing them to move more easily. This solution strongly affects drivers and logistics operators because they have to change their actual processes of delivery. They no longer recollect goods from suppliers and deliver them to end recipients scattered around the cities, but they have to deliver them to fixed locations (consolidation centers). Moreover, there will be a new class of drivers, who are responsible for last-mile delivery only, delivering goods from these centers to end recipients.

Disadvantages: Urban consolidation centers are not effective for retailers that already have a storage area, like grocery stores or retail chains, because they can already consolidate their deliveries and will not

need them. It would actually be a disadvantage for them because they should transport their goods to another place when they have the potentiality to consolidate them on their own.

2.6.1.2 Electric vehicles

Description: With this solution, electric vehicles will replace all freight diesel vehicles.

Problems solved: Electric vehicles reduce the problems of pollution and noise. They do not emit the same level of particulate matter and nitrogen oxide of diesel engine vehicles, and they are very silent, reducing the noise generated by moving vehicles. They can also reduce traffic and safety problems, because electric vehicles have a faster acceleration than diesel ones, thanks to their increased torque.

Benefits: Electric vehicles can circulate in any urban area because they have permission to access even in cities planning to ban diesel vehicles (as the foretold Athens, Madrid and Paris). They are not considered as polluting vehicles and therefore are excluded by all traffic limitations caused by environmental issues. In fact, having electric freight transport now it is mandatory because more and more cities are going to ban diesel vehicles. If in the past it was just useful because it allowed drivers to access cities the few times there were temporary access restrictions to diesel vehicles, now it is compulsory because these restrictions are becoming increasingly common. If a logistics company does not use electric vehicles, soon it will be unable to deliver goods in many cities, with a consequent loss of competitiveness. One example of this is Deutsche Post, which has not been able to find on the market the zero-emission vehicles in the quantity it needed and so it bought an electric vehicle start-up and produced its own custom electric

vehicles, called StreetScooter. Another benefit is that electric vehicles are silent, and this allows drivers to deliver goods even at night time and not only during the day: the lack of noise of electric vehicles will not generate complaints by sleeping citizens, unlike diesel vehicles.

Costs: The costs of implementing this solution are high because it is necessary to replace completely all vehicles buying new ones. The battery of each vehicle has a relevant cost, but the fact that its price is reducing every year (it decreased by 35% in few years, from 2008 to 2014) makes this investment more attractive. On the other part, it is true operating expenses for electric vehicles are much lower than for traditional vehicles, leading to costs reduction in the long term [12]. Operating costs are an important part of the total cost of ownership for commercial vehicles because they are intensively used, making easier for them to reach the break-even point. It is important to consider it is easier to reach the break-even point in cities that have instituted high-cost antipollution regulations. Another important cost to be sustained is the creation of charging network systems able to satisfy the increased demand for energy of electric vehicles. This is a huge investment, considering it requires feasibility studies and enhancement of the current electric network, which has to operate even during demand peaks.

Main stakeholders: This solution influences people living in cities because they will live in a healthier environment with less pollution caused by freight transport. Owners of freight vehicles are influenced too because they have to buy new vehicles to replace their current ones. Moreover, with electric vehicles, they will have the possibility to circulate freely and to deliver goods without time restrictions. Another consequence is they will have to plan carefully their

delivery routes considering the range of vehicles: electric vehicles require a different and slower method of charge than traditional ones, and this should be taken into account at the time of the planning of deliveries. Other stakeholders are governments and electric companies: they have to create the charging network for electric vehicles, following the regulations set by governments and with the infrastructures provided by electric companies. Moreover, electric companies will have another important duty, and opportunity, to provide energy to all these vehicles.

Disadvantages: The main disadvantage of electric vehicles is the fact they have a limited range and their charge process is slower than traditional vehicles. This limits the maximum travel electric vehicles can do in one day: if traditional vehicles could almost travel without stops (just a few minutes to refuel), electric vehicles require more time to be fully charged once their battery is low. This causes the problem of the charge of the vehicles because commercial vehicles are always moving and generally do not stay idle enough time to charge their batteries (unlike passenger cars that on average stay parked 90% of the time).

2.6.1.3 Load pooling

Description: This practice applies to the transport of goods the same principle used to move people adopted by companies like Uber. This solution consists of the match of commercial vehicles with spare capacity with customers needing delivery space. Generally, this match occurs via online platforms, in which drivers communicate their spare capacity, indicating any constraints on goods they can carry (for example liquid or solid materials), the planned delivery route and the available capacity. For their part, customers indicate the goods to be shipped, their location and the destination and

time for the delivery. Having all the information, an algorithm matches both carriers and customers, trying to optimize delivery routes and charging the customer for a variable cost, depending on a few factors, like the kind of goods or the distance of the delivery. This practice is becoming more common, among logistics operators. One example is DHL that has an online platform, Saloodo!, which has 200.000 trucks available to share their capacity in more than 15 countries.

Problems solved: Load pooling helps to reduce the number of freight transport vehicles within city limits, consequently decreasing congestions and pollution.

Benefits: Under the financial point of view, this solution is a win-win situation for both carriers and customers: carriers can obtain an extra income with little additional work (the picking and the delivery of customer's goods should be close to their already planned route), while customers can deliver their goods at a lower cost (they do not need to pay for a whole vehicle to make their deliveries). It benefits carriers also because they are able to use their vehicles more intensively and with better utilization: they no longer travel with spare capacity and thanks to the algorithm matching carriers-customers every single carrier makes more deliveries within a given area. Also, it reduces the average distance traveled by goods because they no longer have to transit through warehouses or sortation centers, but they are directly picked and sent to their final destination. This reduction leads to fewer vehicles and less operating costs. There are also advantages for costumers, and the main one is this solution reduces the delivery time of goods: they are directly delivered without spending time on distribution centers.

- Costs:** This solution has very low costs because it does not require any advanced technology or important investment, not needing infrastructure. The only required costs are for the creation of the website, the database and the algorithm for the online service that matches carriers with customers. It does not require other relevant costs.
- Main stakeholders:** The most interested by this solution are logistics operators because it offers them new possibilities to deliver goods or to have an extra income. In particular, they must be aware their delivery routes could be subjected to slight changes to pick and delivery products on behalf of others. They will also have to measure the capacity left on their vehicles to let customers know they are available to transport their products, adding a new job into the delivery process. Other stakeholders less impacted by this solution are the people that use this delivery service for goods they have bought online because they will notice a lower delivery time. Other stakeholders are the workers of warehouses or sortation centers because they will notice a lower flow of products transiting through them, considering part of goods will be directly delivered.
- Disadvantages:** The main disadvantage is this solution is fully based on an algorithm that in case of errors or problems can provoke the stop of the whole system. Another disadvantage is it could lead to late deliveries: if all parts involved cooperate with each other the system works well and fast, but at the moment of one inconvenience it could create delays. For example, if the first stop of the carrier is for picking goods from its customer and the latter is not yet there or if the freight is difficult to load, this will cause a delay for all subsequent deliveries.

2.6.1.4 Combination of passenger and parcel delivery

- Description:** This solution is based on the fact passenger vehicles travel with a lot of wasted available space: the idea is to combine both passenger and freight vehicles, using public passenger transport systems to deliver goods. This system is already used in many countries: one example is the Netherlands, in which systems combining passenger and freight transport already exist, like the Amsterdam Metro. However, this system is more common and easier to implement in rural areas.
- Problems solved:** Combining passenger and parcel delivery will reduce the number of vehicles necessary to move both, reducing congestion and pollution in cities.
- Benefits:** The main benefit of this method is that it causes a reduction of circulating vehicles: it will make having separate vehicles for freights and passengers not necessary anymore, allowing to take advantage of their respective spare capacities. In particular, this will greatly reduce congestion because if both people and goods can be moved toward their destinations together, there will be just one vehicle and not two competing for the same road space. This will create a huge benefit for retailers because they will be able to deliver their goods in cities even if they do not have their own freight vehicles thanks to the fact that they can use public systems.
- Costs:** This solution has high costs because it needs an initial investment to rearrange the entire infrastructure, adapting all vehicles: they must be able to transport safely both passengers and freight, contemplating also dangerous or liquid goods. Moreover, it is necessary to adjust every station of this system to host a big volume of goods waiting for the arrival of vehicles, more than the

regular flow of passengers. Another important characteristic of this system that needs to be implemented is the creation of a fast way to load and unload vehicles because people are not willing to wait for the preparation of goods.

Main stakeholders: This solution greatly affects different stakeholders. City governments are the main ones because they have to set the rules for this new mean of transport and they are in charge of its practical implementation. This will require many studies and analysis to understand the needs of people and goods, to be able to make a prevision about the most traveled path and the volume of passengers this system must be able to accommodate. Other stakeholders are the sellers because they have now the possibility to send goods using the public system, even if they will still need other means of transport to deliver products to their clients' houses (for example in case of e-commerce clients). This solution affects also passengers of public transport because they will be transported with goods and for sure this will create changes in the way they were used to travel.

Disadvantages: The main disadvantage of this solution is the difficulty to implement the whole system, considering its high costs and the fact goods and passengers have different needs. Another problem is that goods need to be safely loaded on vehicles: this operation requires time, but people are not willing to wait and to depart later due to operations related to freight shipment. The last main problem is that this solution does not bring goods to their final destination, but only brings them closer to the customer.

2.6.1.5 Night delivery

- Description:** This solution proposes to shift goods deliveries at night, or evening hours, reducing the number of deliveries carried out during the day. It is already done in a few countries, even if it is still in an experimental phase. One example is Spain, which uses night delivery to replenish some shops in Barcelona.
- Problems solved:** It reduces congestion during the day because there should be fewer circulating vehicles, considering that most freight transport vehicles circulate at night.
- Benefits:** The main benefit of this solution is for sellers and logistics operators. At night roads are used to be much less busy than during the day, with less circulating vehicles. This allows drivers to drive faster, without the same congestion they would find during the day, allowing them to make more deliveries in less time. Another advantage is that at night they can use bigger vehicles, which are not allowed to enter cities during the day, allowing them to transport more goods and therefore using fewer vehicles. The use of bigger trucks combined with less congestion lead to a significant reduction in delivery cost. There are benefits also for inhabitants of cities because without freights vehicles on the roads they can circulate more comfortably with less congestion.
- Costs:** This solution has almost no costs, considering it will cause only a shift to deliveries, from day hours to night hours. Costs incurred are the ones to install noise-cancelling equipment to vehicles and to train operators to work silently: minimizing the noise is a priority, considering that at night it bothers inhabitants.
- Main stakeholders:** The main stakeholders are sellers and logistics operators because they have to change their delivery habits, delivering at night, and they obtain the possibility to use bigger vehicles. Other

stakeholders are inhabitants of cities because they will be able to travel during the day in cities less congested even though they risk to hear more noise at night hours.

Problems: This solution is mostly limited to B2B deliveries because difficultly buyers of e-commerce products are willing to wait at night to receive their packages. Another problem is that this system requires night workers, and the salary is higher for night hours. However, savings derived from the use of bigger trucks balance this problem. The main problem is noise: as said before, people are sensitive to the noise caused at night by freight transport, and if this system does not work silently inhabitants could complain leading to the block of night deliveries.

2.6.1.6 Autonomous light commercial vehicles

Description: This solution consists in the use of autonomous vehicles to bring goods at their final destination, where operators proceed to the delivery.

Problems solved: This reduces the problem of congestion caused by the load and unload of vehicles

Benefits: The main benefit of this system is that it reduces the time necessary to load and unload vehicles: while the vehicle is driving requiring minimal to no user interaction, the operator on-board can focus on the delivery. During the travel, the operator can already arrange and prepare the goods to be delivered or properly allocate goods that have been loaded. In this way, all products are already ready to be unloaded or can be loaded quickly, considering they will be organized at a later time. The purpose of this solution is to reduce stopping time at the minimum, therefore making more deliveries in less time.

- Costs:** The only cost of this solution is the one required for the creation of a vehicle able to drive autonomously. However, it is a significant cost because it comprehends costs for the engineering of all components, to make autonomous driving safe, and costs for the subsequent production of the vehicles. Moreover, if logistics operators want to use this system, they will have to change their whole fleet.
- Main stakeholders:** This solution affects the automotive industry because producers have to create and produce a new kind of vehicle, which is able to drive safely even without human interaction. This obviously affects logistics operators too because changing their standard delivery process, allowing operators to process deliveries during transport, leads to a reduction of set up time and therefore a faster process. Policymakers are involved too because they have to analyze and regulate the new sector of autonomous vehicles.
- Problems:** This solution has the problem that autonomous vehicles are still in the engineering phase, therefore it is not viable in a short time. Another problem is that this could not work well in cities due to the high variability of delivery routes and delivery points: the vehicles will always face different situations (different signs, new roads...) they may not be able to manage, causing the vehicle to stop and requiring human assistance. Another complication is the behaviour of other people in cities is unpredictable sometimes, just think of pedestrian or bikers, creating a safety issue.

2.6.1.7 Parcel lockers

- Description:** This solution is mostly focused on e-commerce customers. It consists in delivering products not at buyers' houses but to other

places, where there are lockers to which customers can pick up packages at any time.

Problems solved: This solution helps to reduce congestion: leaving the products in a locker, the number of failed delivery attempts decreases, therefore it is not necessary anymore to arrange new deliveries with other vehicles. It is important to consider that 20% of delivery in residential buildings fail on the first attempt, creating a lot of additional traffic [13].

Benefits: This solution has benefits for both customers and shippers. The advantages for customers are that they can select the location they prefer for the delivery and can access the locker 24/7, opening it with a special code they receive at the time of the delivery. They are not obliged anymore to stay at home waiting for the courier to deliver their products, but they can recollect them whenever they want, once the shipper has placed them in the proper locker. The advantages for the shippers are that they have fewer delivery locations, they reduce the number of failed deliveries and save time. They have fewer delivery locations, reducing variability because they no longer have to deliver to each customer, but instead they deliver to parcel lockers centres that collect the orders of many clients. Shippers reduce the number of failed deliveries because they are aware of the status of every locker (empty or occupied) and therefore they know how many products they are able to deliver, planning their routes accordingly. Reducing failed deliveries, shippers save time because they do not have to attempt again to deliver the product, but they can focus on new deliveries. The lower failed delivery attempt rate leads to fewer vehicles used for deliveries and less mileage, with a consequent reduction in costs.

- Costs:** The main cost to realize this solution is the one required for the construction of the structures that host these parcel lockers. These lockers need to be enough to accommodate all products, and they have to be sized properly, to be able to host all kinds of products but without wasting space. Another cost is for security because these lockers will contain valuable products and have to be safe enough to avoid thefts or damages. Like the case of urban consolidation centres, it is possible to adapt existing buildings to reduce costs, even if the expenses required for the implementation of parcel lockers are still very high.
- Main stakeholders:** The main stakeholders of this solution are shippers and customers. Shippers are affected because they change their delivery locations, delivering to these parcel lockers and not to many individual clients, and have to plan their routes considering the variable number of parcels available. Customers are affected because they have another option to receive their products: they can decide to receive them at their houses or receive them to one of these lockers.
- Problems:** One limitation is this solution works mostly for B2C transactions: in the case of B2B transactions, the number of missed deliveries is already very low and the direct delivery of goods is more convenient, without the need to pass for these lockers. One problem could be customers do not recollect quickly the products after they have been stored in these lockers: if they do not recollect them, the lockers will continue being marked as occupied reducing the capacity of this system. One solution to this problem could be promoting clients to recollect quickly their products, for example offering rewards or discounts. Another important problem is the location of these parcel lockers centres because they have to be in places with high foot traffic: if they are

accessible mostly by car, all the advantages (reduction of congestion, number of vehicles and consequently pollution) will be undermined.

2.6.1.8 Bike delivery

- Description:** According to this solution, last-mile deliveries are carried out by bikers instead of vehicles. Bikers are told the pick-up location and the delivery address, and then they proceed with the recollection and the shipment of the parcel. It is a very common practice nowadays, most common for food transport, with a lot of start-ups and companies offering this kind of service like Glovo, Foodora and Deliveroo.
- Problems solved:** This solution helps to reduce the problem of congestion because there will be fewer vehicles along roads, considering deliveries are now accomplished by bike. Another advantage is that the reduction in the number of vehicles alleviates the problem of pollution.
- Benefits:** This solution allows delivering goods in any place, even in places with no car access or in places with restricted access for freight vehicles, because generally bikes are not subjected to any limitations thanks to the fact that they are emission-free. Another benefit is this solution allows cheaper deliveries because a bike has less operative and maintenance costs than a motorized vehicle. The main example is the cost of the fuel, but other examples could be costs of oil, tires, insurance or the cost of repairing possible damages: in case of a bike, these costs do not exist or are significantly lower. The last main benefit of this solution is that it allows faster deliveries for short travels or travels in urban areas: bikers can follow paths not accessible by cars or

different from standard roads, and usually their delivery time is not influenced by congestion or traffic. They can follow shorter routes than the ones vehicles are obliged to follow. Another benefit could be that bikers do not need special places for the loading or unloading, and therefore they can recollect and deliver products no matter where without causing safety problems or congestion like trucks do. The fundamental advantage is that bikes allow extremely flexible deliveries.

Costs: This solution has very low costs because it does not need any special equipment or structure to work. It is necessary to contract people willing to make the deliveries and provide them with bikes. Another option with even lower costs is the one to contract people already owning a bike and pay them with a percentage of the total cost of the deliveries paid by clients.

Main stakeholders: This solution affects drivers of classic freight transport vehicles because bike deliveries could cause lower demand for such services. Other stakeholders can be inhabitants of cities, which will notice a reduction of road congestion but an increased number of bikes circulating within urban limits. Receivers of goods are affected too by the application of this solution, because they could notice an increase in the service level, being last-mile deliveries faster. Finally, also small senders of goods to be delivered within city limits are positively affected because they can quickly arrange the delivery thanks to bike couriers, which are cheaper and which need less notice than truck couriers.

Problems: The main problem of this solution is that it is not suitable for all kind of goods, but only for small and light packages: bike couriers are not physically able to bike carrying heavy products, and the volume of goods they can carry is limited to the volume of

products a single person can handle. The potential of bike deliveries is greatly limited by these restrictions because couriers are not able to deliver a big amount of goods in a single run, but have to deliver few products at a time, having to pick-up new goods every few deliveries.

2.6.2 Choice of the best solutions

All the solutions discussed above have both positive and negative effects, but it is important to choose one according to the different business of the sender company or according to the problems it is facing. Other factors to hold into consideration are the characteristics of the city, like population density or the cost of land and related taxes, and the characteristics of the customers. It is not possible to identify one solution that goes perfectly for all companies, but everyone should choose the one that fits its strategy the most.

Another important consideration is that these solutions can be combined to obtain different effects that improve the final result. Even in this case, they have to be combined considering the strategy of the company and the characteristics of the market in which it is operating.

For example, in the case of B2B, one good solution would be combining night deliveries, electric vehicles and urban consolidation centers. Generally, B2B clients order high volumes of products and thanks to the use of urban consolidation centers goods can be grouped and better loaded on vehicles. With better loading, there is a reduction in the number of vehicles required for transport. Afterward, once the vehicles have been fully loaded, making deliveries at night hours allows them to travel faster and to reduce the time for every shipment, allowing them to save time and consequently to make more deliveries. Finally, using electric vehicles it is possible to work during the night without receiving complaints by inhabitants woken up by the noise of delivery operations. It is clear the combination of these three solutions brings more benefits than each one of them taken singularly: fewer vehicles, better loaded and faster, doing more deliveries in

less time without causing complaints. This combination has benefits both for shippers and for inhabitants of cities: shippers cut their delivery costs, while inhabitants of cities can travel during day hours in less congested roads, thanks to the fact most of B2B deliveries have been carried out during the night.

Taking into consideration B2C deliveries, this combination of solutions is not advisable mostly because customers are not willing to stay awake at night waiting for the shipment of products they previously bought. In order to make this solution viable also for B2C, it is necessary to combine it with parcel lockers too: in this way, shippers can deliver and store products in these lockers at night without the need to interact with clients, allowing them to sleep rather than stay awake waiting for the shipment. The problem is that this solution is subjected to limitations explained above (for example, it is viable only for cities in which parcel lockers are easily accessible by foot).

Another solution for B2C deliveries could be combining passenger and parcel deliveries for the first half of the transport and then continue with bike deliveries or applying load pooling. Thanks to the use of the public transport system, it is possible to move goods closer to their end destination at low costs, and once the products can not be transported even closer, they can reach final recipients by bike or thanks to load pooling system. In the first case, bikers wait for the arrival of the transports carrying goods, they recollect the products, and then they make deliveries at the final recipients. It will be a short trip, considering bikers and recipients are already quite close. Taking into account the case of load pooling, the procedure would be almost the same, with drivers waiting for the arrival of goods and then loading them into their vehicles before making deliveries. These two options are very similar, but have many differences: for example, load pooling allows transporting bigger products, but on the other hand, bikers can deliver goods in places not easily accessible by car and can travel faster in case of congestion. Load pooling is more effective for bigger but less frequent deliveries, while bike delivery is advisable for smaller but more frequent deliveries.

It is therefore clear these solutions can be quite effective if properly combined, but due to the fact that every combination is suitable only for a specific scenario, it is necessary

to identify the combination that brings more benefits for the actual situation. To do so, it is essential to carry out a deep analysis of the company, the customers and the workspace. With this analysis, it is possible to know the weaknesses of the actual transport system, to be aware of the expectations and needs of customers and to identify new opportunities to improve the delivery process. Only then it is possible to choose the combination of solutions that fits the most the needs of the business, obtaining the biggest benefits and advantages.

2.7 LOGISTICS SOLUTION SCORECARD

After this analysis, it is possible to assign a score to evaluate the relation between future logistics solutions and external characteristics. As external characteristics are meant characteristics of cities, feasibility, regulations and environment. Based on the consideration made in the previous chapter, about how each solution affects and is affected by the foretold characteristics, each solution is given a grade from one to ten. One means the external environment hinders the implementation of the solution, ten means the external environment promotes the implementation of the solution. The following table reports the assigned grades.

		External Characteristics
Logistics solutions	<i>Urban consolidation centers</i>	4,0
	<i>Electric LCV</i>	7,0
	<i>Load pooling</i>	5,0
	<i>Night delivery</i>	6,0
	<i>Autonomous LCV</i>	2,0
	<i>Combination of passenger and parcel delivery</i>	2,0
	<i>Parcel lockers</i>	4,0
	<i>Bike delivery</i>	5,0

Table 1 - Scorecard of logistics solution based on characteristics of cities and regulations

The *Table 1* sums up the conclusions of the analysis carried out and discussed in *Chapter 2.6.1*, turning into a grade the observations previously made.

3 LCV MARKET TRENDS ANALYSIS

The second chapter analyzed many logistics solutions, examining their main advantages and disadvantages, costs, and obstacles to their implementation. The purpose of the analysis was to study the relationship between the solutions and the urban environment. To conduct a more complete examination of the foretold logistics solution, it is important to study also their relation with the vehicles that are actually used for the transport of the goods. The implementation of these solutions is strictly related to the development of LCV as much as it is to urban environment: for example, electric transport is not feasible until an electric LCV is engineered, even if the urban environment would be favorable.

For this reason, this chapter is focused on the analysis of the LCV market: the purpose of the analysis is to define its main trends, to understand how the vehicles are changing. In fact, understanding their changes is needed to make a prevision about future vehicles and their characteristics. Finally, it is possible to study the relation between future logistics solutions and characteristics of future vehicles, to verify if some of the proposed solutions are in line with or are promoted by the foreseen future vehicles.

3.1 METHODOLOGY AND TOOLS

The following pages will explain the methodology and tools used for subsequent analysis of available data.

3.1.1 Data sources

All analyses of this chapter are conducted considering data from different sources. Recollecting data from various sources allows the creation of a more comprehensive database, facilitating analysis and allowing to obtain more relevant and more detailed information.

The main sources of data are:

- JATO Dynamics;

- QlikView;
- Fiat Professional internal databases;
- Long-term rental company (LTR) internal databases;

A brief explanation of each one of them is given below:

- JATO Dynamics; it is a global supplier of automotive business intelligence. It was born in the middle of the 1980s when the automotive industry reached an important phase in its development when the concept of globalization reached a tipping point and automotive manufacturers felt the need to expand and develop their presence in new international territories. Automotive manufacturers use it to have a better understanding and knowledge of the market: JATO provides a big database with information about every vehicle and model, facilitating the benchmark. It allows the analysis of both current and historical market, considering its volumes, specifications and incentives data. An important feature of this program is it allows users to make specific queries, generating reports of vehicle data more detailed and more suitable for the analysis to be carried out. In the case of the analysis that will be presented afterwards, the query that has been made considered data from 2015 to 2018. It extracted registrations of light commercial vehicles and the characteristics of every vehicle sold: for example, some characteristics that have been extracted are the country in which the vehicle has been sold, the model and the related manufacturer, its length and the use the customer makes of the vehicle. One advantage of JATO is it grants access to massive data sets;
- QlikView; it is a software provided by Qlik, another provider of software for data visualization and business intelligence. One difference with JATO is QlikView does not need users to write a query and make a subsequent extraction of relevant data, but it allows consulting data faster: it is sufficient to click on a data point in its interface and it instantaneously updates all other fields based on the selection the user made. It grants access to different data from those provided by JATO. One advantage of QlikView is it grants fast and quick access to data sets;

- Fiat Professional internal databases; as internal data sources are meant all databases containing data recollected from FCA. These data are available only within the company and they are shared using the internal network. This kind of data is useful to obtain information that is more accurate and specific for products sold by the company. One example of an internal database used for the development of the analysis presented afterward is the Optional database: it contains information about vehicles sold by FCA (Ducato, in this case), associating to every sold vehicle the codes of the optional with whom it has been equipped. One advantage of this kind of database is it contains fewer but more accurate data;
- Long-term rental company internal database; this set of data was provided by a LTR company client of FCA, which offers solutions for both private and commercial vehicles. The database provided by this LTR company used for this analysis contains the data of more than 1300 vans, used for commercial purposes. Each vehicle has been monitored daily, registering its usage duration and the distance it traveled in urban roads, extra-urban roads or highways. Data have been recollected for six months and they are referred to vehicles operating in Italian territory in 2017. These data have been used for a minor part of further analyses: they have been used only for the definition of main characteristics of the travel of van (in *Chapter 3.3.7*) and not for the definition of the trends concerning their technical characteristics;

3.1.2 Methodology

To proceed with the analysis it is necessary to have a reliable and complete database.

The core of the database consists of the data extracted by JATO. This database aims to obtain a set of data containing information about the number of vehicles registered in every year, from 2015 to 2018, and the basic characteristics of every registered vehicle. The basic characteristics that will be examined in this paper are the body, the gross vehicle weight, the horsepower, the transmission, the driven wheels and the length of every vehicle. All of them will be explained afterward, in the next chapter.

One important thing to consider is that it is not advisable to limit the extraction of data to the foretold basic characteristics because the database would not be yet completed: some information about a lot of vehicles would be still missing because not available in JATO servers. For this reason, it is required to extract even other characteristics of registered vehicles to make up for the missing data and to be able to derive missing information. For example, it is possible to obtain the missing information about the length of one vehicle knowing its model and its version name, among other factors.

Therefore, JATO extraction must consider the registrations of vehicles, the basic characteristics and even “support” characteristics that allow to make up for the basic ones missing.

After having extracted all these data, it is possible to work on this database: it is necessary to obtain the missing basic information and afterwards it is possible to segment each one of the basic characteristics to carry out a more accurate analysis.

Once this more comprehensive database has been obtained, it is possible to mix it with other internal data sources and QlikView, cross-referencing information to obtain a database that is even more accurate and that will be the starting point of all subsequent analyses.

3.2 LARGE VAN SEGMENT ANALYSIS

After having considered and examined the theoretical causes of the changes in the goods transport market in the second chapter, it is interesting to verify how they reflect in the market of light commercial vehicles.

The more suitable vehicles for urban transport are the ones belonging to the Large-size segment. For this reason, all subsequent analysis will be focused only on this segment.

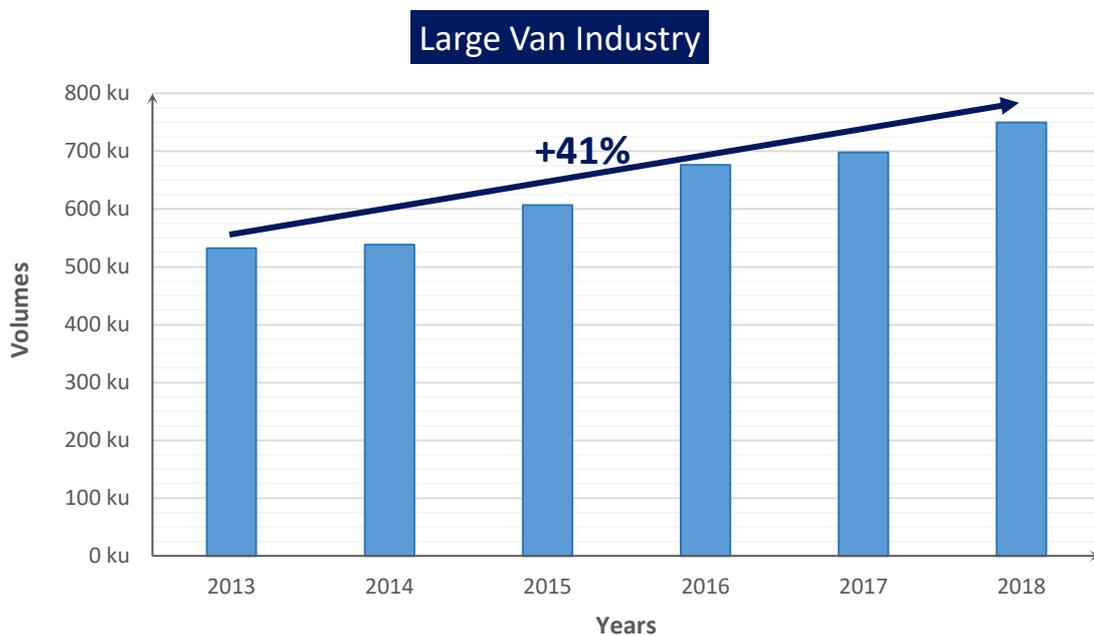


Chart 6 - Large Van Industry from 2013 to 2018, source [23]

The *Chart 6* shows the sales of vehicles in the Large-size segment in the European market from 2013 to 2018.

It is very clear that the market had an important growth, increasing by 40.9% since 2013 (and by 23.5% since 2015). This is in line with what has been stated in the second chapter, regarding the increased demand for goods transport services and the consequent greater number of vehicles required to meet this need.

As previously anticipated, the analysis of this segment will focus on:

- Vehicle body type;

- Gross vehicle weight (GVW);
- Horsepower (HP);
- Transmission;
- Driven wheels;
- Vehicle length;

3.2.1 Vehicle body type

The body type divide all light commercial vehicles of the Large Van segment in three main groups:

- Van, it includes vehicles used for the transport of goods. Vans are used for freight movement within the city, up to 4.5 tons GVW;
- People mover, it includes vehicles used for the transport of passengers. These vehicles can transport up to 9 seats and are ideal for hotels, rent-a-car companies and park-to-fly services among others. They derive from Van vehicles;
- Cab, it includes special vehicles. They are specific conversions bases for refrigerating boxes, dropsides, tippers, mobile kitchens, ambulances and many others;

The following chart represents the division of the European market of Large Van vehicles according to vehicle body type.

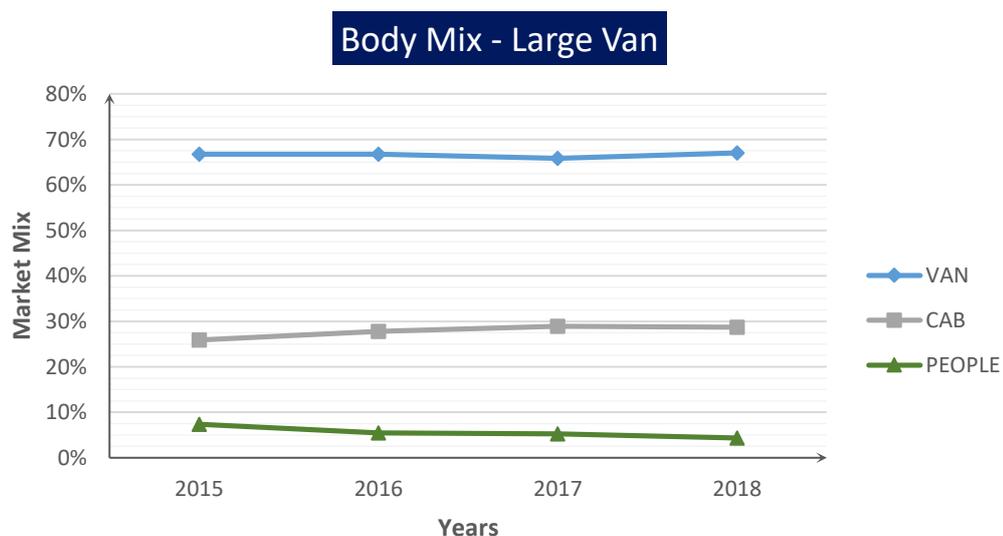


Chart 7 - Large Van Industry, Body Mix, source [23], [24]

As shown in *Chart 7*, Van vehicles are the most sold and they kept the same market share in the last 4 years. They have a stable trend. It is different for Cab vehicles: they slightly increase their market share during the years, having a positive trend. Considering People vehicles, they had a decrease in market share, with a negative trend. This is consistent with what has been explained in the second chapter, that there are more and more vehicles used for goods transport: even if Van kept the same market share for the last 4 years, this does not mean the number of sold Van has been stable. It is important to remember the related industry has grown by 23.5% during the same years, so it is reasonable to assume the number of registered Van has grown too.

3.2.2 Gross Vehicle Weight

Gross vehicle weight is the total weight allowed for the vehicle, including its curb weight, crew weight and payload weight. In the case of LCV belonging to the Large Van segment, the maximum GVW allowed is 3.5 tons. Higher GVW allows the transport of higher volumes of goods or more passengers, but it requires more powerful engines.

Because every vehicle has its own GVW depending on its conversion and customer's customization, all possible GVW are segmented in five groups to facilitate the analysis:

- “≤ 29Q”, it includes vehicles with GVW lower than to 2.9 tons;
- “30Q”, it includes vehicles with GVW greater than 2.9 tons and lower than 3.2 tons;
- “33Q”, it includes vehicles with GVW greater than 3.2 tons and lower than 3.4 tons;
- “35Q”, it includes vehicles with GVW greater than 3.4 tons and lower than 3.5 tons;
- “> 35Q”, it includes vehicles with GVW greater than 3.5 tons;

The following chart represents the division of the European market of Large Van vehicles according to vehicle GVW.

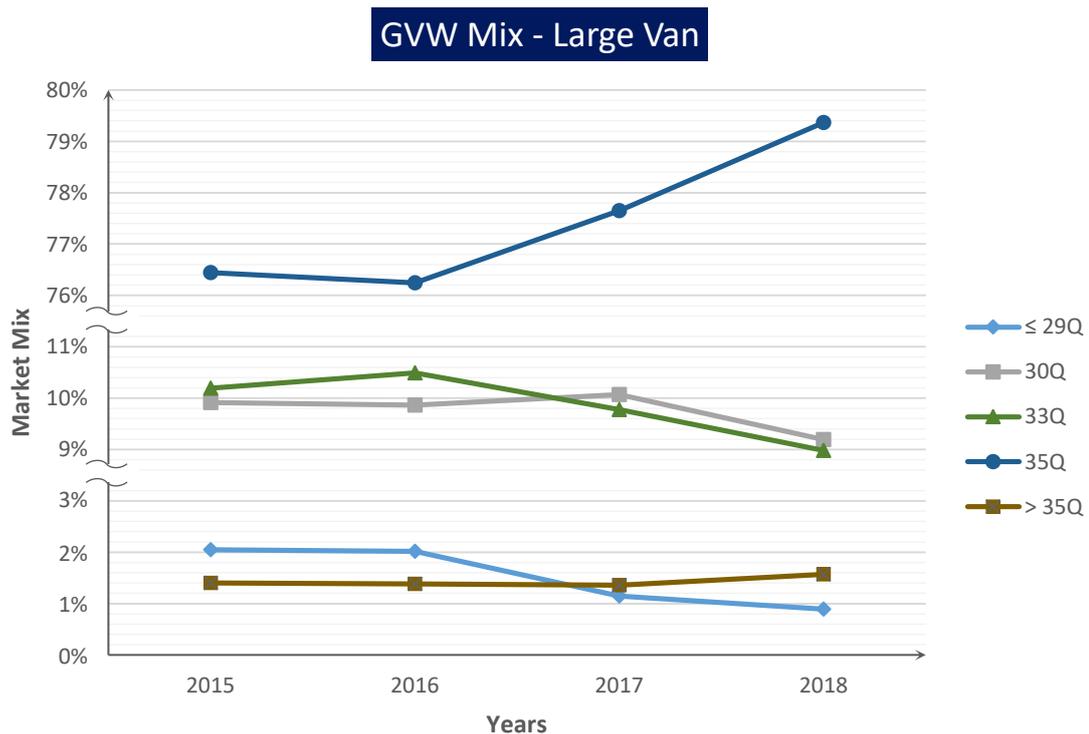


Chart 8 - Large Van Industry, GVW Mix, source [23], [24]

As shown in *Chart 8*, “35Q” vehicles are the ones with the greatest number of registrations and they slightly increased their market share in the last 4 years. While “30Q” and “> 35Q” vehicles kept constant their market share, “≤ 29Q” and “33Q” slightly decreased theirs.

3.2.3 Horsepower

Horsepower is the measure of the power of an engine. It is not the official unit to measure the power according to SI, but it is commonly used for commercial purposes.

As in the case of the GVW, every vehicle has its own HP. All possible HP are segmented in four groups to facilitate the analysis:

- “≤ 119 HP”, it includes vehicles whose power is lower than 120 HP;
- “120-139 HP”, it includes vehicles whose power is greater than 120 HP and lower than 139 HP;

- “140-164 HP”, it includes vehicles whose power is greater than 140 HP and lower than 164 HP;
- “ ≥ 165 HP”, it includes vehicles whose power is greater than 165 HP;

The following chart represents the division of the European market of Large Van vehicles according to vehicle HP.

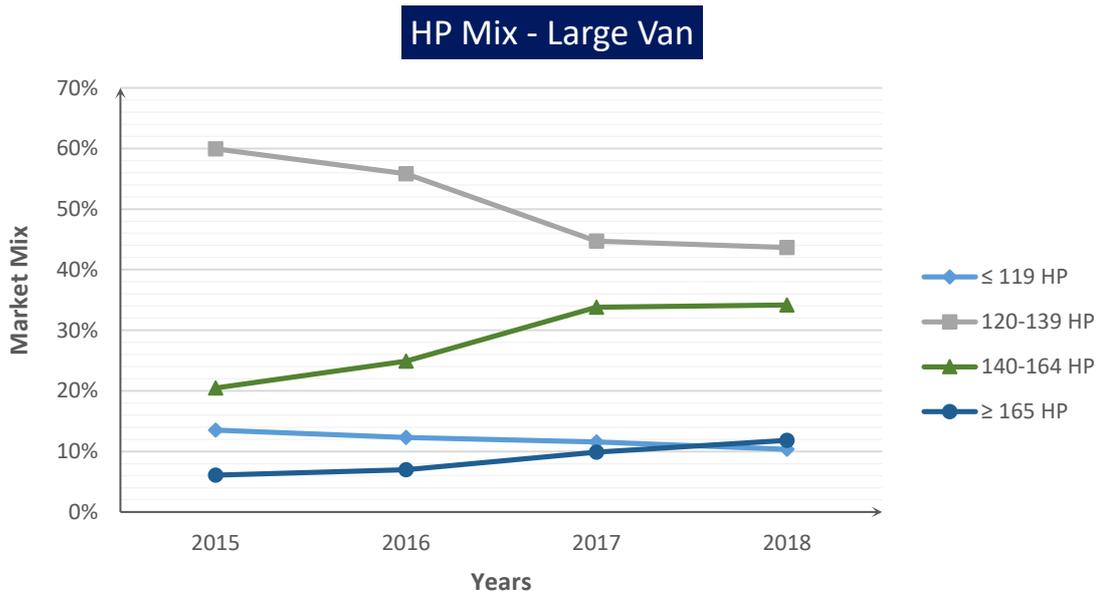


Chart 9 - Large Van Industry, HP Mix, source [23], [24]

As shown in *Chart 9*, vehicles with lower HP have reduced their presence in the market, helping the spread of vehicles with higher HP. In fact, it is interesting to notice that “140-164 HP” vehicles had almost doubled their market share during the last 4 years, while “120-139 HP” vehicles market share has decreased more or less to the same extent.

3.2.4 Transmission

Transmission for LCV can be either automatic or manual. In the case of the manual transmission, every gear change needs human actions: the driver has to perform manually all gear changes, usually using a shift lever. Instead, in the case of the automatic transmission, the transmission can automatically change gear ratios as the vehicle moves, freeing the driver from changing gears manually.

The manual transmission has the advantage to allow drivers more control while driving the vehicle because they can change gear according to their driving style. On the other hand, a manual transmission can cause safety problems while the driver is changing gear: the driver has to release the grip from the steering wheel, and this can be dangerous in case of abrupt maneuvers.

The automatic transmission is safer because the driver does not need to use hands to manage the gear, and even less stressful because, in particular in urban areas where there are a lot of stops and starts (queues, traffic lights, pedestrians...), the driver can be more relaxed not concerning about gear shifts. On the other hand, an automatic transmission could increase fuel consumption.

The following chart represents the division of the European market of Large Van vehicles according to vehicle transmission (Manual or Automatic).

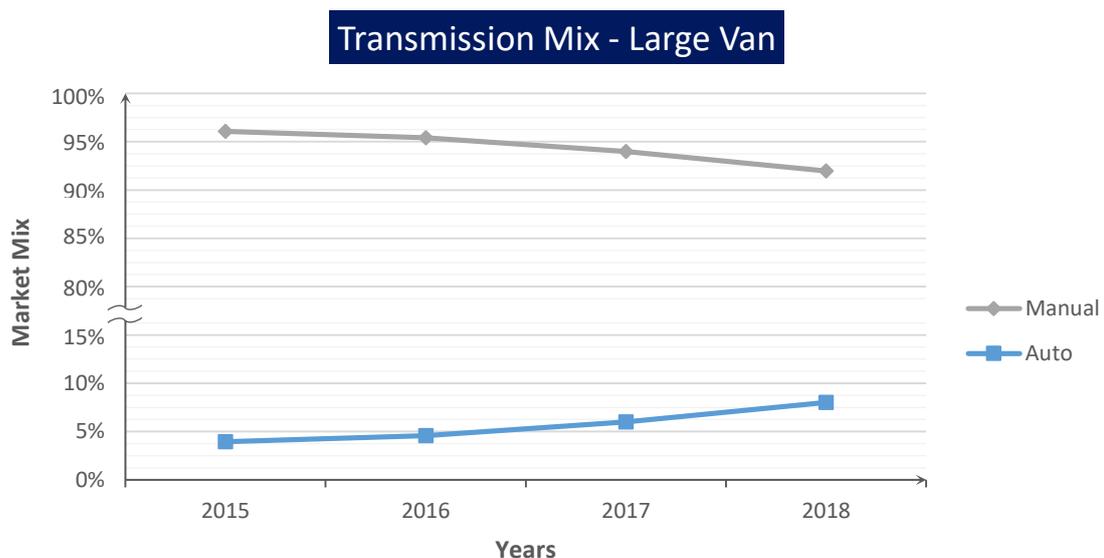


Chart 10 - Large Van Industry, Transmission Mix, source [23], [24]

As shown in *Chart 10*, while manual transmission keeps being the more common, being present on more than 90% of vehicles, it is losing market share in favour of Automatic transmission. The automatic transmission has a growth trend; consequently, the manual one has a negative trend.

3.2.5 Driven wheels

Driven wheels are the wheels that allow vehicles to move: they transmit force, transforming torque into tractive force from the tires to the road. There are three main kinds of driven wheels: front, rear, and 4x4.

Front driven wheels vehicles are cheaper because they are easier to manufacture than rear driven wheels vehicles. Vehicles are less heavy because they do not need driveshafts to front wheels, and the engine is placed in the front of the vehicle: both these advantages improve payload and they allow to have more space available in the rear, useful to transport more goods or passengers.

Rear driven wheels are more expensive because they are more difficult to produce and they need more components, increasing vehicle weight. Another disadvantage is they have the engine placed in the rear part, reducing available space. The main advantage of rear driven wheels vehicles is they are the most suitable for the transport of heavy loads: loading too much weight on front driven wheels vehicles could cause a loss of grip, while this does not happen for rear driven wheels vehicles.

The last, 4x4 driven wheels vehicles balance both advantages and disadvantages of front and rear driven wheels vehicles. 4x4 driven wheels are more suitable for vehicles that have to travel along difficult or rough roads, needing more grip.

The following chart represents the division of the European market of Large Van vehicles according to driven wheels (Front, Rear or 4x4).

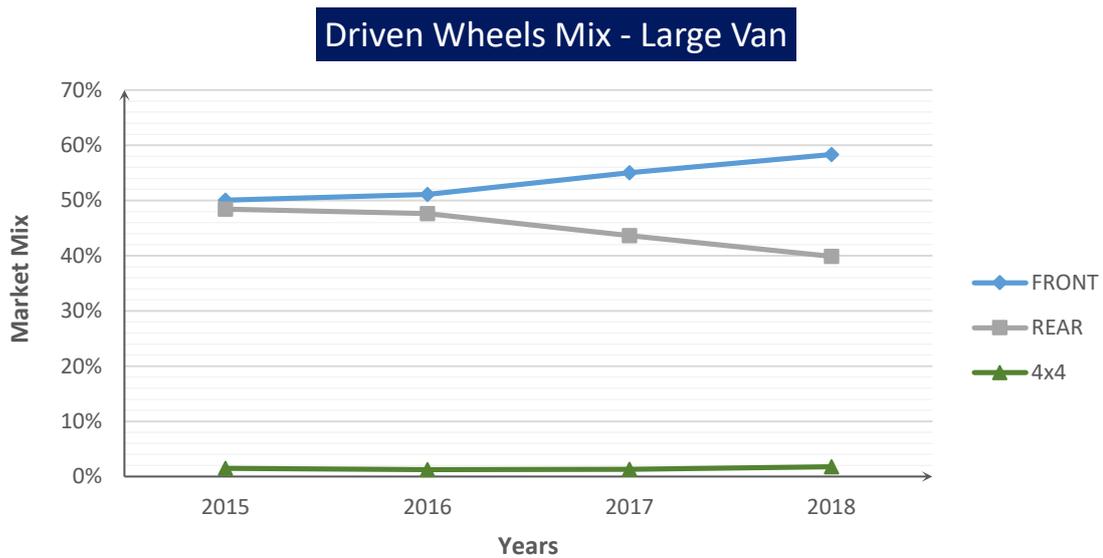


Chart 11 - Large Van Industry, Driven wheels Mix, source [23], [24]

As shown in *Chart 11*, front driven wheels vehicles have a strongly positive trend, rear driven wheels have a negative trend, and 4x4 driven wheels vehicles are stable. It is interesting to notice that in 2014 the market was equally divided between front and rear driven wheels vehicles (due to their little market share it is possible to not consider 4x4 in this analysis), but in 2018 front driven wheels vehicles have around 20 percentage points lead over rear driven wheels vehicles.

3.2.6 Vehicle length

LCV have different external lengths. To facilitate analysis, all lengths are segmented into five groups:

- "L1", it includes vehicles whose length is lower than 5.35 meters;
- "L2", it includes vehicles whose length is greater than 5.35 meters and lower than 5.75 meters;
- "L3", it includes vehicles whose length is greater than 5.75 meters and lower than 6.27 meters;
- "L4", it includes vehicles whose length is greater than 6.27 meters and lower than 7.05 meters;

- “L5”, it includes vehicles whose length is greater than 7.05 meters;

The following chart represents the division of the European market of Large Van vehicles according to vehicle external length.

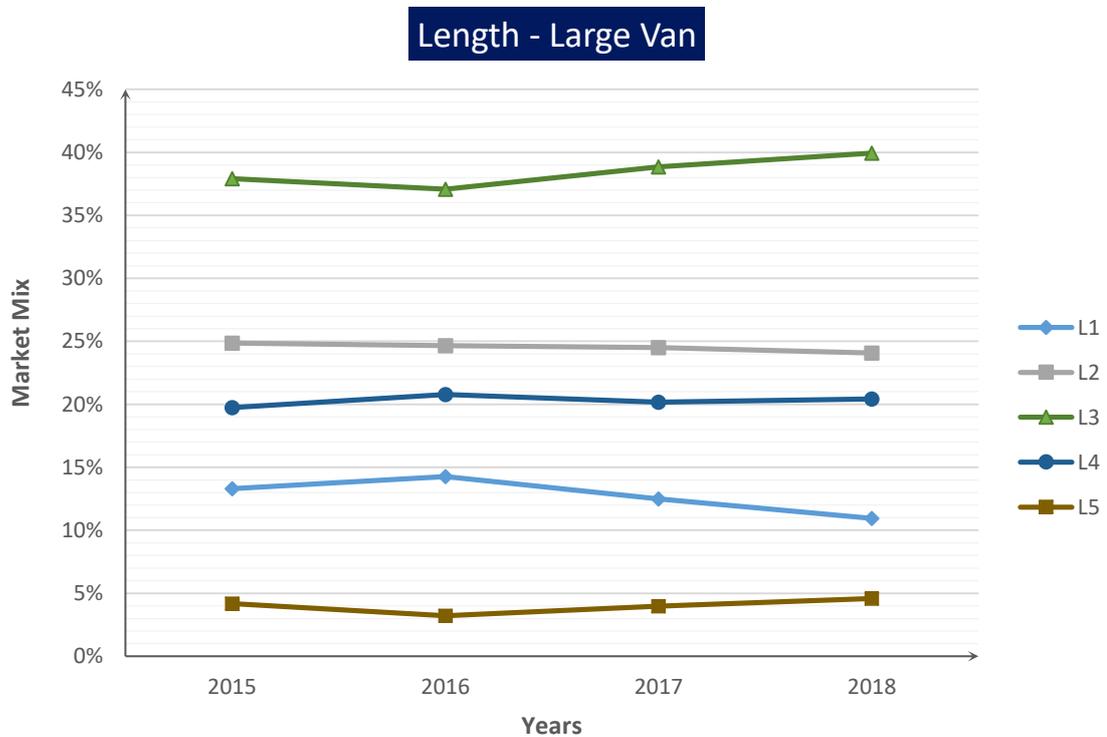


Chart 12 - Large Van Industry, Length Mix, source [23], [24]

As shown in *Chart 12*, all segments are quite stable. The main important note is that L3 segment is having a slight growth since 2015, while L1 segment is having a slight decrease. L3 segment keeps being the most popular one.

3.3 VAN ANALYSIS

The previous chapter analyzed the whole market of the Large Van segment. The focus of this chapter is the vehicles used for urban freight transport. Therefore, this chapter analyses the vehicles belonging to the Large Van segment having the Van body type: as previously stated, vehicles used for urban transport are belonging to the Large Van segment, and among them in particular, the ones used for goods transport have Van body type.

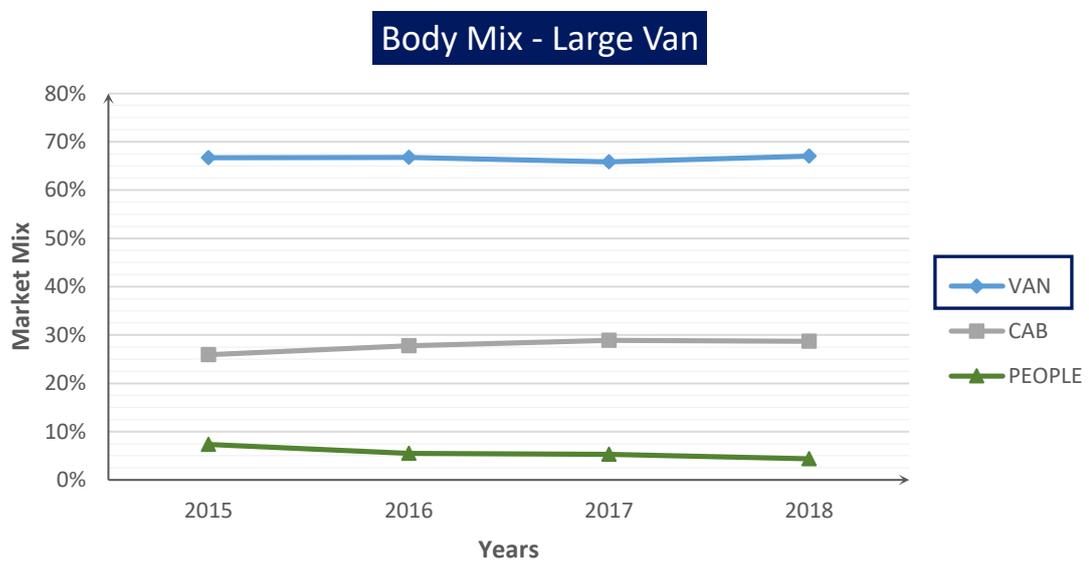


Chart 13 - Large Van Industry, Body Mix, source [23], [24]

3.3.1 Gross Vehicle Weight

The following chart represents the division of the European market of Van vehicles according to vehicle GVW.

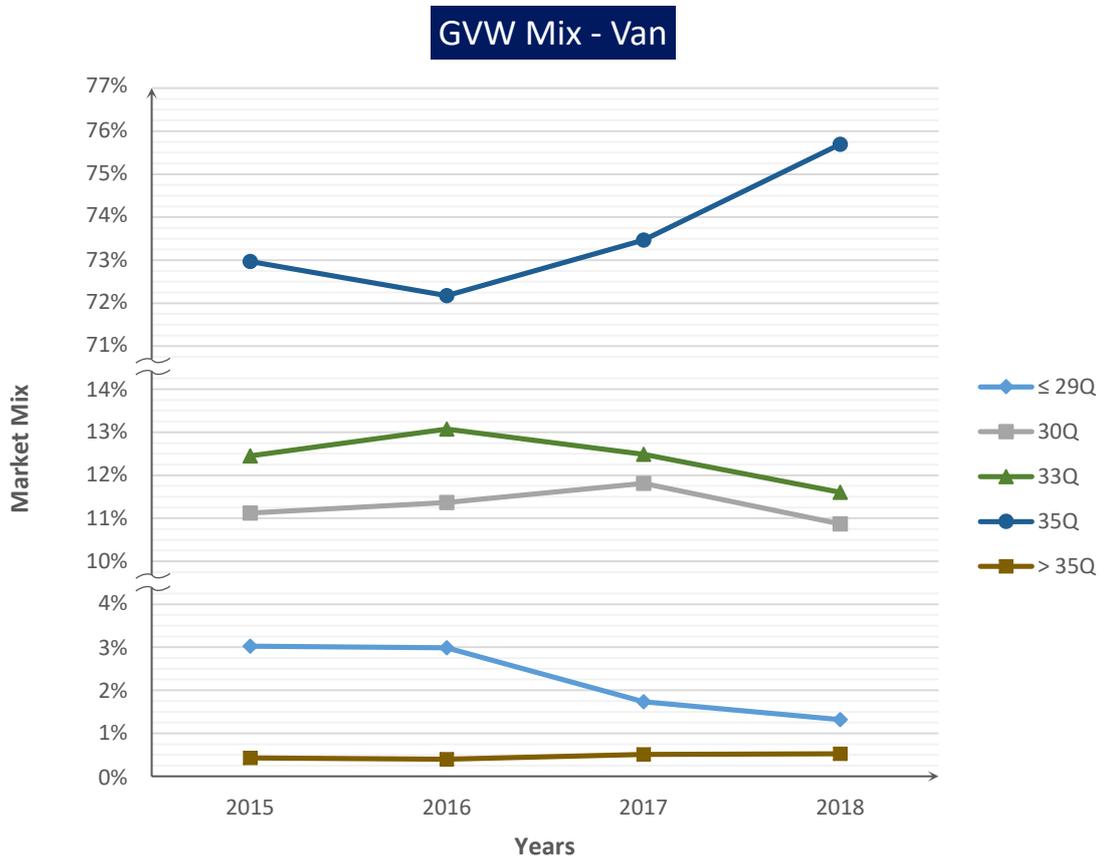


Chart 14 - Van Industry, GVW Mix, source [23], [24]

There are few relevant differences between GVW Mix of Large Van and Van. The main one is in the case of Van the only segments with positive trends are “35Q” and “> 35Q” segments, while all the others have negative trends. However, the variation is minimal: positive trends have very little growth (especially “> 35Q” segment) and negative trends have a very little decrease.

Considering the fact the industry has grown, it means there are more vehicles able to transport heavier goods, increasing average vehicle payload. This supports what claimed in the second chapter, that nowadays usage of vans must be optimized to be able to

deliver in cities with restricted access and to reduce costs: if vehicles have a greater payload, they can transport heavier goods or they can be loaded with more light goods, reducing the number of vans required for all deliveries.

The fact that the positive trend for “35Q” and “> 35Q” vans has a little growth can be explained by the fact drivers have the need to fully load their vehicles, therefore transporting more weight but most of the goods they have to transport is becoming lighter (which explains why the growth is not very evident). Another fact that explains these trends is that Vans are becoming bigger (it will be analysed in the *Chapter 3.3.5*), consequently gaining more loading space and therefore needing more payload.

To support the previous statement that transported goods are becoming lighter, it is necessary to know what products are usually transported. Considering what said in the second chapter, that e-commerce has a big influence on the goods transport sector, knowing the best selling categories for e-commerce platforms will help to be aware of what kind of goods carriers have to transport with high frequency. According to researches, some of the best selling categories for e-commerce platforms are Electronic & Accessories, Clothing & Accessories, Books, Health & Beauty [14]. While books can be compact and heavy, all other categories are quite light and take a lot of space in carriers van: for example, electronic accessories are usually small, but considering the package and their protections their volume increases considerably. Similarly, clothing products and a lot of beauty products are very light but they take a lot of space when they have to be safely delivered: it is enough to think about a pair of shoes or a tube of cream. This confirms the fact that carriers are transporting lighter goods, because light but bulky products are transported with high frequency, occupying a large section of the loading space available in vans.

This trend affects some of the possible new logistics solutions that have been previously analysed:

- Urban consolidation centers. The objective of this solution is to consolidate goods in fewer transports, fully loading vehicles leaving these centers. For this reason, considering the fact that the aim is to reduce the number of vehicles at

the minimum, improving GVW of vans allows them to transport more weight (and consequently more goods), improving their usage. The diffusion of vans with increased GVW promotes the development of this solution, by increasing its potential benefits;

- Load pooling. Similarly, the advantage of load pooling is to have fewer vans circulating along urban roads. If vans have a higher GVW, they will be able to be loaded with more goods. Therefore, the increased payload allows vans to transport more goods on behalf of others in addition to their own, increasing pooling capacity. From this point of view, the diffusion of vans with increased GVW promotes the development and encourage the use of load pooling practice. Despite this, there is also the possibility that thanks to the increased payload many carriers will be able to load all goods in their vehicles, without remaining with spare goods that would have delivered with other carriers, using load pooling. In fact, it is not easy to determine whether or not the increased GVW of vans helps the popularity of this solution;
- Night delivery. Even in this case, one of the advantages of this solution is carriers have the possibility to use bigger, and consequently heavier, vehicles to carry out deliveries, loading vans with more goods. Vehicles with increased payload encourage the development of this solution;
- Autonomous light commercial vehicles. Autonomous vehicles need more components and more electronic and mechanical parts: they are required for the vehicle to be aware of the external environment, to assure the safety of people both inside and outside the vehicle, and to circulate along roads with obstacles following the correct path. The problem is these parts add weight to the vehicle, but they should not reduce available cargo weight too much. For this reason, vans with higher GVW promotes the development of this solution;

3.3.2 Horsepower

The following chart represents the division of the European market of Van vehicles according to vehicle HP.

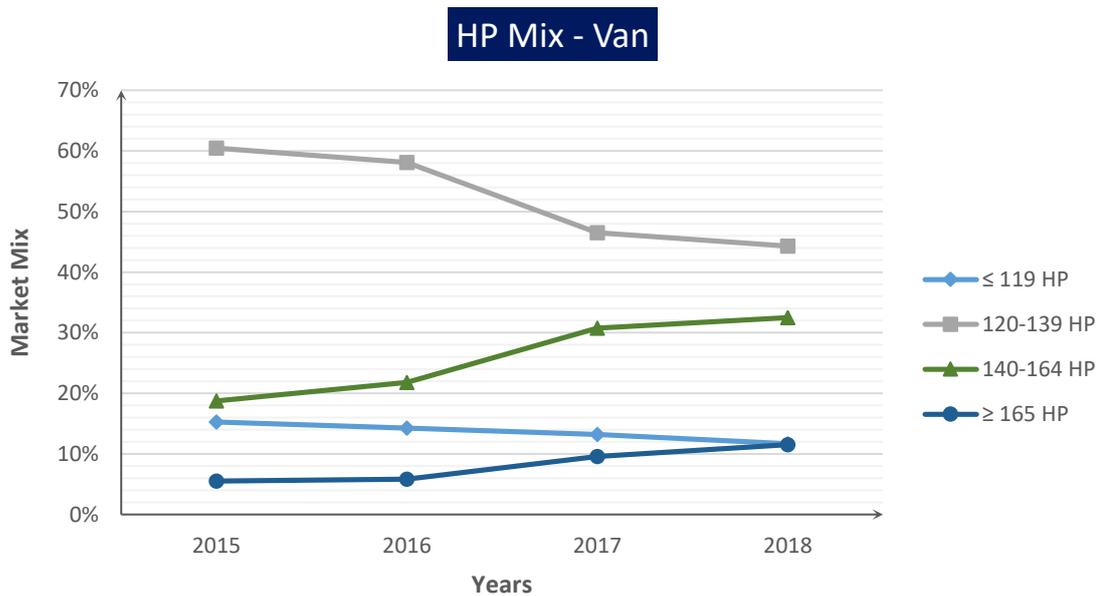


Chart 15 - Van Industry, HP Mix, source [23], [24]

As in the case of the Large Van market, vans with higher HP are becoming ever more common. This is easy to understand, considering the fact that GVW for vans is slightly rising. A vehicle is considered to have high performance if it has a lot of power relative to its weight: the more weight it has, the more power it takes to accelerate it. Considering the fact that the GVW for vans is rising, it is clear they need more powerful engines.

It is not always true, but usually higher horsepower correspond higher torque, which is responsible for the acceleration of the vehicle. Higher torque and higher horsepower give vans more acceleration, which allows them to become faster. It also improves circulation in urban areas, because vans are able to gain speed more quickly after a stop, causing less traffic in urban areas.

It is fundamental for drivers to have performant vans because they are used for business purposes, therefore their engines have to be reliable, being powerful enough to move heavier vehicles (as discussed in *Chapter 3.3.1*). This justifies the foretold general increase of horsepower of vans.

This increase of horsepower does not promote directly any of the solutions examined in the second chapter, but it is fundamental for the development of more performing and advanced vehicles. For this reason, it is possible to affirm it promotes indirectly the foretold solutions, because their implementation is supported by the development of more performing vehicles.

3.3.3 Transmission

The following chart represents the division of the European market of Van vehicles according to the type of transmission.

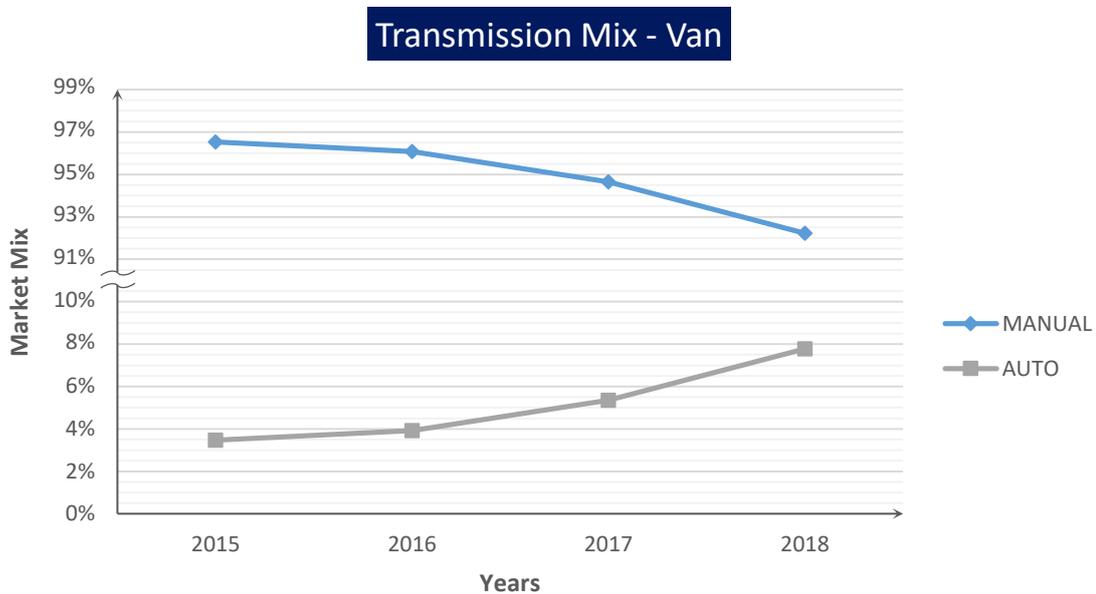


Chart 16 - Van Industry, Transmission Mix, source [23], [24]

As in the case of the Large Van market, the automatic transmission has a low market share, but it is becoming increasingly popular. The growing trend of automatic transmission vans is explained by the fact vehicles became the working place for their drivers, therefore they have to be comfortable and they must reduce any difficulties or stressful situations. As explained before, the manual transmission allows drivers to change gears according to their driving style, but in the case of commercial vehicles, this advantage of "customized" drive is second compared to safety issues and more stressed

drivers. In fact, the automatic transmission reduces safety problems: drivers never lose grip on the steering wheel, always maintaining the full control of their vehicle. This allows reducing the risk of accident improving both the safety of drivers and pedestrians and improving the circulation in cities, thanks to the fact there should be fewer urban roads blocked by accidents caused by commercial vehicles. Regarding the stress of the drivers, using automatic transmission they are more relaxed because they do not have to change gears, and they can fully focus on the road: this is particularly useful in urban streets, where vehicles are prone to continuous stops and starts. With more relaxed drivers, also safety is enhanced. Considering that automatic transmission makes safer and easier the driving experience and that drivers of commercial vehicles spend a lot of time driving, it is easy to understand why manual transmission has a negative trend.

The main new logistics solution affected by the growth of the market share of the automatic transmission is the development of autonomous commercial vehicles: having a vehicle able to manage gear on its own, shifting gear when needed, is another step towards vehicles able to transport passengers and goods without needing human assistance. In fact, autonomous vehicles are basically normal vehicles to which have been added sensors able to receive signals from the environment and an algorithm able to take decisions accordingly to the signals it receives from sensors.

The automatic transmission is another improvement that adds to the already existing ones. In fact, automotive manufacturers are already developing systems to enhance safety for car and road called ADAS (Advanced Driver Assistance Systems). ADAS have been designed for safety purposes, but they can be used without any problem in future autonomous vehicles due to the fact they allow vehicles to be aware of the environment around them. For example, some among the already existing ADAS are [10]:

- Adaptive cruise control, which automatically adjusts vehicle speed to maintain a safe distance from vehicles ahead, relieving the driver of the task of controlling the speed;
- Automatic lane centering, which automatically maintains the vehicle centered in its lane, relieving the driver of the task of steering;

- Full brake control, which identifies obstacles and alerts the driver in case of potential collision, and if the collision is imminent it automatically triggers an emergency braking;
- Traffic sign recognition, which recognises roadside signs (eventually reproducing them on on-board displays);
- Tyre pressure monitoring systems, which monitors the pressure of the tyres constantly, indicating when low pressure could cause inconveniences in the drive;
- Blind spot assist and rear cross path detection, which use radar sensors to identify obstacles or other vehicles approaching from the side or the back of the vehicle;
- Rain and dusk sensor, which can activate and regulate the speed of the windscreen wipers automatically and according to the intensity of the rainfall, and it can automatically activate headlights when the outside light is insufficient;

Considering the combined effect of all ADAS, it is possible to affirm a vehicle is already able to drive safely, remaining in its lane and avoiding obstacles, even with variations on its speed and recognizing the weather (which is useful to change the driving style in case of strong wind or rain). Adding to this the fact that vehicles are able to change gear autonomously, it is obvious it is a big improvement toward the creation of a fully autonomous vehicle. For this reason, the fact vehicles with automatic transmission are increasing their market share encourage the development of autonomous light commercial vehicles.

3.3.4 Driven wheels

The following chart represents the division of the European market of Van vehicles according to driven wheels.

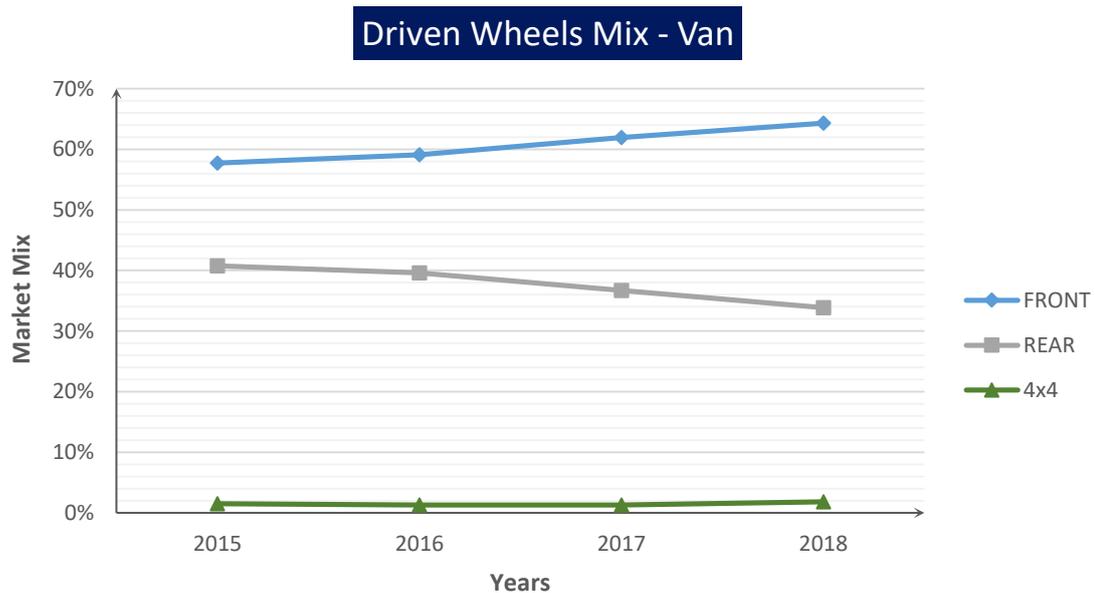


Chart 17 - Van Industry, Driven wheels Mix, source [23], [24]

Chart 17 is a bit different to the related one of the Large Van segment (Chart 11), but the conclusions are the same: front driven wheels vans have a positive trend, rear driven wheels vans have a negative trend, and 4x4 driven vans are stable.

Considering vans, this is perfectly in line with what has been stated in the second chapter about the fact that the utilization of vehicles must be optimized: vans must have as much loading space as possible. Rear driven wheels vehicles have the problem that the engine placed in the rear of the vehicle reduces the loading space. In the case of front driven wheels vans, the engine is placed in the front of the vehicle allowing them to have much more loading space and to meet the needs of the drivers. Another advantage is that front driven wheels vehicles are lighter, allowing them to be loaded with more weight, always respecting their GVW.

The fact they have more loading space and a better payload makes them preferable over rear driven wheels vehicles for all those who want to load their vehicles at the maximum capacity.

Rear wheels driven vans are preferred in the case of the transport of heavy goods. Even considering the fact that the GVW of vans is rising, it is not high enough to justify a massive use of rear wheels driven vans, reducing their loading capacity. In general, the whole GVW range of Large Van vehicles is adequate for front wheel drive.

4x4 wheels driven vans are very few because they are not the best option for urban transport, but they are used to deliver goods in places difficult to reach with front or rear driven wheels vans. Considering that most of the goods are delivered in urban areas and that urbanization is increasing, it is easy to understand why the market share of 4x4 wheels driven vans is so low.

This trend affects some of the possible new logistics solutions that have been previously analysed:

- Urban consolidation centers. Front driven wheels vehicles gain loading space, therefore they can be loaded with more goods. Considering what commented previously in *Chapter 3.3.1* dedicated to GVW of vans, that vehicles able to transport more goods at once increase the potential benefit of this solution, it is reasonable to believe that the front wheels drive trend encourages the development of this solution;
- Load pooling. Similarly, front driven wheels vans have a wider cargo area that can accommodate more goods, bringing both advantages and disadvantages: having more loading space allows carriers to have more spare capacity to share with other people, but it also means other carriers are able to load all goods on their vans without the need to use load pooling services. For this reason, the positive trend of front wheels driven vehicle affects this solution, but it is difficult to determine if the influence is favourable or unfavourable;

3.3.5 Vehicle length

The following chart represents the division of the European market of Van vehicles according to van external length.

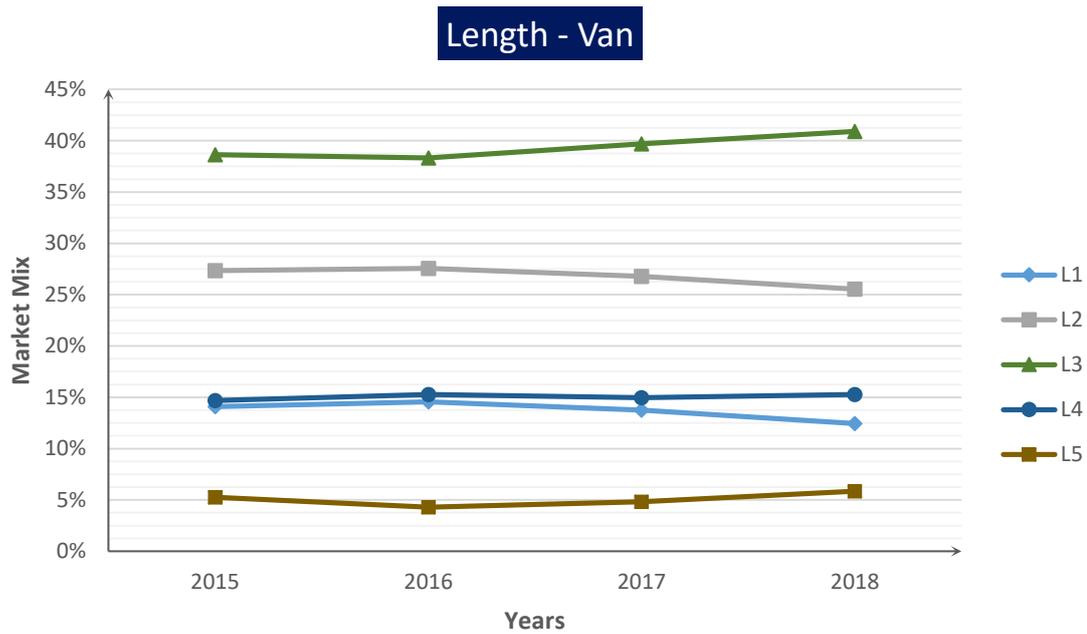


Chart 18 - Van Industry, Length Mix, source [23], [24]

Chart 18 is very similar to Chart 12. Their conclusions are very similar. L1 and L2 segments have negative trends, while L3 has positive trend. The situation is more complex for L4 and L5 segments: both of them are almost stable, with barely visible growth trends. As already anticipated in Chapter 3.3.1, it is possible to say that the average dimension of vans is increasing.

Considering the average increase in the length of vans, it is reasonable to affirm that their loading space has increased too. This supports what was claimed in the second chapter, that nowadays carriers must optimize the usage of vans to be able to deliver in cities with restricted access and to reduce costs: if vehicles have a greater loading space, they can load more goods, reducing the number of vans required for all deliveries and improving the usage of every vehicle.

Reducing the number of commercial vehicles, thanks to the fact that vans are bigger and they can transport more freight, will help to reduce the problem of the lack of parking spots and safety problems caused by the loading and unloading of goods. With fewer vans, there is a lower number of vehicles looking for parking spots: this reduces the probability for van drivers to find their spots occupied by other commercial vehicles,

engaged in loading or unloading operations. Moreover, bigger vans lead to fewer loading operations (vehicles do not have the need to be refilled, but can transport all freight at once) and consequently fewer stops required for the loading of vehicles: every stop, as commented previously in the second chapter, is a risky situation, and reducing their number helps reducing the probability of accidents.

The fact vehicles are becoming bigger does not exacerbate accessibility problems because the ones discussed in the second chapter refer mostly to bigger commercial vehicles: even though vans are growing in size, they still belong to the category of the LCV therefore their dimensions are in general limited, allowing them to circulate in cities.

This trend affects some of the possible new logistics solutions that have been previously analysed:

- Urban consolidation centers. If vehicles are becoming bigger, it means their cargo area is growing too, therefore they can be loaded with more goods. As in the cases of GVW and driven wheels trends, the use of bigger vans brings even more advantages to this solution, promoting its development;
- Load pooling. The growing trend for the length of vans affects this solution in both positive and negative ways: a bigger cargo area means carriers can transport more goods on behalf of others, but it also means that some carriers no longer need to use load pooling to send their freight;
- Night deliveries. One advantage of this solution is carriers can use bigger vans to transport more goods because they can travel along roads without the same constraints they would have during the day. The fact that the market is moving towards bigger vans supports the development of this solution;

3.3.6 Electric vehicles

Another notable trend for vans is the change in the engine of vehicles: they are changing engine passing from diesel to electric.

There are not yet market data to support this statement, because the change in motorization is very recent and vehicles are not yet been sold, but it is a fact automotive manufacturers are developing their electric commercial vehicle, which will be sold probably during next year. One example is Fiat Professional, which has just presented the new model, “Ducato MY2020” which is one of the first full electric LCV.

Automotive manufacturers are pushed towards this change in motorization by regulations are becoming stricter, limiting the access to diesel vehicles for sustainability reasons. In fact, electric vans will allow carriers to deliver goods in cities without any restriction, due to their high sustainability.

There are different types of engines for electric vehicles [15]:

- Hybrid electric vehicles (HEV). They have an electric motor that supports the internal combustion engine to improve the efficiency of the vehicle. The regenerative braking technology allows the charge of the batteries of these vehicles. For this reason, they are more efficient in cities, where vehicles are subjected to a lot of stops and starts. Hybrid electric vehicles are usually not rechargeable by external sources. Hybrid vehicles can be further classified into three technologies:
 - Micro-hybrid. It stops and restarts the combustion engine thanks to the system Start&Stop;
 - Mild-hybrid. There is an electrical motor that turns off the combustion engine when the vehicle is coasting or braking (not only when it is stopped, as in the case of micro-hybrid), quickly restarting it when the driver accelerates;
 - Full-hybrid. It allows to propel the vehicle without a combustion engine, relying only on an electric engine;
- Plug-in hybrid electric vehicles (PHEV). They are very similar to hybrid electric vehicles, but they can recharge their battery in two different ways: one is thanks to the regenerative braking, and the other is using an external source (usually plugging the battery to a charging station). PHEV vehicles have longer autonomy

than HEV vehicles before their batteries run out of charge (they have larger capacity compared to the ones of HEV vehicles);

- Battery electric vehicles (BEV). They are fully electric vehicles, without a gasoline engine and with rechargeable batteries. They need batteries with very high capacity, considering their power is used to run the electric motor and all onboard electronics. For this reason, batteries are recharged using external sources;

The market introduction of electric vans strongly affects some of the possible new logistics solutions that have been previously analysed:

- Electric vehicles. The launch into the market of the newly produced electric light commercial vehicles is logically a big step towards this solution, which purpose is the replacement of all traditional diesel vehicles by electric vehicles. This solution is supported also by the fact that electric private cars are already known and common: governments are already planning a proper infrastructure to recharge electric vehicles, and charging stations already exist. For this reason, the introduction of electric commercial vehicles finds a favourable environment: some infrastructures already exist and the market is aware of the benefits of electric vehicles;
- Night delivery. The main problem is the one related to the noise of vans: night delivery is not feasible with traditional vehicles because they annoy sleeping inhabitants with the noise of their engines. One of the advantages of electric vehicles is their engines are silent. In fact, electric vans would be suitable for this kind of delivery because they can transport many goods and they can do it silently. For this reason, the development of electric vehicles supports the implementation of this solution;

3.3.7 Characteristics of the travel

For this last part of van analysis, more than 150 fleets and more than 1300 van vehicles have been examined to determine the most common characteristics of the travel of LCV. In particular, the characteristics that will be discussed are the average daily distance covered and the average length of the travel.

The next chart shows the average distance covered by LCV for each day of the week, differentiating between urban road, extra-urban road and highway. The average distance has been calculated considering only traveling LCV. Traveling LCV are vehicles that have covered more than 5 kilometers during the day. Stationary vehicles have been excluded for this calculation, avoiding them to lower the average distance: the purpose is to calculate the average distance actually covered by vehicles during their job activities. The chart also shows the percentage of traveling LCV on the total number of LCV.

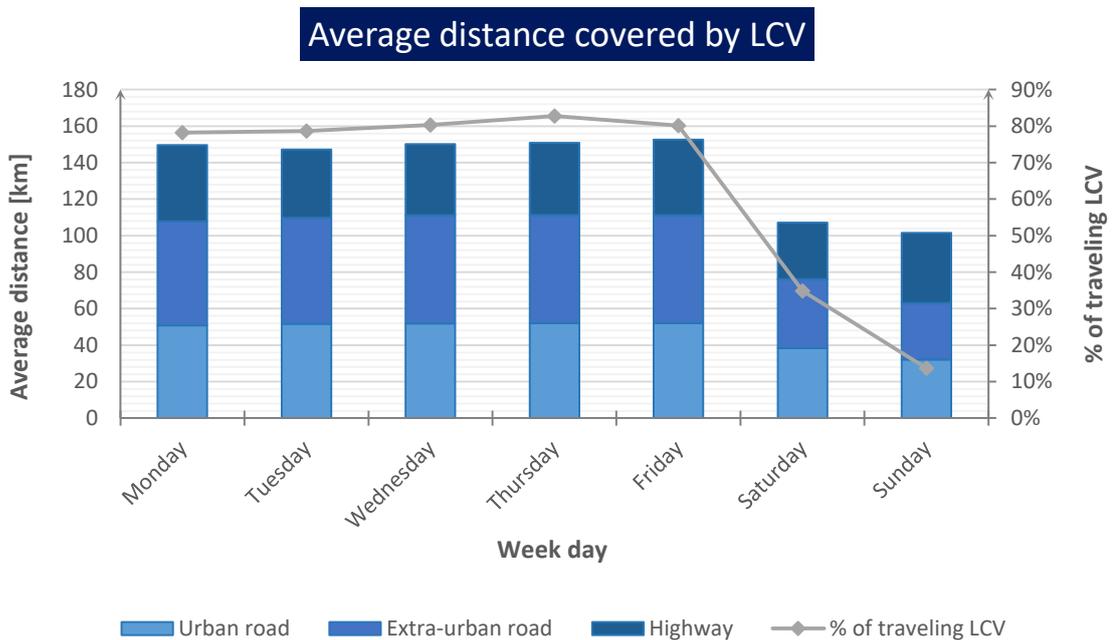


Chart 19 - Average daily distance covered by traveling LCV, source [23]

Considering the different types of roads (urban, extra-urban and highway), it is interesting to notice that on average vehicles travel equally among them: considering

total kilometers covered during the day, 1/3 has been covered in urban roads, 1/3 in extra-urban roads and 1/3 in highways.

Another consideration is there are many more traveling vehicles from Monday to Friday than from Saturday to Sunday. In fact, during the first five days of the week, the traveling vehicles are more than 80% of the total number of LCV examined, while during the weekend the traveling vehicles are only 20% of the total number of LCV.

This reduction is similar also considering the daily distance covered by LCV: vehicles cover a greater distance from Monday to Friday and a lower one from Saturday to Sunday. During each one of the first five days of the week, LCV cover more than 150 kilometers, but during each day of the weekend, they cover less than 110 kilometers.

Once examined the daily distance covered by LCV, it is interesting to analyze how much time they have their engines turned on, to know the average duration of the travel. The next chart shows the frequency distribution of the duration of travels for all LCV (as before, only travels longer than 5 kilometers have been considered).

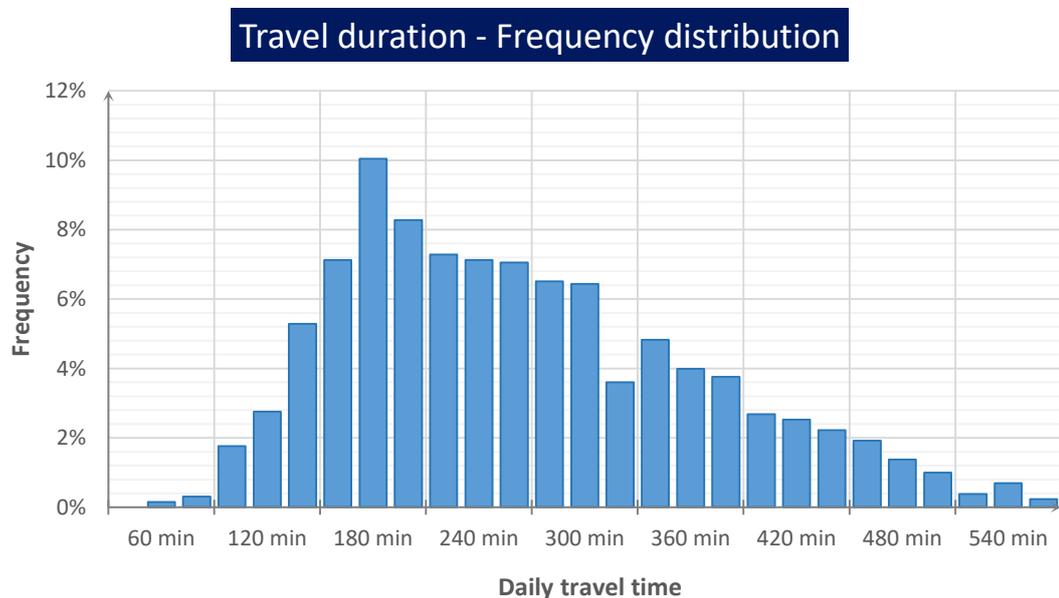


Chart 20 - Frequency distribution of LCV travel duration, source [23]

It is important to notice that on average the engine is turned on but idle for 12% of the time.

The average travel duration is slightly less than 4 hours. The maximum duration registered is of more than 11 hours, but a duration greater than 9 hours have been registered for less than 1% of the cases (and the average idle time for these cases is abnormally high, more than 20%).

It is possible to divide the observations into quartiles:

- First Quartile, 25% of the observations has duration lower than 2h 40m;
- Second Quartile, 50% of the observations has duration lower than 4h;
- Third Quartile, 75% of the observations has duration lower than 5h;

After this analysis, is it possible to affirm on average van vehicles travel more than 150 kilometers every day, and their travels last on average less than 4 hours.

3.4 LOGISTICS SOLUTION SCORECARD

After this analysis, it is possible to assign a score to evaluate the relation between future logistics solutions and the foreseen characteristics of future vehicles. Based on the considerations made in the previous chapter, about how each trend affects each solution, each set solution/characteristic is given a grade from one to ten. One means the trend of the characteristic under examination hinders the implementation of the solution, ten means the trend of the characteristic under examination promotes the implementation of the solution. The following table reports the assigned grades.

		Characteristics of future LCV					
		Gross vehicle weight	Horsepower	Transmission	Driven wheels	Vehicle length	Electric vehicles
Logistics solutions	<i>Urban consolidation centers</i>	8	6	5	7	8	5
	<i>Electric LCV</i>	5	6	5	5	5	10
	<i>Load pooling</i>	6	6	5	6	6	5
	<i>Night delivery</i>	6	6	5	5	6	8
	<i>Autonomous LCV</i>	8	6	10	5	5	5
	<i>Combination of passenger and parcel delivery</i>	5	5	5	5	5	5
	<i>Parcel lockers</i>	5	6	5	5	5	5
	<i>Bike delivery</i>	5	5	5	5	5	5

Table 2 - Scorecard of logistics solution based on characteristics of future LCV

Table 2 sums up the conclusions of the analysis carried out and discussed in Chapter 3.3, turning into a grade the observations previously made.

4 CONCLUSIONS

4.1 FUTURE LOGISTICS ESTIMATION

As previously analyzed, every trend affects some of the new logistics solutions examined in the second chapter. Based on the result of previous chapters, it is possible to rank the foretold solutions using a semi-quantitative method, from the one with the highest to the one with the lowest probability to be developed and applied in a few years.

Each solution is given a final grade and the greater the grade, the biggest the probability of its implementation. The final grade is the weighted average of other two grades, one that evaluates the influence of external characteristics (already presented in *Chapter 2.7*) and one that evaluates the influence of internal characteristics on the solution in question (already presented in *Chapter 3.4*). To internal characteristics has been given slightly greater weight, considering the high importance of vehicles in urban goods transport operations.

As external characteristics are meant characteristics of cities, feasibility, regulations, environment or other factors not depending on vehicles. To evaluate the general influence of external characteristics on each solution, each solution is given a grade from one to ten. One means the external environment hinders the implementation of the solution, ten means the external environment promotes the implementation of the solution. The results of external characteristics influence have been presented in *Chapter 2.7*.

As internal characteristics are meant characteristics of vehicles. In this analysis, the ones that have been considered are the ones examined in the previous chapter (GVW, HP, transmission, driven wheels, vehicle length, electric engine). To evaluate the influence of the trends of each characteristic on each solution, to each set solution/characteristic is given a grade from one to ten. One means the trend of the characteristic under examination hinders the implementation of the solution, ten means the trend of the characteristic under examination promotes the implementation of the solution. The grade given is based on the analysis presented in the previous chapter, and all grades

have already been presented in *Chapter 3.4*. After that, to each characteristic is assigned a weight to identify the most relevant ones and the less important ones.

The weights have been assigned considering the impact of each characteristic on the future LCV market. GVW, HP, Transmission, Driven wheels, and Vehicle length have the same weight, considering that their trends will not cause disruptive changes in the market. Instead, electric vehicles have a greater weight, even considering that they are quite new and they are now entering the market: in the current market electric LCV are very few, but considering what discussed in *Chapter 2.4* and *Chapter 3.3.6* it is reasonable to assume in a few years they will have a much more significant market share, with explosive growth. For this reason, to GVW, HP, Transmission, Driven wheels, and Vehicle length has been assigned a lower weight (15%) while to Electric vehicle has been assigned a greater weight (25%).

Considering the scores given to each set solution/characteristic and the weight of each characteristic, it is possible to calculate the weighted average to determine a grade for each solution that measures the general influence of internal characteristics.

Once obtained the two grades for each solution, one that evaluates the influence of external characteristics and one that evaluates the influence of internal characteristics, it is possible to calculate the final grade for the solution.

According to this method, the most probable solution is the one regarding electric vehicles, followed by night delivery. The solution less probable is the one that involves the combination of passenger and parcel delivery.

The results of this analysis are presented below.

		Weight	15%	15%	15%	15%	15%	25%	60%	40%
		Internal characteristics						Internal Characteristics Total	External Characteristics Total	Logistics solution Final grade
		Gross vehicle weight	Horsepower	Transmission	Driven wheels	Vehicle length	Electric vehicles			
Logistics solutions	<i>Urban consolidation centers</i>	8	6	5	7	8	5	6,4	4,0	5,4
	<i>Electric LCV</i>	5	6	5	5	5	10	6,4	7,0	6,6
	<i>Load pooling</i>	6	6	5	6	6	5	5,6	5,0	5,4
	<i>Night delivery</i>	6	6	5	5	6	8	6,2	6,0	6,1
	<i>Autonomous LCV</i>	8	6	10	5	5	5	6,4	2,0	4,6
	<i>Combination of passenger and parcel delivery</i>	5	5	5	5	5	5	5,0	2,0	3,8
	<i>Parcel lockers</i>	5	6	5	5	5	5	5,2	4,0	4,7
	<i>Bike delivery</i>	5	5	5	5	5	5	5,0	5,0	5,0

Table 3 - Logistics solutions: final scorecard

Rank	Logistics Solution	Grade
1 st	<i>Electric LCV</i>	6,6
2 nd	<i>Night delivery</i>	6,1
3 rd	<i>Urban consolidation centers</i>	5,4
4 th	<i>Load pooling</i>	5,4
5 th	<i>Bike delivery</i>	5,0
6 th	<i>Parcel lockers</i>	4,7
7 th	<i>Autonomous LCV</i>	4,6
8 th	<i>Combination of passenger and parcel delivery</i>	3,8

Table 4 - Logistics solutions: final ranking

The highest grade for electric LCV is the consequence of the development of electric engines and the positive influence of the external environment. In fact, the development of electric engines is very important, but also the external environment is pushing towards electrifications of LCV: regulations are banning diesel vehicles forcing this change, citizens are asking for silent vehicles and the implementation of an efficient recharge infrastructure is already in progress. For these reasons, using electric vehicles seems to be one of the most probable ways to accomplish deliveries in the future.

Night delivery also has one of the highest grades. This solution is supported by both internal and external characteristics. In fact, vehicles are becoming bigger, allowing transporting more goods, and their engines are becoming electrics, allowing delivering at night without any noise. Moreover, the fact that roads of cities are full of vehicles during the day, slowing down traffic, pushes logistics operators towards night deliveries.

Urban consolidation centers are among the top three solutions. Although they are not really supported by external conditions due to their high cost of implementation and due to the difficulty of finding spaces big enough to build these centers, they are highly supported by characteristics of vehicles. In fact, vehicles are becoming bigger, increasing their loading space and their payload, allowing the transport of more goods and therefore increasing the benefits of this solution, pushing towards it.

This solution is followed by load pooling, which is mainly promoted by characteristics of vehicles: in fact, it is possible to assume that the wider loading bay slightly encourages the sharing of the spare capacity of vans. On the other hand, external conditions are not really in favor of this solution, because it is true online sharing platforms already exist, but they are mainly used by people who need to deliver a small number of goods, not being the first option for those who need to deliver a large volume of goods on a regular basis.

Bike delivery is the next solution, which is neither supported nor hindered by both internal and external characteristics. In fact, it is not influenced by LCV improvements and it is not influenced by external condition: even if bikes are significantly more agile and faster than vans in congested roads, they can be used only for individual deliveries

and not for the transport of a lot of goods. For this reason, they will never be used as the main mean of urban goods transport, but they will still be used for the last-mile delivery of individual packages.

Parcel lockers are not very likely to be commonly used because, even if they are slightly supported by the fact that vans are becoming more performant, they are hindered by external conditions. In fact, even if parcel lockers bring a lot of benefits for carriers, greatly reducing failed delivery attempts and simplifying their routes, they need high implementation costs, they can create congestion in their surrounding areas and especially they do not bring any particular benefit for customers, which could prefer their products to be delivered at their houses.

One of the least feasible solutions is an autonomous LCV: external conditions strongly hinder its implementation. Even if more and more systems that help the driver by automating the driving are developed, there are still too many factors hindering the implementation of autonomous LCV. For example, laws regulating this topic are still missing, and urban roads are subjected to too much variability (for example considering the behavior of pedestrians or other vehicles) that could create safety problems and needs autonomous LCV to have very complex algorithms. For this reason, this solution is not likely to be used in a few years for urban goods transport, but it could be used in the future for extra-urban goods transport: in extra-urban roads there is a lot less variability, routes can be fixed, and a lot of systems and sensors are already been developed and tested.

The last solution is the one that involves the combination of passenger and parcel delivery. This is the least feasible and least advisable solution for urban goods transport. Even if it is not particularly influenced by the characteristics of vehicles, this solution is strongly hindered by external characteristics. It has very high costs of implementation because it is necessary to readapt existing infrastructures, and this solution could create complaints by passengers that have to travel with goods and consequently wait for their loading and unloading operations, increasing the time the vehicles are stopped.

4.2 FIAT DUCATO

The purpose of this chapter is to define the characteristics of future vehicles used for urban goods transport and to make an improvement plan for a current model, preparing it for the future market.

The model that has been chosen for this benchmark is the Fiat Ducato: it is the model with the highest market share in the Large Van market (as said previously, vehicles used for urban goods transport belong to the Large Van segment) and for this reason, it could be a very representative model.

This chapter follows introducing the main characteristics of Fiat Ducato, and after it suggests an improvement plan with the purpose to align its current characteristics to the foreseen ones.

4.2.1 Present

Ducato is the vehicle made by Fiat Professional belonging to the Large Van segment. It is a successful vehicle: in the European market, it has the highest market share among all competitors for the fifth year running. To give an idea, considering vehicles of the Large Van segment, more than 1 in 5 vehicles sold in 2018 were Fiat Ducato. It is even more successful focusing on the recreational vehicle market: approximately 3 in every 4 motorhomes sold are Fiat Ducato.

It has different Van, People mover, and Cab models. Considering only the van, its compact dimensions give it a big advantage on all competitors. In fact, Ducato has a wider cargo area but in smaller vehicles. This is the result of its better Internal/External Length Ratio. This ratio is calculated by comparing the internal loading length on the external vehicle length.

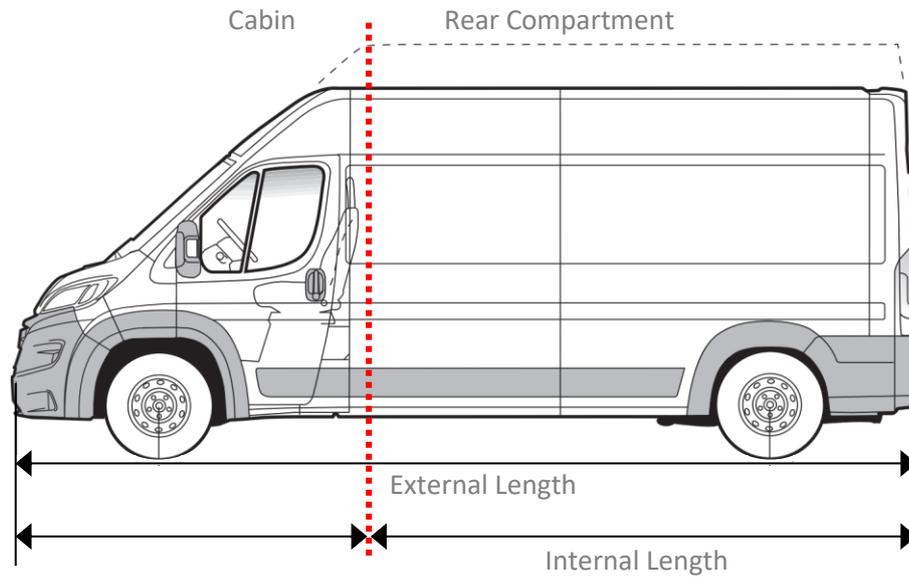


Figure 11 - Internal/External Length Ratio, source [23]

Higher ratio means the vehicle has a wider loading area, to parity of dimensions.

Its better ratio is clearly shown comparing three Fiat Ducato models to three Mercedes Sprinter models. All six are front driven wheels vehicles.

Length	Fiat DUCATO			Mercedes SPRINTER		
	Internal Length [mm]	External Length [mm]	Ratio [%]	Internal Length [mm]	External Length [mm]	Ratio [%]
L2	3120	5413	57,6	2600	5261	49,4
L3	3705	5998	61,8	3265	5926	55,1
L4	4070	6363	64,0	4300	6961	61,8

Table 5 - Comparison Internal/External Length Ratio, Ducato vs Sprinter, source [23]

Especially considering the L4 segment, Ducato has lower external length but larger internal length, which cause its ratio to be higher than the one of its competitor.

Moreover, Ducato tries to exploit at maximum its loading area by making the loading bay more regular and increasing its width. In fact, a more regular and squared loading bay allows improved utilization of the available space: it is possible to load goods easily

and in a more organized way, reducing the waste of space. The *Table 6* compares the loading bay width of Fiat Ducato with the one of Mercedes Sprinter.

	Fiat DUCATO	Mercedes SPRINTER
Loading bay width [mm]	1870	1780
Loading bay wheelarches width [mm]	1422	1350

Table 6 - Comparison loading bay width, Ducato vs Sprinter, source [23]

Mercedes Sprinter has a smaller loading bay width, which consequently reduces its cargo volume. In fact, Sprinter has a smaller cargo volume compared to Fiat Ducato, which is best in class for loading area dimensions.

Another characteristic of Ducato models is they are all front wheel drive. In Ducato vans the engine is placed in the front of the vehicle, allowing them to have much more loading space available in the rear part. Moreover, they are lighter and less expensive for the customer.

Fiat Professional intends to offer different engines, each of which suitable to a specific mission. For this reason, Ducato has a wide range of engines called Multijet. An important note is that newer Ducato models have more horsepower and more powerful engines than the previous ones. Still considering the engine, Ducato has launched a new model, Ducato MY2020, which is one of the first fully electric light commercial vehicles.

Following the improvement of its engine, Ducato has improved its automatic transmission launching a new nine-speed automatic transmission, a latest-generation torque converter. Still referring to technological equipment, Ducato has also a wide set of ADAS available, like blind spot assist, lane departure warning system, and full brake control among others.

4.2.2 Future

Considering the different trends for van vehicles examined in the third chapter, it is possible to make some predictions about future vehicles used for urban goods transport and to examine if Ducato is following these trends.

The trend of electric vehicles is one of the most important. Electric vans are still few, but it is reasonable to assume that in a few years they will become very popular, following the electric car trend. For this reason, it is advisable for Ducato to develop new electric engines, adding to or even replacing the already existing diesel engines. Future goods transport vans will probably be hybrid electric vehicles or battery electric vehicles. Because Ducato has been one of the first automotive manufacturers to launch an electric van, it means it is already following the electrification trend and it is in an advantageous position.

Considering the driven wheels trend, if a few years ago it was difficult to predict which would have become more popular between front driven wheels vans or rear driven wheels vans, now is clear rear driven wheels vans are greatly reducing their presence in the market. For this reason, following the trend is it possible to affirm future vans will have front driven wheels. Considering the case of Ducato, it finds itself again in an advantageous position because its vehicles are already front wheels driven. The brand is already well known and for this reason, it is advisable for it to keep improving its current front driven wheels engines more than developing new ones as other manufacturers will have to do, to change their vehicles from rear to front wheels drive.

Considering the horsepower trend, the engines are becoming more powerful. For this reason, future vans will have engines a little more powerful than the current ones. Ducato has less powerful engines, considering that front driven wheels vehicles are lighter and require less power. In fact, most of Ducato vans that have been sold (around 70%) belong to “≤ 119 HP” and “120-139 HP” segments, which are the ones that are decreasing. It would be advisable for Ducato to empower its engines, but it is what it has actually done with the new model, Ducato MY2020. For this reason, it seems it is already

following the trend and therefore its engines are already in line with current and future markets, no needing further power-ups.

Another clear trend is the transmission one. Even though the manual transmission has the highest market share, its trend is negative in favor of automatic transmission. Following this trend, in the future, a higher number of vans will have an automatic transmission, even if nowadays they are relatively few. They will not totally replace manual transmission vans, but surely they will have a considerable market share. For this reason, Ducato is in a favorable position because it has just launched its new model with advanced automatic transmission, and it is advisable for Ducato to keep improving it. It is also possible to consider this trend not only related to automatic transmission, but in a broader way related to “comfort drive” including also all devices that make the driving experience more comfortable and safer (as ADAS). Even in this case, Ducato is already following the trend (it has developed new ADAS for its new model) and it is advisable for it to keep improving them not to lose its advantage.

Considering the gross vehicle weight trend, vehicles are becoming slightly heavier. In fact, the trend for vehicles with GVW greater than or equal to 3,5 tons has a little increase. However, the increase is very low. This could be partly caused by the fact that the common B license allows to drive vehicles up to 3,5 tons. In fact, people tend to buy 3,5 tons vehicles even if lighter vehicles would fit their business: heavier vehicles do not bring license complications and they could be easily shared among different business activities. According to this trend, future vans will have the same or a bit higher GVW. Considering Ducato, its situation is quite good, because it already has the most of its sales concentrated in the “35Q” segment, which is the one with the highest projected growth. For this reason, it is advisable for Ducato to keep maintaining its focus on this segment.

The last trend that will be examined is the one regarding the length of the vehicles. According to this trend, vehicles are generally increasing their length: for this reason, it is reasonable to assume that in future vans will be longer. Considering Ducato, it seems to focus mostly on shorter vans (more than 50% of its sales come from L1 and L2

segments). For this reason, it is advisable for it to increase its presence in the other segments, focusing more on L3 and L4 segments. In particular, Ducato has a relatively short length: its longest model belongs to the L4 segment, but it is much shorter than many vehicles belonging to its competitors. In fact, the longest Ducato is 6.36 meters long, and considering the L4 segment goes from 6.27 meters to 7.05 meters, it is clear it is one of the shortest vans of the L4 segment (which is growing, as analyzed in *Chapter 3.3.5*). Considering this, it would be advisable for Ducato to design and produce a new longer van, to be more competitive against all vehicles of the L4 segment. However, this new vehicle should not be a replacement for the already existing L4 or L3 van. In fact, adding a new longer van, Ducato will have three vehicles for two segments: one to compete in the L3 segment, and two to compete in the L4 segment. This will help to increase its customers, considering the new vehicle joins those offered by Ducato, with the purpose to attract customers needing a longer van with increased loading capacity. Moreover, considering that both the L3 and the L4 segments are growing, improving the product range of these segments will help Ducato to be closer to its customers' needs.

4.3 FINAL CONSIDERATION

The goods transport sector is rapidly evolving, in consequence of changes in the behavior and expectations of people. People are moving from rural areas to urban areas, consequently increasing the number of people living in cities, which are becoming bigger to host more and more citizens. Therefore, cities need more goods to supply their shops and markets, considering there is a higher demand. For this reason, it is necessary to transport an increasing number of products, requiring logistics operators to organize more efficient deliveries.

Another important change is the diffusion of e-commerce: more and more people are now used to online purchases and related benefits. In fact, people tend to buy a lot of products online, from sellers all around the world, and often they return the products they do not like. For logistics operators, this means more products to be delivered and, most importantly, a bigger variability of delivery locations: people expect to receive at their houses products they bought.

The last main change is the rise of people's expectations: this makes more complicated the transport of goods because it has to be even faster and it must not hinder the transit of the means of people transport.

Goods transport has to adapt to all these changes. It has to meet the needs of increased and more variable demand, but it has to operate with more and more constraints: for example, goods transport vehicles are polluting, and a lot of cities are banning them. Another constraint is they are noisy, and this greatly limits their efficiency because carriers have to operate without annoying citizens with their noise and without causing any complaint. Moreover, carriers are asked to make more and more deliveries in a shorter time and keeping in mind they have more restrictions, they could tend to drive fast to accomplish all deliveries, ignoring safety rules.

For this reason, it is fundamental to find new ways of transporting freight in urban areas, in order to deliver all goods without prejudging the quality of life of inhabitants of cities. Several new logistics solutions could be very popular and common in the future, and

each one of them have been examined in this paper, highlighting its main benefits as its main disadvantages. After their examination, each solution has been given a grade to evaluate its feasibility according to the current situation (characteristics of cities, regulations, and environment).

Afterward, the analysis focused on the LCV market to investigate vehicles used for urban goods transport. The purpose of the analysis of van vehicles was to define their main trends to make a reasonable forecast about the characteristics of future vehicles. The trends that came out have been examined in relation to the logistics solutions that have been previously analyzed, and also in this case, each solution has been given a grade to evaluate its feasibility according to the characteristics of future vehicles.

To achieve a better result, the conclusions of the two previous analyses of the feasibility of each solution (one according to the general situation and one according to the characteristics of future vehicles) have been put together. It has been therefore possible to rank all the examined logistics solutions and to make a prevision of which ones will be applied in a short future.

Lastly, this paper focused on future van vehicles, making a comparison between the characteristics of future vans and the characteristics of current vans. To represent current vans, a Fiat Ducato van has been chosen, because it has the highest market share among all competitors in the Large Van segment, and a plan of improvement has been suggested, to ensure it is ready for future years.

4.4 RESULTS

The analysis presented in this paper have led to three main results:

- Prevision about future urban goods transport logistics solutions. This paper examined the urban goods transport market, with the purpose to identify the main needs of customers and its problems, in order to understand the reasons for its evolution. The LCV market has been examined too, with the purpose to analyze the characteristics of the vehicles used for goods transport operations to have a better understanding of how they are changing. The combination of the results of these two different analyses allows making a prevision about which logistics solutions are more likely to be applied in the future, and about which ones have a more complicated implementation;
- Advice for Ducato. Focusing more on the details of goods transport vehicles, this paper analyzed their market and the Ducato model. Thanks to the analysis of the vans market, it has been possible to understand how vans are evolving and which characteristics drivers appreciate the most. As a result, it has been possible to define the main characteristics of future vans. Thanks to the analysis of Ducato, it has been possible to be aware of its strengths and weaknesses and to know the segments in which it wants to compete. Both these analyses allow knowing the most appreciated characteristics of future vans and the characteristics of current Ducato models: it is possible to verify if they are similar and, in case they are not, it is easier to give suggestions about how Ducato can improve its vans;
- Tool for faster analysis. The analyses presented in this paper lead to the creation of a tool for an improved analysis process: it was necessary to have a tool that allows the analysis considering different factors (for example market, characteristics of vehicles, years...) quickly switching from one to another but also that allows to combine them. For this reason, it has been necessary to create a system able to easily organize and to segment all data, that allows standardizing them in order to be comparable and finally that makes their analysis possible, allowing to select and to switch among multiple factors;

REFERENCES

- [1] OECD, *Delivering the Goods – 21st Century Challenges to Urban Goods Transport*
- [2] Michael A. P. Taylor, *The City Logistics paradigm for urban freight transport*
- [3] Arthur D. Little, *The Future of Mobility 3.0 – Reinventing mobility in the era of disruption and creativity*
- [4] McKinsey&Company, *An integrated perspective on the future of mobility, part 2: Transforming urban delivery*
- [5] Deloitte, *The 2017 MHI Annual Industry Report – Next-Generation Supply Chains: Digital, On-Demand and Always-On*
- [6] Schöder D., Ding F. and Campos J.K., *The Impact of E-commerce Development on Urban Logistics Sustainability*
- [7] MDS Transmodal Limited, *DG MOVE European Commission: Study on Urban Freight Transport*
- [8] Civitas, *Goods distribution and city logistics*
- [9] *Fiat Professional company history*, website: <http://www.fiatprofessional-me.com/en/Company/History>
- [10] *Fiat Professional presents its best ever Ducato*, website: <http://www.fiatprofessionalpress.com/press/article/fiat-professional-presents-its-best-ever-ducato>
- [11] *E-commerce Product Return Rate – Statistics and Trends*, website: <https://www.invespcro.com/blog/ecommerce-product-return-rate-statistics/>
- [12] *Electric cars are already cheaper to own and run, says study*, website: <https://www.theguardian.com/environment/2019/feb/12/electric-cars-already-cheaper-own-run-study>
- [13] *How does the last mile delivery impact your e-commerce?*, website: <https://www.ecommerce-nation.com/last-mile-delivery-impact-ecommerce/>

- [14] *These were 2018's top selling product categories at Amazon and eBay*, website:
<https://medium.com/edison-discovers/these-were-2018s-top-selling-product-categories-at-amazon-and-ebay-1c8a5c62d49c>
- [15] *Types of Electric Vehicles*, website: <https://www.evgo.com/why-evs/types-of-electric-vehicles/>
- [16] *Urbanization: An Environmental Force to be Reckoned With*, website:
<https://www.prb.org/urbanization-an-environmental-force-to-be-reckoned-with/>
- [17] *The future of freight – How new technology and new thinking can transform how goods are moved*, website:
<https://www2.deloitte.com/us/en/insights/focus/future-of-mobility/future-of-freight-simplifying-last-mile-logistics.html>
- [18] *The future of urban logistics*, website: <https://www.mazars.com/Home/Sector-expertise/Transport-Logistics/Urban-Logistics>
- [19] *Insights into Last Mile Failed Deliveries*, website:
<https://www.beetrack.com/en/blog/understanding-failed-deliveries>
- [20] *Survey: Consumers expect e-commerce deliveries within 3 days*, website:
<https://www.supplychaindive.com/news/survey-consumers-expect-e-commerce-deliveries-3-days/546645/>
- [21] United Nation, website: <https://population.un.org/wup/DataQuery/>
- [22] Eurostat, website:
<https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do>
- [23] Fiat Professional. *Fiat Professional internal databases, analyses, documentations*
- [24] JATO Dynamics. *Databases*