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Sustainability in passenger transport: the relevance of punctuality in rail and modal choice in commuting

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Introduction

The overall purpose of this PhD research is the analysis of the sustainable passenger mobility, both on long and short-distance trips. Mobility plays a central role in the social system and it is a key driving force for socio-economic, global and local development, but it produces also negative externalities on the territory. The thesis, in particular, has the aim to explain the main elements of sustainable mobility from a theoretical point of view and, successively, to apply these concepts to two empirical cases with the use of Italian real data. These empirical analyses can help in underling the importance of sustainable mobility and of the efforts to improve it, influencing the transport modal choices of the commuter journeys. The first case regards the most sustainable mode of transport for medium-long distance trips, the train, and particularly the problem of delay that strongly affects the performance of the train, influencing the choices of the commuters that prefer the more punctual car. The analysis is based on data collected in the period 2013-2016 on the railway line from Milano to Genoa. The second case concerns medium-short trips, focusing on the issue of home-work commuting of a multipoles medium Italian university located in two different cities (Varese and Como) in the north of Italy. The data come from a survey performed in November 2017.

The thesis is organized in three chapters. The first chapter describes the results of the literature review of the papers related to the concept and the evolution of sustainable mobility with an overview on European and Italian data. It is aimed to explain the role of sustainability in transportation and the innovation in the transport sector, with a specific focus on all the most relevant (collective and individual) transport modes that can be considered as alternatives to the car, with their features. More in depth, the structure of the chapter is organized as follow: first it is presented an analysis of passenger transport, modal share and the impact on the environment of mobility, using European and Italian data. Second, the sustainable mobility concept is explained. Third, the chapter examines the new forms of sustainable mobility such as carpooling, bike sharing and long-distance bus, underlining features, positive and negative aspects.

The second chapter concerns the railway transport system and, in particular, a selected sample of inter-regional passenger trains of an Italian medium-distance line (Milan- Genoa) from January 2013 to December 2016. It considers the elements related to the train journey, the track and the causes of delay that can influence the final performance, in terms of punctuality and, as a consequence, the transport modal choice of travelers. The railway system is a fundamental component of the economy in most of the countries with a developed network. In fact, it can transport millions of passengers and goods with a value of millions of dollars every day from origin to destination. Scholars (see for example, Schafer & Victor, 1999; McKinnon, 2007; Hickman &

Banister, 2007; Cartenì & Henke, 2016) sustain that the railway sector, as it produces very low CO_2 emissions and is appreciated for its high energy efficiency, is the more environmental friendly and safer mode of transport. One of the most common and frequent problems of this transport modality is the concept of (un)punctual arrival time that is discussed widely in literature (Glyee 1994, Dingler et al., 2010, Gibson et al., 2002, Carey 1999, Higgins et al., 1995, Müller-Hannemann and Schnee 2009, Nelson and O'Neil 2000, Harris 2015, Harris et al., 2013, Harris and Andersson 2007). Moreover, the purpose of the chapter is twofold: first, it provides a critical review of the literature on delay categories as a starting point for the development of a new classification of delay based on the link between motivations, causes and responsibilities. Secondly, by applying this new classification, an analysis of the available data is performed to understand the motivation and responsibility of the delay on the analyzed line. The data shows that the external causes and the failure of the infrastructure (track, power line) are the most relevant elements that affect the railway performance. Furthermore, the application of the survival analysis is used to evaluate the probability of a train failure and to estimate the percentage of trains that arrive to the predefined destination. From the analysis it emerges that there is a coherence between these results (that consider only the trains of the Milano-Genoa line) and the official data (about all the Italian railway lines) elaborated and promoted by Trenitalia in its official documents.

The third chapter aims to understand and explain the main drivers and features of commuting in a multipole university system. This chapter is based on the "Insubria Mobility Survey 2017" carried out in November 2017 (about 2,800 observations), which concerns the commuting habits of students, professors and administrative staff in the home-work(study) journey. The University of Insubria (also called Uninsubria) is an Italian state university founded in 1998 with a universe made by 11000 people. It is located in Lombardy and has two main poles, Varese and Como and a third secondary and smaller pole: Busto Arsizio. Considering the concept of pole attractor, it is clear that a University or a college is an institution that attracts students and workers, with different working hours and traffic rush period that are different from a standard firm or a high school pole, but it contributes in various ways to the demand of local and regional transport. For these reasons, there is the need to identify all the possible positive and negative impacts that this kind of structure produces on the area in which is located. To overtake the problems of traffic, congestion and to reduce pollution the involved actors should implement strategies to make more sustainable the commuting flows, increasing the level of livability. It is possible to detail more the four objectives of the chapter: (i) to verify if the car is the dominant transport mode in the commuting habits of the different poles of the Insubria University; (ii) to identify the main drivers of the user's modal choice of the related sample; (iii) to evalutate, from a policy perspective, the commuters'attention to the sustainable mobility; (iv) to understand the modal change propensity of the commuters from the actual means of transport to green alternatives.

The methodology used for verifying these research questions is based on different tools: descriptive statistics, multinomial logit model and pairwise T-Test.

The results of the analysis provide a useful base to identify and implement some policies to improve the sustainability and the level of accessibility to the academic sites: Como and Varese. As regards the commuting flows' sustainability, it is relevant to consider the differences between the two main poles. In fact, to reach Como, the car is not the first transport mode used, due to a relevant number of public transportation alternatives (firstly, train), while in Varese, where the majority of users are concentrating, there is a very strong car dominance. The position of the Varese campus is peripherical and the combination of a big free parking space and a lack of public transport services affects the choice of the travellers. The analysis made on public transit evaluation confirm these findings.

Nevertheless, the analysis of the propensity to change the personal travel behavior reveals that the users of Varese are more willing to consider some alternatives to their actual modal choice than the users of Como.

For these motivations, especially in Varese, policies able to increase the transit accessibility of the campus and to encourage more environmental transport solutions, such as carpooling and car/bike sharing, are needed. From the sample it emerges that carpooling is considered an interesting alternative to solely drive a car or ride a motorbike and thus it may increase the sustainability of auto-dependent users.

In Como, the policies should be focused in improving the level of service of local bus and in promoting, also in that case, sharing mobility for the commuters that haven't a train connection from their home, maybe using some incentives such as a discount on parking fee.

Finally, the last chapter draws some conclusions and mentions some upcoming evolutions of mobility that could give a strong contribution in achieving sustainability.

Chapter one

Relevance and evolution of sustainable mobility in passenger transport: a theoretical overview

1.1. Introduction

Mobility plays a central role in our social system and represents a fundamental driving force for socio-economic, global and local development (Banister et al., 2000). On the one hand, it affects international trade, the economic growth of a country and the displacement of economic activities within a territory, determining accessibility and improving the quality of life of its citizens (Camagni et al., 2002). On the other hand, since it produces negative externalities, environmental and social policies can be decisive for the reduction of polluting emissions and for life quality, guaranteeing at the same time social cohesion, urban or regional development and security (Gudmundosson & Hojer, 1996).

In Europe, sustainability principles with regard to mobility started to be introduced in the second half of the 1990s. The aim was to reduce the use of private vehicles in favor of less polluting methods which was also linked to improving the level of public health. Nevertheless, the dependence on the car has continued to prevail strongly, although there is a recent increase in the users' propensity to change their travel behavior. This was first indicated in the Isfort report[1] (2010) which is one of the most important studies relating to the mobility demand of Italians (with a sample of 15,000 respondents aged between 14 and 80 years). This was a positive sign, but not yet sufficient if we consider that most urban pollution is attributed to vehicular mobility.

All strategies to face climate change in the transport sector are aimed at improving urban mobility. The European Community is currently sending out signals, from green papers to action plans on urban mobility, to urge local authorities to adopt integrated policies for a sustainable future of transport. These actions are necessary to improve the health and the environment of any urban and regional areas. In fact, the transport sector represents one of the main sources of air pollution in Europe and there can be no doubt that the policies aimed at favoring the use of alternative means to the car have improved the air quality in several major cities. In Europe, on average 4 urban journeys on 10 take places on foot (Isfort, 2018). This number increases in the major centers (capitals and cities over 550,000 inhabitants) to 66% of the total trips (EEA, 2018). In Italy, indeed, around 60% of journeys in urban areas are made with private cars. Nevertheless, Italians may be ready for a modal change, in fact, according to the EEA survey (2018) 40% would like to use the car less and 49% say they would be more inclined to use more public transport.

[1] http://www.isfort.it/

Despite the exceptional success that the term "sustainability" has enjoyed over the last thirty years, there is still criticism. The concept of sustainability continues to be controversial and the difficulties of applying the principles to totally complex contexts such as urban areas, compel us to use it with greater caution. The perspective of sustainability seems increasingly oriented towards modifying or at least questioning the current models of socio-economic growth that, at the moment, cannot be called "sustainable". Currently, humanity consumes the equivalent of 1.5 planet-earth each year (Wright & Østergård, 2016; Bratspies, 2011), despite the awareness that the system in which we live is a "closed" ecosystem. For this motivation it has numerous constraints (land, waste and pollutant absorption, large life cycles, indiscriminate population and production increases) that necessarily determine limits (Tiezzi & Marchettini, 2001). The California Redefining Progress Institute of the World Wild Foundation calculated that if the current population remained stable, the per capita bio producing space should be reduced to 1.8 hectares per capita instead of the current 2.2 hectares (Wheeler & Beatly, 2014), but the ecological footprint highlights strong disparities between different countries. The essence of sustainability should be to re-establish a relationship between the available resources and the level of well-being that people want to achieve (Szigieti et al., 2017). This would at least imply containing consumption in favor of forms and models of "green" economies or economies that, in addition to being focused on profits, also consider the effects on the environment and the benefits deriving from a better use of the resources.

1.2 Mobility data overview

To introduce the concept of mobility, it is possible to make a comparison between the evolution of transportation and the innovation in the internet industry. In fact, there are some similarities for these two sectors, regarding quality, requests of the users and final results. In the case of the experience of internet and social media on mobile phones, tablets or notebooks, there is an obvious interest in receiving data packages in a quick and safe way. Similarly, travelers are not necessarily interested in the transportation mode, but only in arriving at their destination as quickly as possible in a safe and comfortable way. Moreover, the interoperability of digital networks and devices is comparable to multimodality organized in the transport world. In fact, multimodality makes mobility more efficient and sustainable but requires interoperability between different transport means and services. The availability of multimodal transport alternatives can modify the travelers' decisions and lifestyles, by improving their decision-making skills.

Considering the data, it can be underlined that the rate of mobility has increased overtime in all the world countries; for example, as shown in Figure 1.1, in Italy the percentage of people completing one trip per day has increased from 75.1% to 83.6% from 2012 to 2016 (Isfort, 2016). This trend is matched with the greater importance of the "non-systematic" component of mobility (e.g. for leisure and free time) and the increase in creative and knowledge-intensive professions. The physical presence of the workforce for the conventional 8-hour-day is no longer mandatory and this has contributed to a more flexible and less predictable demand for mobility.

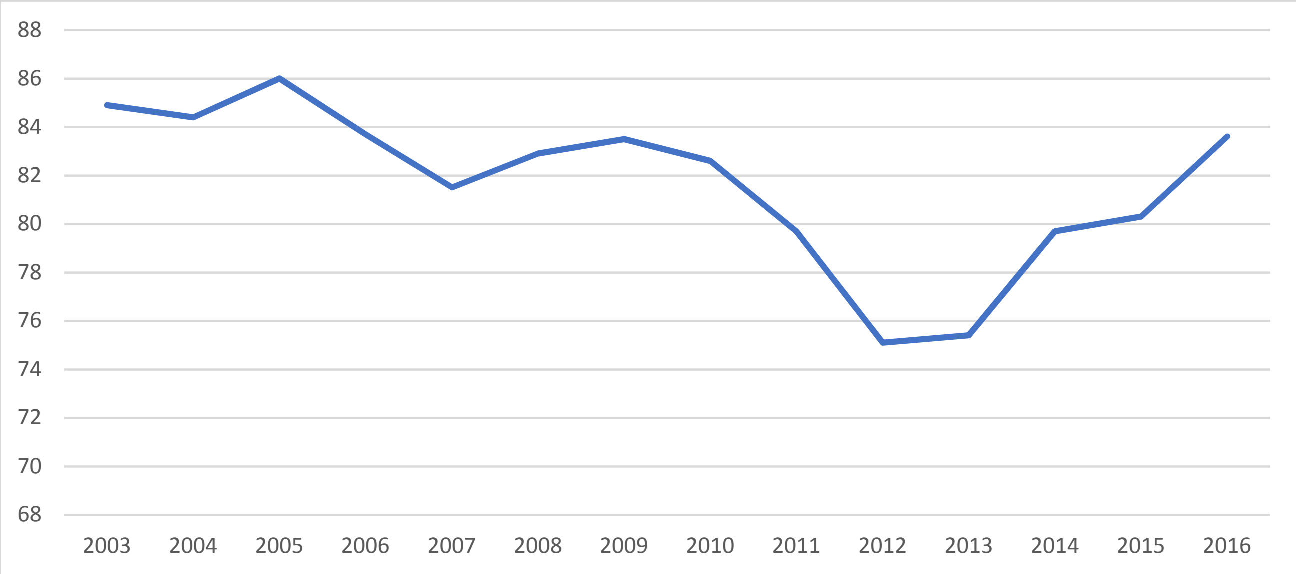

Figure 1.1 Percentage of people completing one trip per day in Italy. Personal elaboration of data from Eurostat and Isfort.

As regards the modal choice, individual road transport is close to 83% of passenger land transport in the EU-28 in 2016, while bus (local and interurban) decreases to 9% and rail transport is at 7.6% (Figure 1.2). The public transportation sector accounts for less than one tenth of total traffic (measured in number of passengers per kilometer (pkm) for each land transport mode) (EEA, 2018; Isfort, 2016).

Between 2004 and 2016, the relative importance of car use remained stable between 83.0% and 83.7%. During the same period, the relative importance of passenger rail transport recorded a fairly constant growth (albeit with small declines between 2008 and 2009 and between 2012 and 2013) from 6.7% to 7.6% in 2016. Along with this development, there was a reduction in the importance of passenger transport on buses, buses and trolley buses, which fell from 9.9% in 2004 to 9.1% in 2014, with the most part recorded between 2008 and 2009 (EEA, 2018; Isfort, 2016). In ten years, from 2007 to 2016 (Figure 1.3), the European rail mobility rate in terms of millions of passengers per kilometer increased of 14,7%% (from 14,293 to 16,400).

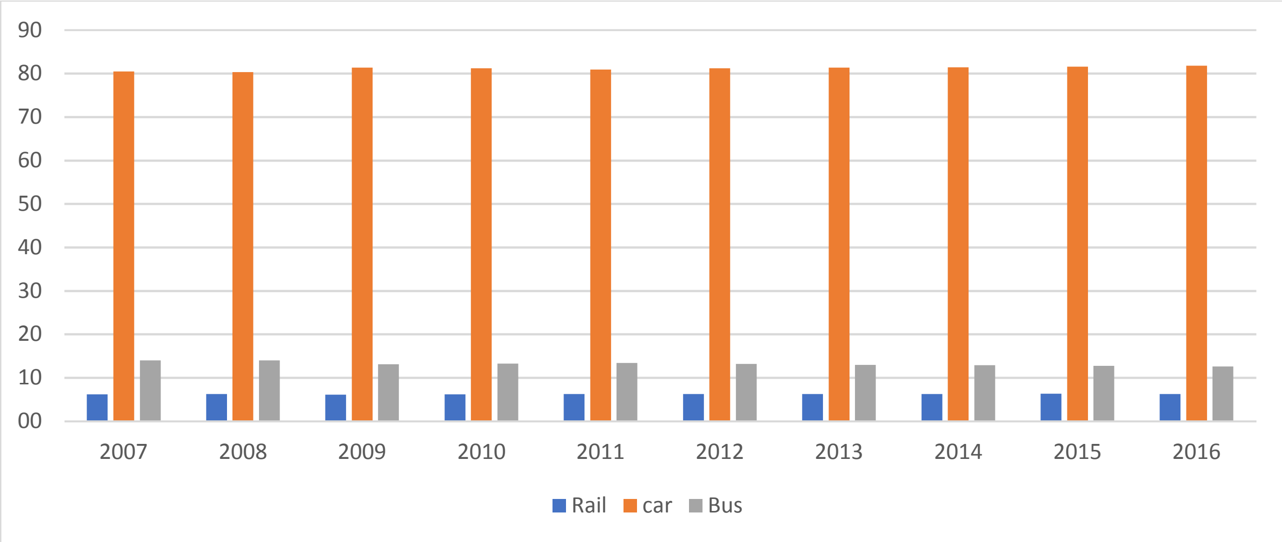

Figure 1.2 Percentage of modal distribution of transport means in Europe. Personal elaboration of data from Eurostat.

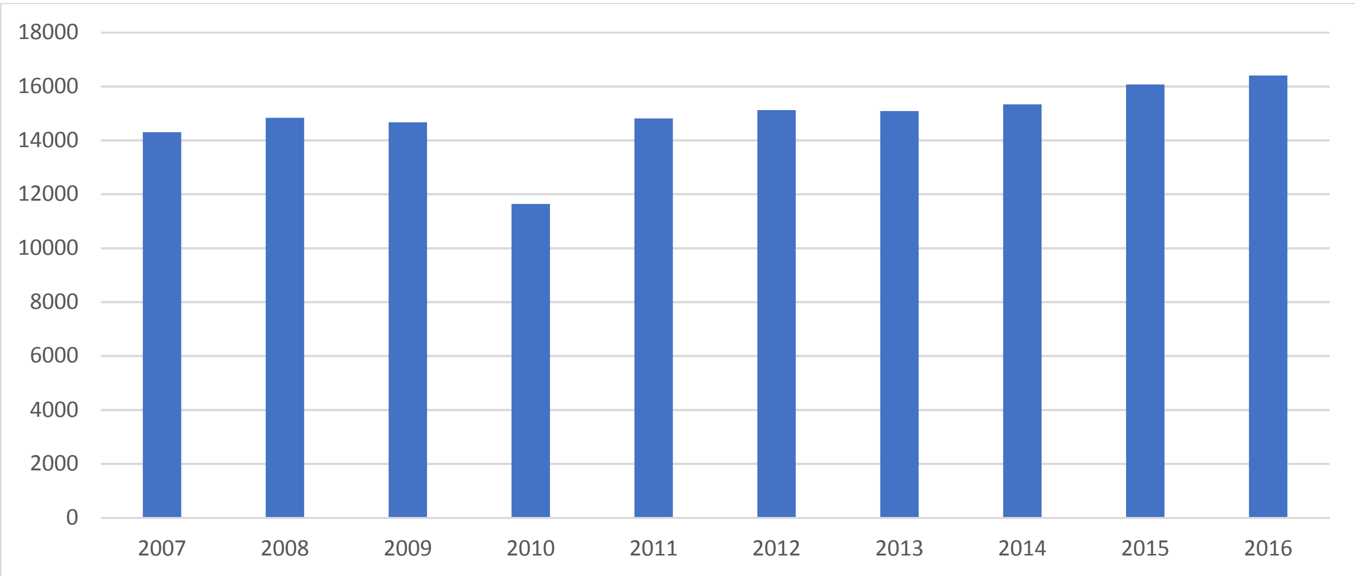

Figure 1.3 Railway mobility in Europe million passengers per kilometer. Personal elaboration of data from Eurostat.

Focusing on urban transport modal share, in Europe it is clear that there are some differences between countries as explained in figure 1.4. Considering a selected sample of nations, it is possible to underline some peculiarities, in fact the use of the private vehicle (car or motorbike) has the main percentage in all the countries. Moreover, it is possible to analyze the differences between the use of railway: for example, in Switzerland the percentage is 3 times than Spain.From the picture it emerges also that Iceland and Malta have not a railway system.Considering the bus or coach, Hungary has the highest percentage of the sample and curiously this country has the highest percentage of sustainable transportation (summing bus and rail) with a value of 31%. The situation of Italy is discussed more in detail in Figure 1.5.

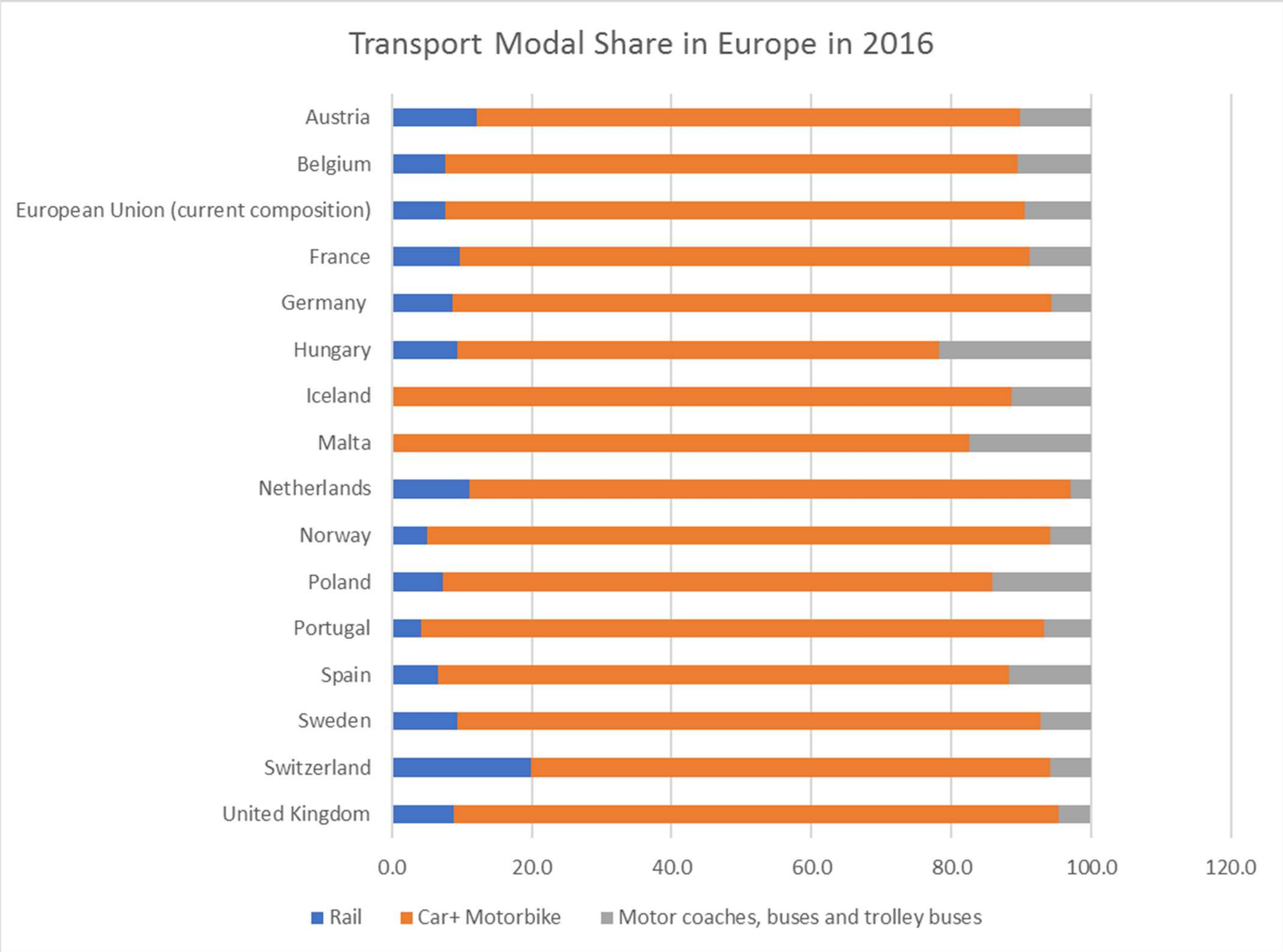

Figure 1.4 Transport modal share in Europe. Personal elaboration, data from Eurostat.

Referring to Italy, the car tends to centralize the choice of transportation means for people (Figure 1.5). Overall, more than 2 out of 3 trips are made by car (largely as a driver) and this rate has grown by almost 8 points in the last 15 (it is important to underline that this index is not correlated with the economic period and financial crisis). Public transport has a very low share when compared to other modes and its reduction from 2001 to 2016 is only partly counterbalanced by intermodal movements. As for "active" mobility, that is walking or cycling, the share is around 20% (2016) and it decreases in the long run, also due to the impact of urban dispersion processes and the subsequent lengthening of commuter journeys (EEA, 2018; Isfort, 2016).

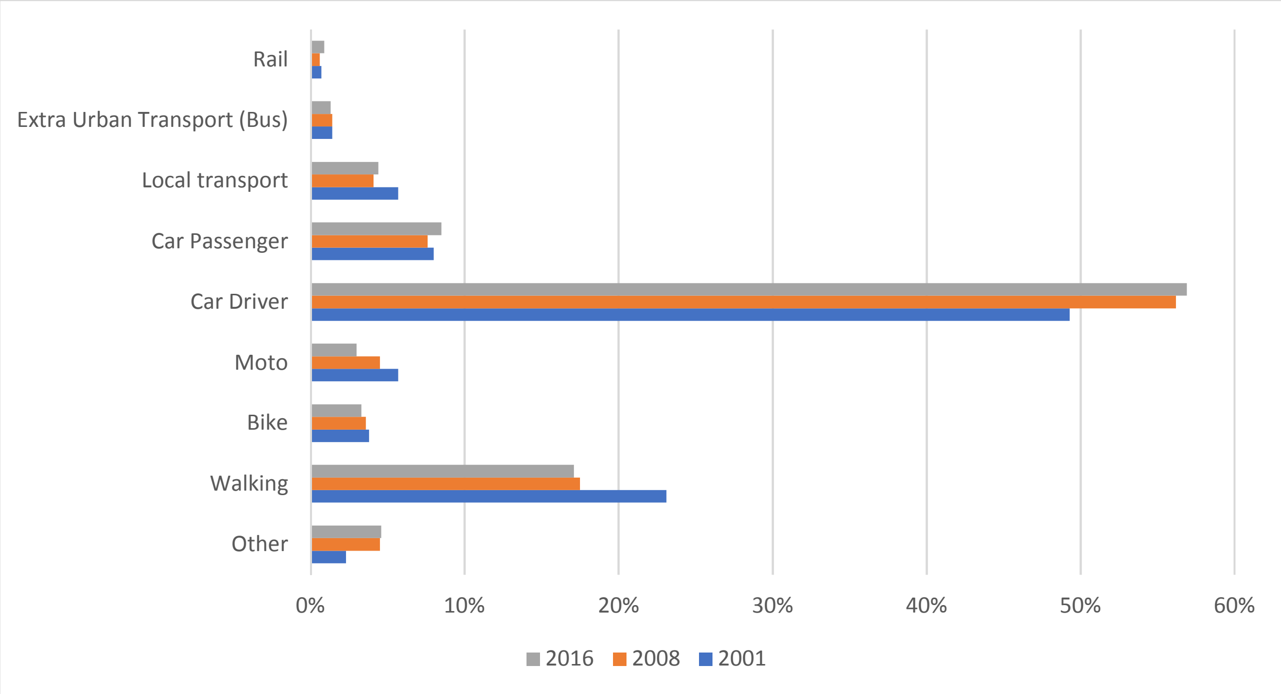

Figure 1.5 Transport modal share in Italy. Personal elaboration of data from Isfort.

Moreover, according to data from the AudiMob Observatory[2] (ISFORT, ASSTRA, ANAV) (Isfort, 2016), between 2001 and 2016 the eco-friendly means of transportation (feet, bikes, public transport) lost more than six points of modal share (from 37.2% 31.1%), while there was an increase of 6 % of car while the extra-urban train and bus remained more or less constant, while the Local Transport has a decrease. About 2 trips out of 3 are carried out by car (mostly as a driver) and the motorization rate in Italy is the highest in Europe, with the exception of Luxembourg.

In these dynamics, urban mobility is the determining factor: 73.6% (Isfort, 2016) of Italian mobility takes place within the city with proximity routes (on average about 4 km). However, Italian mobility, compared with other European nations, has some peculiarities. First, individual mobility (typically cars and motorbikes) is predominant. In Italy, in the major cities, the car has a share of 65%, while the percentage is 34% in France, 36% Germany and not more than 50% on EU average ((ISFORT, ASSTRA, ANAV; Isfort, 2016). Second, the average age of the vehicles is higher than in other countries (11.4 years in Italy, 7.8 in France and 6.9 in Germany) and this causes an increase in cost and pollution. Third, another Italian anomaly, compared to other European countries, is the undersized railway network: in Italy the metropolitan network has 3.8 km per million inhabitants, half than the one of Germany and one third of Spain (Eurostat, 2018). The result is a collective

[2] The AUDIBOM observatory, that is coordinated by ISFORT, carries out its activity through quarterly surveys on the mobility behaviour of Italian population, combining qualitative and quantitative aspects .

transport system that struggles to provide for mobility growth with standards comparable to those of the most advanced countries.

The strong "car dominance" is confirmed by the analyses on daily journeys to work (home to work or home to school), as explained in chapter 3. Using appropriate long-term structural measures affecting socio-cultural habits, this behavior could be changed to more sustainable practices for public services (where the service is available) or private (adopting solutions such as company or university carpooling or car sharing) (Colleoni et al., 2017).

In short, both modal shift strategies, (i.e. support for the transfer of demand from more polluting means of transport to those less polluting), from the road to the rail for passengers and goods, and the drive to use the best technologies, have so far obtained results that significantly reduce the social, economic and environmental cost of mobility (Rabl & De Nazelle, 2012; Blauwens et al., 2006; Chapman, 2007).

1.3 Environmental impact of mobility

As underlined in the Introduction, transport supports the growth of all the economic activities and it is a key element for citizens quality of life (Albalate & Bel, 2010; Woodcock et al., 2009). For these reasons the demand for mobility is constantly growing on a global scale (Enoch, 2016) and the rate of transport costs on family expenses is an increasingly important item, equaling to 12% in Italy, substantially in line with the European average (13%) (Rademacher et al., 2013; Eisenkopf & Knorr, 2018).

At the same time the sector is responsible for about 25,8 % of the energy consumption of the European Union (EEA, 2016) and represents an increasingly central element in European policies to combat climate change and reduce pollution in urban areas. The European statistics referring to the 28-member countries show that as much as 30.4% of greenhouse gases and 30.5% of carbon dioxide emissions, as well as a considerable part of the urban atmospheric and acoustic pollution, can be attributed to transport (EEA, 2016). These values for Italy rise to about 34% (Rademacher et al., 2013) and contrary to what has been accomplished in the industrial sectors, real estate and agriculture, the transport system in Europe and the rest of the world, has not been able to reduce its environmental impact during the last decades. In particular, between 1990 and 2014, the level of greenhouse gas emissions in transport in the 28 countries of the European Union increased overall by 20%. There were no discontinuities in the organizational or technological trends of the sector, which continues to remain dependent by as much as 94% of its energy demand on fossil fuels, without highlighting significant changes from this point of view for many decades (Arbolino et al., 2017; Ciacci et al., 2014, EEA, 2016).

Transport is the third largest sector responsible for greenhouse gas emissions in the 28 European Union countries, contributing 25.8% of total emissions in 2015 (Figure 1.6).

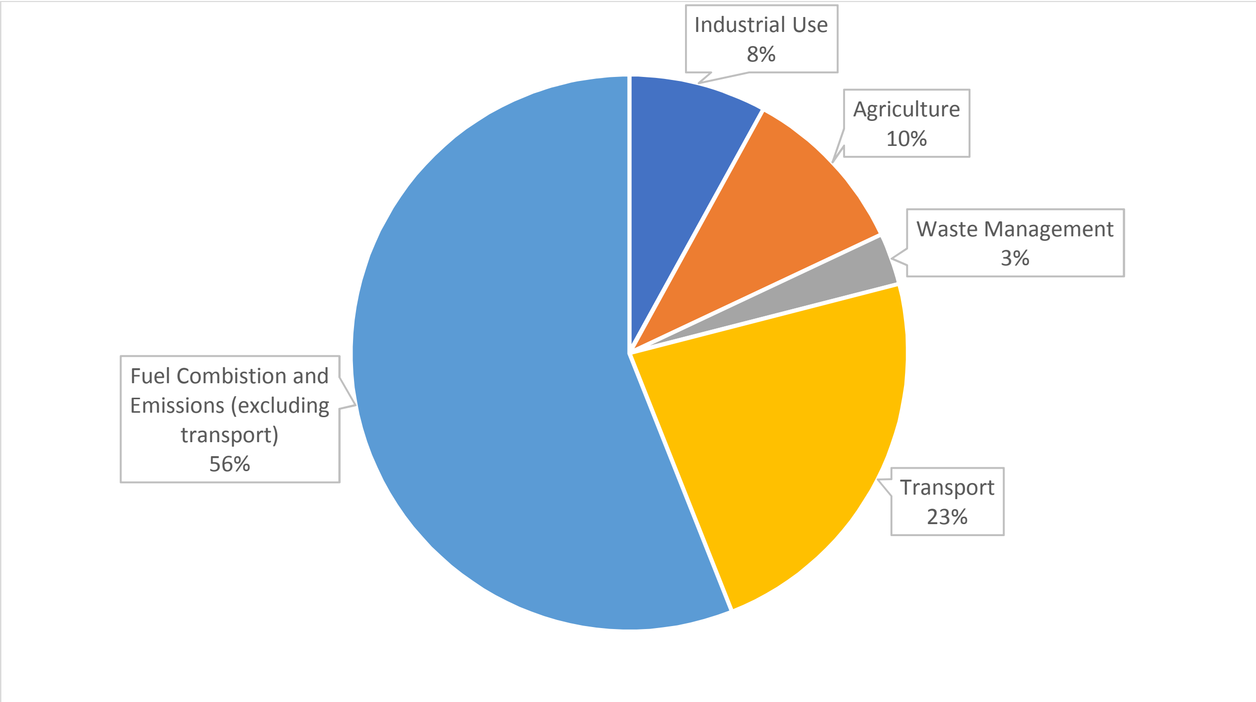

Figure 1.6 Sources of greenhouse gas emissions. Personal elaboration of data from Eurostat (2018).

In this context, 72.8% of the emissions of greenhouse gases produced by transport are related to the road mode, which includes (i) private cars, accounting for as much as 44.4% of the total emissions, constituting the main means of transport; (ii) trucks and buses, responsible for 18.4% of emissions in the sector and (iii) commercial vehicles used in urban distribution, producing 8.9% of total emissions (Eu Open Data Portal, 2018). For the above indicated reasons, it is important to find effective ways to encourage the population to use sustainable means of transport but, as sustained by Frändberg and Vilhelmson (2010), the promotion of sustainable transportation technologies and the behavioral change of people to into an eco-way mode is a very complex matter.

The descriptive picture of the transport sector emerging from the European data is therefore very complex, because although it is the protagonist of the main industrial innovations, it is not currently able to mitigate the environmental effects deriving from the ever-increasing demand for mobility (Holden, 2016; Vuchic, 2017; Russo & Comi, 2012).

The framework on the relationship between transport and the environment, although it highlights clear problems of a structural nature and which are difficult to solve, must take into account some recent innovations that result from a series of investments in research and development. In fact, large European companies producing the means of transport invest particularly heavily in research and development (4.4% of their turnover) and are responsible for 25.4% of total investments in research and innovation in Europe, according to the European Commission estimates for 2012 (Weber et. al, 2016; Proost et al., 2014; Urry, 2016; Rademacher et al., 2013).

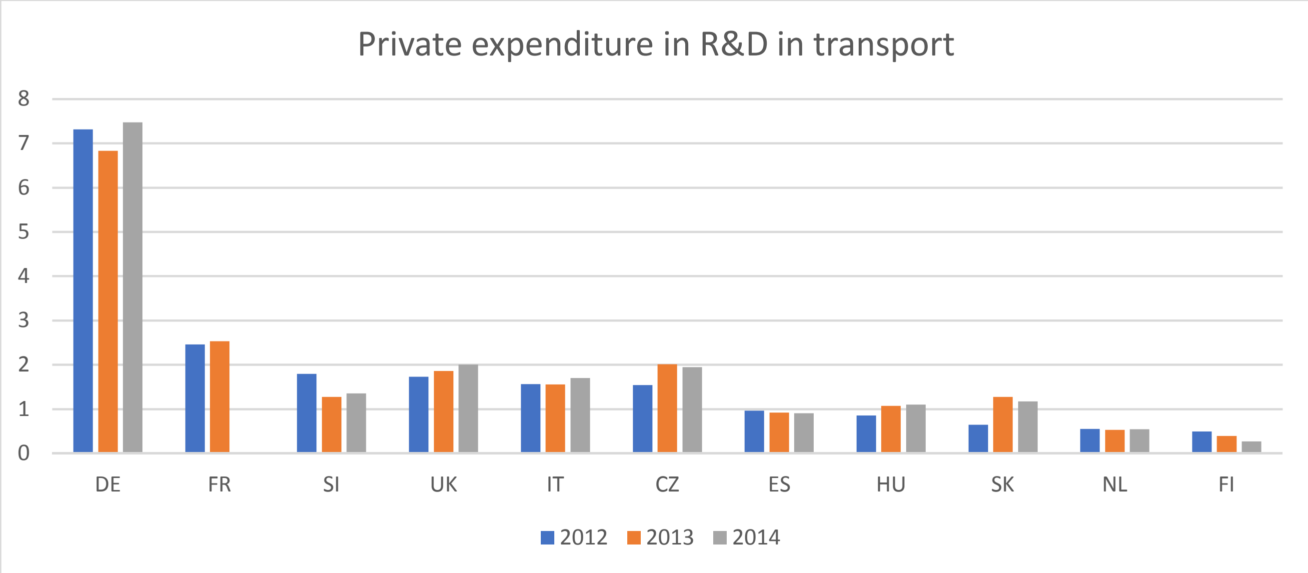

Figure 1.7 Investments of transport companies in research and development, as permillage of GDP. Source Eurostat (2018)

Considering the ten countries that invest mostly in the transport sector (permillage of national GDP) it emerges, from figure 1.7, that from 2012 and 2014 there is a permanent positive, with an increase of the investments in almost all the countries. This is a relevant information because, even in a period with a moderate economic growth, the transport sector is not affected by relevant reduction of investments in innovation and one of the main drivers of that situation is sustainability.

1.4 Sustainable Mobility

A relevant number of urban areas are dealing with the changes of environment and society due to traffic congestion, air pollution, urban over-growth and road safety problems. In the recent decades the increasing growth of urban areas has induced a growing demand for housing, building areas, infrastructures and services and sustainable mobility has become a crucial component for the city development (Campos et al., 2009; Beria et al., 2012). The excessive expansion of urban centers, together with shortages in public transport services, has led to a wider use of private means of transport, with a consequent increase in traffic and pollution (Brueckner & Selod, 2006; Albalate & Bel, 2010; Woodcock et al., 2009). of the car-based mobility has led to the awareness of an automobile dependence (Newman & Kenworthy, 1999).

The notion of sustainable development started to be applied to the transportation sector of the developed countries mainly from the 2000.

Sustainable mobility can contribute to social and economic welfare, avoiding damages to the environment (Nykvist and Whitmarsh, 2008). The structural dimension of sustainable mobility is an element that must combine ecological decisions with sustainable practices on a daily basis. (Naess, 2011; Naess 2006). One of the goals of sustainable mobility should be the maximization of loading factor of the collective means and infrastructure with a lower impact for the environment. (Kenworthy, 2006; Schmale et al., 2015).

More in depth, the aims of sustainable mobility can be divided into four macro areas, described in Figure 1.8. First, the investments in more accessibility should be concentrated in increasing the availability of sustainable transport services. This is one of the most important challenge of the Sustainable Urban Mobility Plans (Litman, 2003). Second, more liveability can be pursued by reducing atmospheric and noise pollution, congestion and the space used by motorized vehicles and guarantying more safety to pedestrian and bicycle users (Holden, 2016). As a consequence, this implies also more environmental sustainability (third aim). The fourth objective regards economic sustainability that can be achieved mainly by improving the efficiency of public transport services and infrastructure.

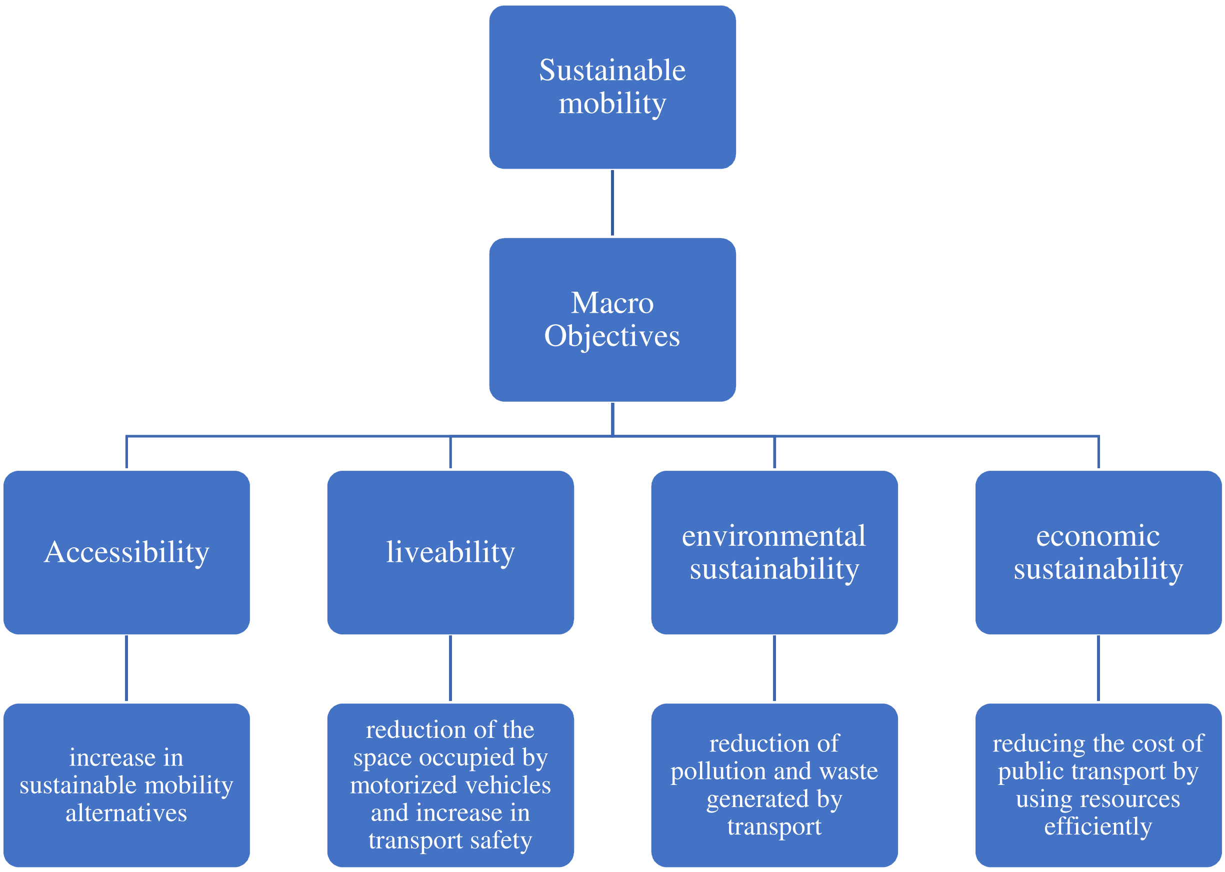

Figure 1.8 Aims and dimensions of sustainable mobility (author's elaboration).

1.5 Strategies and measures to implement sustainable mobility

According to the literature, the possible tangible measures to implement sustainable transportation can be of different types:

1) measures to foster the demand for sustainable private and public solutions, supporting actions and tax reductions or exemptions for multimodal transport systems, integrated mobility, shared mobility (Banister, 2008; Nykvist & Whitmarsh, 2008; Rye, 2016; Rotaris & Danielis, 2015; Valeri & Danielis, 2015).

2) Measures to encourage low-carbon private mobility, through the activation of bonus/malus systems, direct incentives and indirect incentives (tax exemption, vehicle tax exemption) (Heiskanen et al., 2010; Geels, 2012; Waisman et. Al., 2013).

3) Measures to support the transport supply, aimed at supporting innovation and industrialization of zero and low emission technologies, which are based on remuneration mechanisms (Benevolo et al., 2016; Burlina, 2017; Mwsailu et al., 2014; Haddadian et al., 2015; Gazzola & Querci, 2017).

4) Non-economic measures that provide incentives for the reduction of private mobility and the increasing use of intermodality and sharing: for example, education and communication campaigns and the promotion of suitable infrastructure (Rode et al., 2015; Diao et al., 2016).

The choice of the strategies is a political decision, and as such may depend on several factors over time and external constraints, such as international climate agreements (Fiksel, 2006). Since there is no universally transferable and valid strategy, different measures can be used, such as the renewal of the vehicle fleet (Zacharidis et al., 2001), the construction of the distribution and recharge infrastructures (Schroeder & Traber, 2012), the planning and integration of the collective and non-motorized mobility systems and the support to research and development investments (Prideaux, 2000). The definition of investment and incentive opportunities on different time horizons can be assessed using a set of variables that takes into account the costs and possible environmental benefits, the perspectives of technological evolution (through private research and development) as well as economies of scale that can be activated by the support of less mature technologies. Synergies with other industrial sectors will be important, as will the integration between the different services involved in sustainable mobility (Elzen et al., 2004).

Moreover, the decisions should be supported by citizens and stakeholders: their involvement in the implementation of the sustainability strategies will make decisions more legitimized by society (Renn et al., 1993; Khalili & Duecker, 2013).

Legal obligations imposed by the European Commission Directives on air quality or other international agreements can reinforce the success of sustainable plans (Banister, 2008). The same

result can be ensured by the availability of European funds for innovative solutions (Schiller & Kenworthy 2017; Holden 2016).
Moreover, mobility actions should be integrated with measures referred to other connected sectors (environment, economic development, health, safety, social inclusion).

1.6 The development of new forms of sustainable transportation

The relevance of the link between the transport system and the strategic objectives of sustainability (social, environmental and economic), which are the main challenge of the 21st century, is clear and should bring about a transition to new forms of mobility as a process of decision management (Robert, 2000; Mihyeon & Amekudzi, 2005; Elzen et al., 2004).
As previously mentioned, the transport market has moved towards sustainable alternatives that favor the decrease of C02 and tries to shift the user's attention to more efficient forms of mobility. It is possible to find these innovative forms for long distance journeys as well as for city journeys. They also cover individual forms (bike sharing, car sharing) as well as collective forms (carpooling, long distance bus). For this reason, in the next part of the chapter the salient features of these means of transport are outlined, underlining the most relevant theoretical references.

1.6.1 Carpooling

Carpooling is a transportation mode that aims to share the use of a private car among several people, with the main purpose of reducing transport costs and improving sustainable transportation to preserve the environment (Katzev, 2003; Dixit et al., 2012; Charles & Kline, 2006).
This mode of transport can take place spontaneously between individuals who have similar journeys by route and time slot, who agree to travel together, thus dividing travel expenses. The travelers can interchange in making their vehicle available or giving a sufficient sum of money to cover the drivers' car costs (Charles & Kline, 2006). In this way, a preventive organization of a necessary trip leads to an economic saving for all users involved. Regarding mobility, this practice allows the load factor of private vehicles to increase and is perfectly in line with mobility policies that aim to reduce congestion. There are two forms of carpooling, the spontaneous (Vincent-Geslin, 2010; Xin et. Al., 2009) and the organized (Berman & Radow, 1997; Correia & Viegas, 2011). The first refers to individuals who decide independently to have an informal agreement for systematic mobility journeys (home-work, home-study) by sharing or alternating the use of the private car. The second regards the organization and promotion, generally by the mobility manager, of this transport solution within companies (Donati & Petracchini, 2015; Marioli, 2013). The mobility managers are mandatory figures in companies that have more than 300 employees (in Italy) and are responsible

for organizing and encouraging different modes of transport than the use of private cars, such as for example the use of bikes, public transport and carpooling (Rugiero, 2012). For example, they should reduce the use of individual means of transport for public transport, improving the promotion of information on issues concerning sustainable mobility and favor the progressive diffusion of vehicles with minimal environmental impact between the employees and in the company fleet (Mulley, 2017; Barabino et al., 2012; Van Malderen et al., 2013). There is also the figure of the area Mobility Manager who is responsible for organizing and coordinating the company Mobility Managers and their initiatives (Bertuccio & Cafarelli, 2006; Millard-Ball, 2008). In the case of carpooling, the company mobility manager generally takes care of the incentive and organization of this practice, verifying the compatibility requirements between the participating employees (such as the proximity of the residences) and promoting the potentiality of this home-work mobility method between the employees.

Considering a geographical perspective, the practice of sharing cars is more common in the countries of northern Europe and in the USA where specific associations exist and where the practice is also shown by road signs, while it is still moderately applied in Italy (Van Vugt et al., 1996; Galizzi, 2004; Bertolin et. al., 2016; Danielis, 2014). In the last ten years, however, some specific initiatives have begun to be developed in various Italian regions, including Lazio and Lombardy. For example, a relevant, but not well known or sponsored, is the official initiative by Autostrade per l'Italia for carpooling. This initiative (one of the first in Italy, started in 2009) is currently active and it only operates on the A8 and A9 motorways to spur the idea of carpooling with the benefit of reducing the amount of motorway tolls (http://www.autostradecarpooling.it/). Another phenomenon that has been witnessed in the last decade is the creation and development of websites (such as BlaBlacar) dedicated to carpooling which facilitate the way passengers and drivers meet.

It is very clear that carpooling is a mixed form of mobility between the use of private transport (flexible and fast but not economical nor environmentally sustainable) and public transport (economical, sustainable but with obligatory solutions and coincidences for those using multiple means of transport). The literature underlines both advantages and disadvantages which are explained and analyzed below (Huang et al., 2014; Dewan & Ahmad, 2007; Vanoutrive et al., 2012; Hartman et al., 2014; Handke & Jonuschat 2013).

The main advantages are:

- Less vehicles in circulation, sharing a single vehicle reduces the number of cars with a single user on board
- Less pollution, a direct consequence of the lower number of vehicles in circulation

- Lower transportation costs, passengers divide direct costs such as fuel, parking and tolls
- Less wear of the private car, alternating the use of the car with other passengers
- Less psychophysical stress and a lower risk of accidents, alternating driver with passenger
- More parking, thanks to the lower number of cars in circulation
- Socialization, the passengers can share the means, as well as their own experiences and alleviate the boredom of the trip.

Despite these tangible advantages both at the individual level and towards the community, there are some points that hinder this practice (Xin et al., 2009; Ciasullo et al., 2018; Oppenheim, 1979; Hartman et al., 2014):

- Behavioral and cultural reasons, some people may prefer to travel alone due to the lack of privacy with carpooling.
- The journey can be made with unknown people.
- Constraints arise as it is no longer possible (or more difficult) to make stops on the outward journey (such as to take children to school on the outward journey when going to work) or on the way back (e.g. business reasons or commissions).
- Convenience of using carpooling only on longer routes, because otherwise the percentage of time necessary for any diversions and collecting passengers becomes not negligible on the total travel time and discourages the use of this practice.
- Contrast between carpooling and public transportation, even if they are both choices for sustainable mobility it is clear that commuter choices alternate between them.

Finally, it is important to note that there is less flexibility related to the individual use of the vehicle due to the fact that a prior agreement is needed (about the travel times and the effective route).

Nevertheless, the development of carpooling is increasing overtime and different measures are applied to promote it. Several cities around the world have created specific lanes called HOV lanes (High Occupancy Vehicles) dedicated to the exclusive travel by vehicles with more than one passenger on board (Konishi & Mun, 2010; Kwon &Varaiva, 2008; Shewmake, 2012). The first lane of this type was created in the seventies in the United States. Following this example, they were adopted in other countries and today they can be found in various places in the United States, Canada, Europe (Holland, Spain, United Kingdom, Austria, Sweden and Norway), New Zealand and Australia. However, this system is only useful where the rules are respected, otherwise it necessitates enforcement measures. Moreover, the economic incentives of companies for employees who practice carpooling can be introduced in private companies. Without these supporting actions, it is more difficult to implement these measures in schools and universities due to the different

working or studying times of people (Santi et al., 2014; Ben-Akiva, & Atherton, 1977; Rotaris & Danielis, 2014).
Another incentiving measure can be the reduction of parking spaces to encourage carpooling or the allocation of some parking places to carpoolers (Ciari & Axhausen, 2013; Ben-Akiva & Atherton, 1977). Carpooling between individuals has emerged in numerous companies and many websites try to meet the demand and supply. Some of them offer incentives for the busiest travelers (travel discounts, discount coupons, promotions regarding gadgets or tickets for events) (Griffin et al., 2015; Vanoutrive et al., 2012).
In recent years carpooling has seen an important evolution based on the creation of systems that use applications on smartphones or special devices which allow supply and demand to be synchronized in real time making dynamic carpooling possible (Ferreira et al., 2009; Ricci, 2015; Silwanowicz, 2017; Arcidiacono & Pais, 2016; Levofsky & Greenberg, 2001).

1.6.2 Bike sharing

Bike sharing, or shared bicycles is an important way for public administrations to implement sustainable mobility policies. The system of bicycle sharing, widely used in Europe, is also spreading in Italy where some municipalities have introduced this alternative mode of mobility in order to reduce pollution and congestion in urban centers by making public bikes available to citizens (by purchasing from the municipality itself or through agreements with private companies) (De Maio, 2009; Shaleen et al., 2010; Martens, 2004; Raviv et al., 2013). The system is generally organized in stations located at strategic points of the city, where it is possible to rent bikes that can then be left in the various bike parks located in the area of the service (Meng, 2011). Compared to the early days, technological innovation has allowed a significant increase in shared bikes users especially in Central European countries. Nowadays in many cities it is possible to locate the user in real time and access the rental bike quickly and easily through a downloadable app on a smart phone or with a text message. In addition, some companies offer a bike sharing station-free service, also called Free Floating. Compared to the traditional service, the difference here is the greater parking flexibility of the bicycle which can be left anywhere.
It soon became clear that the bicycle had many advantages over other means of transport on medium-short distance urban routes. It also does not create traffic congestion and manages to serve areas of the city that would normally require infrastructure or that are even inaccessible or not appropriately served by public transport.
This means of travel is affordable and cheap to maintain. Moreover, it is a good solution not to increase pollution and favor physical exercise which was gradually waning in an increasingly

sedentary society. Over the last 40 years there have been three generations of bike sharing (Fishman, 2016; De Maio, 2009). The first was born in Amsterdam in 1964 with the "*Witte fietsen"* or white bicycles which involved normal bicycles that were painted white and made available to citizens. Although the initiative was positive and unprecedented, it did not go as planned. In fact, the bikes were thrown into canals or they were the subject of vandalism of all kinds, even stolen and repainted for private use. Due to these problems the program collapsed within a few weeks. The failure of the project was due to a lack of public awareness as well as technical problems. The bike design was not one immediately recognizable or distinctive in shape or color. This made it possible to steal easily and repaint without being detected. Another important date followed in 1995 with a new bike sharing project called Bycyclen (in Danish), introduced in Copenhagen, which made many improvements to the previous one (De Maio, 2009; Shaleen et al., 2010). However, despite using the most reliable bicycles, the service lasted less than two years due to continuous thefts and damage.

A new variety of bike sharing was born some years later at the University of Portsmouth in England. The name of the new English bike service was "Bikeabout" (Black, et al., 1998; Black & Potter, 1999; De Maio, 2009; Henry & Paul, 2018) and proposed to use a university card, with a magnetic strip that, when it was passed in the appropriate service machine, allowed a bicycle to be taken. This allowed customer traceability for the first time, discouraging damage, theft or sabotage to the bicycle.

With the increase of bike sharing, companies that had to produce more parts grew more involved in the industry, producing technologies and their own parts. Many of the new systems have no components and are entirely sponsored by large agencies, but still require subsidies from local governments and user payments to be completely cost-effective (Midgley, 2009; Petri et al., 2016; Tran et al., 2015; Wang et. al, 2010).

The benefits of moving around by bike are well known; bikes do not pollute and allow people to socialize with each other as well as promote physical activity. Renting a bike also allows you to reach destinations that would otherwise be difficult to reach due to traffic and provides access to areas with limited transit, such as historic centers or areas for public transport. The main advantages of using this mobility solutions are the following (Wang et al., 2010; Midgley, 2011; Fishman et al., 2012; Raviv et al., 2013; Fishman et al., 2013; Yao et al., 2009; Marshal et al., 2016; Bush, 2012; Gazzola et al., 2018):

- *Sustainability:* using bicycles for city journeys reduces the pressure of vehicular traffic and consequently the pollution from the exhaust gas produced by the vehicles in circulation.

- *Increases free space:* bicycles take up less space than cars and therefore require less parking space. This, in addition to free space, allows the user to identify a parking zone more quickly and easily.
- *Health:* the use of bicycles, even for short trips, promotes daily physical exercise. This helps maintain better health and raises average health levels of the population.
- *Increases accessibility:* bicycles make it easier to access areas with limited traffic and historic centers allowing you to reach your destination more quickly and simply, avoiding having to cover long stretches on foot.
- *Saving time:* cycle lanes do not suffer from congestion and bicycles are able to go through city traffic fast, especially in typically congested urban areas traveling by bike is faster than using motorized vehicles.

Regarding the disadvantages of bike sharing, it is generally clear that the bike is a vehicle which is easy to steal and to damage. A possible problem is represented by the lack of available stalls or the lack of bicycles in the desired station. In addition, problems could arise with the magnetic card, although they are marginal events. Finally, the concept of road safety is fundamental to guarantee service development, but this element is relevant for all bike users and it is part of a broader mobility policy. Some of these disadvantages have been solved by the free-floating solution. In fact, bike sharing in free floating is a revolution compared to the traditional sharing systems, in which a person was forced to leave the bike in a certain location with the risk of not finding or finding them full. Often you need to make a detour of a few hundred meters from your destination, by bike and then on foot to find the stalls (Pal & Zhang, 2017; Wu & Zhu, 2017; Reiss & Bogenberger, 2015). Thanks to this feature there is no necessity to build special racks that are expensive structures for the municipality and they occupy sidewalks and parking lots in central areas (Reiss et al., 2015; Pal & Zhang, 2017). Another advantage is that, especially at peak times, the stations may be full, so you have to leave the bike in the nearest one, wasting time and having to make a detour. So far, the excuse of many cities and small urban centers in Italy has been the cost of implementing and disseminating the service / system (Pal & Zhang, 2017).

In urban centers where bike sharing systems have been implemented with few stations and bikes, bike sharing has proved to be a failure. People did not use it and did not subscribe to the service.

In addition, many bikes have become prey to vandalism and theft. In the case of Ofo and Mobike, on the other hand, a large number of them have been used improperly by parking them in their own backyard or locked up by others (Shaleen et al., 2010; Midgley, 2011).

It must be said that the Mobike service has implemented a defense service to prevent damage or theft by the uniqueness of the bike components that cannot be adapted to other bicycles, thus minimizing the risk of theft.

1.6.3 Car sharing

In recent years the concept of car sharing has gained attention in the metropolitan areas of North America and Western Europe. The aim is to offer a new mode of urban transport giving to the users the opportunity to access a fleet of shared vehicles for a shorter period of time, ensuring the comfort of the private vehicle combined with ecological and sustainable attitudes (Rotaris & Danielis, 2018).

The term "car sharing" defines the sequential use of a vehicle by several users, for the mobility time that they need. This is a service that allows a person to use a car on reservation, paying for the effective use on the basis of several variables such as time, distance, kind of vehicle and number of passengers (Bardhi & Eckhardt, 2012; Galatoulas et al., 2017; Rabbit & Ghosh, 2016).

Car sharing and car rental (it is important to make a distinction between them) are mobility solutions, alternatives to the conventional car ownership designed to offer the same services that the latter offers in the case of need (in the hinterland of residence). For example, a user can use car sharing when there is a need for flexible intermodal transport that is autonomous without having to use an owned vehicle.

From a market point of view there are an increasing number of societies all over the world that bring and provide mobility alternatives to individuals with respect to the traditional modalities of travel with their own vehicle, such as TPL or Taxi. These enterprises present the advantages of private cars providing effective services in terms of comfort, flexibility of use and choice of vehicle, using the car, without owning the property (Steininger et al., 1996; Shaleen & Cohen, 2013) A possible aim is to move from the ownership of the vehicle to the use of the same, so that the car is no longer perceived as a consumer good, but as a service; all this, however, guaranteeing similar benefits to those of private cars in terms of flexibility and comfort, but with lower costs if it is compared with ownership (Litman, 2000; Erceg, 2014).

It is important to remember that sometimes car sharing is improperly considered a synonym of carpooling, but the two concepts are different.

In an urban landscape in which car dominance is a distinctive element, shared cars can have extremely positive effects on the community (Zhou, 2012). In fact, car sharing can discourage the use of private cars. It would be included in urban areas as a complementary service to public transport (for example, Padua and Biella have stipulated agreements between the companies that deal with carpooling and local public transport, allowing users to take advantage of discounts for the shared use of these mobility options) contributing to a clear improvement of the offer, to a satisfaction of the needs of the citizens, and to a greater attraction of customers (Donati & Petracchini, 2015; Villani et. Al., 2004).

The operating scheme of car sharing (generally) is represented below in Figure 1.9:

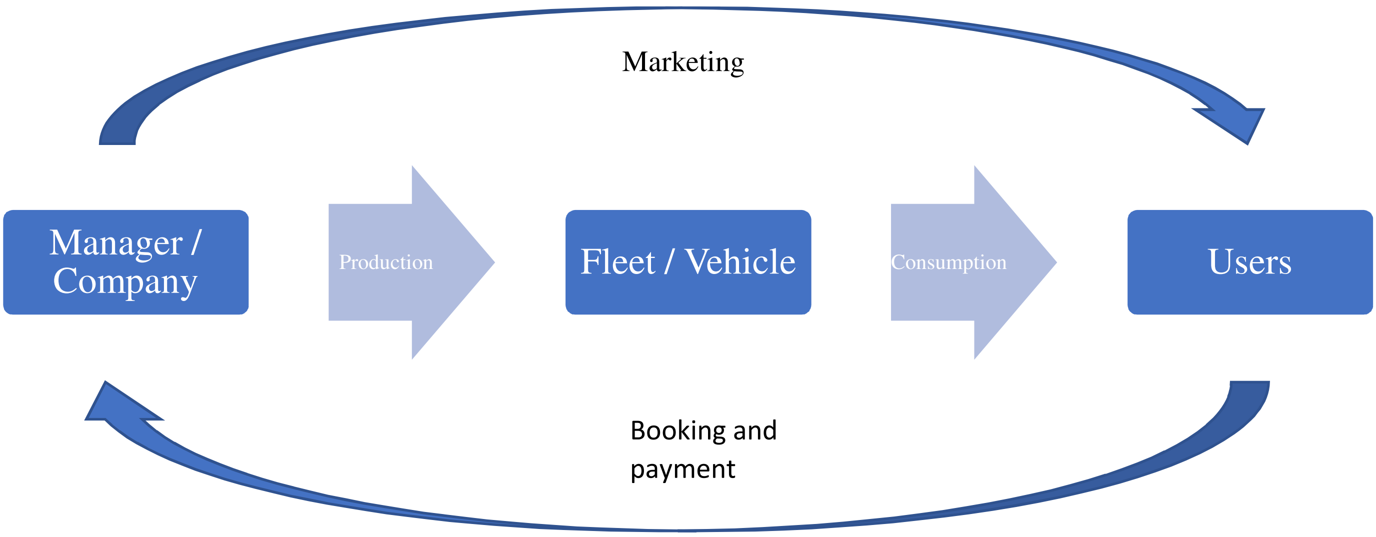

Figure 1.9 Car sharing organization. Author's elaboration.

It is possible to divide car sharing into 3 categories:

1. Car sharing P2P (Peer to Peer), or car sharing between individuals; this includes a fleet of vehicles owned by individuals or a community. The market combines the owners of cars available to rent them to people who are without a vehicle and are interested in using the car on certain occasions (Mariotti et al., 2013; Bignami et al., 2017);

2. B2C (Business to Consumer) car sharing, i.e. the shared car service offered by companies, which invest in this business with the aim of obtaining economic returns; among the various entrepreneurial subjects we find car sharing companies, car rental companies and even car companies (Novikova, 2017; An & Gu, 2015; Bardhi & Eckhardt, 2012);

3. Car sharing NFP (Not For Profit) is a local organization or community that seeks to encourage and facilitate car sharing with the aim of changing people's driving habits and making them aware of environmental sustainability issues, where sustainable urban mobility plays a very important role (Bardhi & Eckhardt, 2012);

As regards the history of car sharing, notwithstanding its only more recent development, the concept of car sharing originated in Zurich in 1948, where a cooperative called "Sefage" was established. In this cooperative, it was possible to find people who could not afford to buy a car and consequently they shared one for a purely economic purpose. Other attempts were made in the seventies in Europe (Montpellier and Amsterdam) but without success.

Starting from the eighties multiple actors decided to enter this market, the following table summarizes the most important development steps.

Year	**Place**	**Main elements**
1987	Switzerland	Creation of "Mobility": a private society that aimed to sensitize people to ecology and energy saving with the goal of sharing a car bought in timeshare.
1988	Germany	Creation of "Stattauto": a private society that also aimed to make mobility more environmentally-friendly, improve the ecological sustainable culture and to favor sustainably shared mobility.
1991	Europe	Founding of the ECS (European car sharing association) with the aim of standardizing objectives and results at a continental level. The ECS is a non-profit organization and in particular the following aims are proposed: - promote collaboration between organizations in order to facilitate user access to the service in all the cities of the ECS network - manage the preparation and supervise the standards of service and qualities that distinguish car sharing from other alternative forms of use in common car - devise appropriate ecological standards in the service and check the trend of environmental management - promote and support studies and research for the achievement of a high-quality service and greater environmental compatibility - provide assistance to new car sharing organizations during the setting up and roll out phase
1997	Switzerland	Birth of "Mobility Car Sharing Switzerland".
1994-95	Canada	Quebec City was the place of the first Canadian cooperative named "Auto-Com"; the same group of founders in 1995 extended the service to

		Montreal, giving life to "Commonauto" (the largest Canadian car sharing operator).
2000	USA	Born in Cambridge, Massachusetts, Zipcar is a company that then led to a breakthrough in the car sharing business. Taking example from the German and Swiss experiences, this company was a huge success immediately thanks to its program of collaboration with numerous American colleges and universities (more than 300). The novelty of Zipcar was the size, in fact, it was the first national-scale car sharing company able to provide a service in several regions. The strengths are the geographical extension of the network and the use of more than 10,000 vehicles.

Table 1.1 History of Car Sharing (Katzev, 2003; Muheim, 1998; Kemp et. al., 2000; Doka & Ziegler, 2000; Prettenthaler & Steininger, 1999; Steininger et al., 1996; Shaleen et al., 2006; Matzler et al., 2015).

In literature, there are a wide number of works that underline the main features of car sharing, dwelling on its advantages and disadvantages (Erceg, 2014; Ciari et al., 2008; Huwer, 2004; Litman, 2000; Kim et al., 2014; Bonsall et al., 2002; Agapitou et al., 2014; Shaheen et al., 2006; Millard-Ball, 2008; Efthymiou et al., 2013).

The most relevant advantages are:

- A low number of parking spaces is needed.
- Searching for parking spaces is far easier. It is also possible to park in LTZ without paying the parking fee. This can also decrease the time needed to find a parking space.
- Car sharing vehicles have a low average age and a high technological level.
- The number of private vehicles is reduced.
- Less car passengers causes a change in mobility behavior.
- Creation of contractual forms between local public transport and new forms of sustainable mobility (for example a season integrated ticket allowing the use of bike sharing and public transport).
- Breakdown of fixed costs more efficiently.
- Improved safety devices due to new generation cars.
- Reduction of C02 due to the lower number of cars and an improvement of the environmental impact of transportation.

Nevertheless, it is important to stress some disadvantages of this transport method. Considering personal and behavioral factors of sharing a car with strangers, there are some limitations in comparison to the use of private cars. For example, the car in CS cannot be used as a "traveling home", as it needs to be free of any personal items or customization, as well as be left reasonably clean and ready for the next customer. Moreover, this service could be not useful when there is not a car near the house or the work place. Another factor that could be a problem in sharing the vehicle with other users.

Despite car sharing is undoubtedly a novelty of the last decade, both on the demand side and on the supply side (Möhlmann, 2015; Munzel et al., 2017; Kathan et al., 2016), the empirical analyses of car sharing have revealed a market segment that has not yet proved totally effective and efficient for the citizens and also for tourists, as underlined by Danielis et al. (2012)

1.7 Long distance transport: the rediscovery of buses

In the previous paragraphs the analysis was mainly focused on sustainable mobility solutions for urban or medium-short travels. As regards the medium-long distance inland trips - typically of more than 100 km according to the European Commission (2005) - the only transportation solutions to cope the above described car dominance are trains and long-haul buses. It is well known that the train is an environmental friendly transport, which currently allows us to save C02 and, on the high-speed tracks, to travel quickly (van Essen & van Grinsven, 2011). The traveler is willing to pay the right price for an efficient and above all punctual service. This element is essential in choosing this transport mode. In fact, train delays (combined with the infrastructure constraint and low frequency) do not make it the best choice for all the trips and destinations (Olsson & Haugland, 2004). The importance of punctuality in affecting train performance and so in influencing the modal choice is analyzed in depth in the second chapter. Here the attention is concentrated on an alternative collective means that can be used for long distance: the long-haul coaches (Beria et al., 2016). In the last years, this service has evolved and has grown rapidly especially in Europe, because of low prices and high capillarity; but the journey times are longer than the train (Blayac & Bougette, 2017)

The bus is considered a sustainable means of transport, in terms of safety, environmental impact (with respect to private cars), flexibility and ability to respond quickly to changes in demand, without receiving substantial public funding. In particular, by encouraging people to use the bus as a means of collective transport it would create important environmental benefits, since the bus entails lower levels of CO_2 emissions per passenger than cars and air transport (van Essen & van

Grinsven, 2011). Moreover, energy consumption per passenger-kilometer is lower than most other means of transport.

According to the study by Stear Davies & Gleave and DG Move-European Commission (2016), it emerges that the interurban coach transports more than 9% of total passengers in the EU-28 (in the same period trains transport less than 7.5%). The prices for this type of transport are very attractive for groups, young people and people who need to go to a specific site without having time constraints. In fact, long-distance buses cover routes that are possible (in most cases) to travel with high-speed trains or airplanes but with a significantly lower cost and without the necessity to build a new infrastructure (Davies et al., 2004; Aarhaug et al., 2018; Augustin et. Al., 2014).

This is due to the laws introduced by many countries to facilitate the activities of private companies in the sector. An example of this vertiginous growth can be seen in Germany where the service (in terms of kilometers) has grown from 26 million km in 2012 to 220 million km in 2015, with more than 50 operating companies.

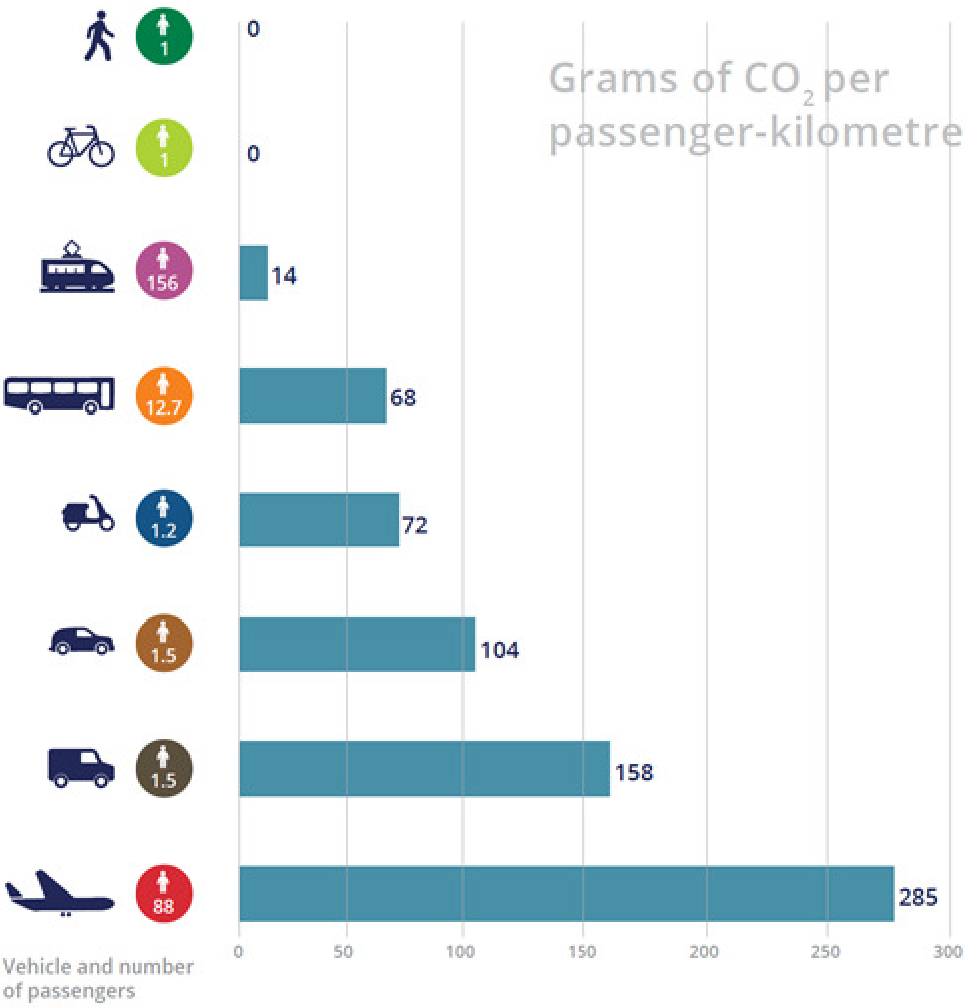

Figure 1.10 Pollution: Co2 grams per km. —Data from EEA (2018).

The regulation rule can vary according to the various European countries; three categories can be identified as follows:

- Full liberalization: in a fully liberalized market, operators can act freely with prior authorization from their respective authority. Depending on the country, there are some restrictions on long-distance lines. For example, in Germany, the authorization constraint consists of operating lines exceeding 50km or over distances where the distance by train is more than one hour (Jandovà & Paleta, 2018; Beria et al., 2018; Van de Velde, 2009).
- Liberalization by state concession: operators suggest new services to the authorities and request authorization to operate. This concession is guaranteed by the authorities without further analysis on the "need" of the market for this additional service or regarding the existence of another operator providing a similar service, or the other aspects of the service, such as ticket price (Van de Velde, 2009; Aarhaug et al., 2018).
- Liberalization based on "assignment": to operate a service, an official application must be submitted to each regional administration concerned, which thoroughly analyzes this request. The operator must provide, together with the official application, a contract that allows it to use the stations and stops along the line (Van de Velde, 2009).

The diffusion of the different forms of regulations is represented in Table 1.2.

No Coach Services	**Full Liberalization**	**Concessions**	**Assignment**
Switzerland	Ireland	Latvia	Poland
	Great Britain	Estonia	Lithuania
	Norway	Netherlands	
	Sweden	Belgium	
	Finland	Austria	
	Denmark	Hungary	
	Germany	Croatia	
	Czech Rep	Greece	
	Slovakia	Spain	
	Romania		
	Bulgaria		
	Turkey		
	Italy		
	France		
	Portugal		

Table 1.2 Long distance bus regulations by country.

Numerous studies have been carried out in this field. Some studies related to the performance of urban and interurban coaches analyze the relationship between efficiency and ownership, often identifying different results. For example, Vinning and Boardman (1992) found that there are differences between private and public companies in terms of efficiency, while other studies found no differences (Jørgensen et al., 1997; Odeck & Alkadi, 2001). Other studies highlight the role of competition on bus lines and found that there is more efficiency where there is higher competition (Borcheding et al., 1982; Odeck & Sunde, 2001; Fageda & Sansano, 2018).
Albalate et al. (2012) argue that the best solution for efficiency is to combine the public sector with privatization.

1.8 Concluding remarks on sustainable mobility

The concept of mobility has changed radically during the last decades. Transport sustainability, intermodality and technological development have changed (and continue to change in a quick and responsible way) people's habits and opportunities for movement. At an urban and interurban level, the panorama of data shows an increase in the demand for mobility (after a negative trend between 2009-2013) which it is attested in 2016 (Isfort, 2016; Isfort, 2010) on pre-crisis economic levels (in fact the European sample analyzed about 88% of people who make at least one journey per day).
In order to develop sustainability in the transport sector properly, it is important to observe and implement the following steps:

- inter-modality as a lever of change, which means a strong application of "network" logics on the operational side and of the programming of alternative services to private cars, as an element of managerial and economic success in transporting the urban centers: information apparatus with common, integrated and promotional tariff proposals, joint marketing between scheduled transport, taxi and call services, bicycle rental systems and the associated services.
- The innovation of the sector's governance systems according to the principles of territorial integration, transparency, participation. This aim should be used firstly to establish metropolitan authorities operating as a "control room" suitable to provide unitary guidelines, to orientate various actors and established interests, providing above all appropriate scale dimensions to the interventions. Moreover, along with the systematic nature of the public action, the spatial diffusion of the information (regarding the involved territory and the population) is a fundamental requirement to achieve significant results of environmental sustainability.

- The implementation of an extraordinary program of technological investments in ecological networks and local services. This should be related to urban planning and implemented according to criteria set out in specific national and community guidelines, paying attention to the definition targets that should be evaluated over time.
- The diffusion of urban space management policies, according to schemes that, over time, include urban development planning orientations targeting public transport ("transit oriented") and, in the short term, widespread solutions of traffic such as speed zones, protections to pedestrians and cyclists. In terms of development in more balanced regions, the "non-motorized" passengers, cyclists, pedestrians of various states (able-bodied, disabled, elderly, children) will become more widespread and full users of the roads, as it is already evident in some European countries (Belgium, Norway, Netherlands).

The conclusions lead us to surmise that there is certainly no lack of technical solutions in the world of passenger mobility (urban and interurban) that have been partially tested or that are viable in the next few years and which are moving towards more efficient transport systems from an environmental point of view. Indeed, the interaction of the "pushing factors" can be the starting point for policy making to become more effective and coherent in the long run.

The best way to contribute to economic well-being and social diffusion without destroying the environment or depleting natural resources will be to act quickly and carefully on different levers (regulatory, investment, promotion, technological innovation) and to consider the multiple territorial components of urban development to improve the eco-friendly modal choices instead of promoting the use of the private car as a primary means of transport.

It is clear that the change of user preferences in accordance with significant sustainability is relevant for the various transport companies that need to re-evaluate their value proposition process and adapt to the new market requirements.

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Chapter 2

The importance of punctuality in rail transport service: an empirical investigation on the delay determinants

2.1 Introduction

An efficient rail system is an important element for the development of the economic activities of a specific country or region. Economic exchanges, trade development, the possibility of improving communications and travel are the basis of railway development (Vickerman, 1997; 2018; Ponti & Beria, 2007).

Over the time the expansion of rail track has favored an increase in the productivity of different industries and in the accessibility and competitiveness of various cities and regions with the opportunity for a face-to-face communication process for knowledge production (Kobayashi et al., 1997). As sustained by Romer (1986), knowledge is a non-rival partially excludable good that can be available for firms or individuals through an exchange process that happens crosswise the spatial networks (Batten et al., 1989). However, the use of this transport mode is often curbed by the problem of low punctuality of many trains. Thus, the concept of arrival time (Sahin 1999; D'Ariano et al., 2008), i.e. of punctuality and delay, is one of the key issues to be afforded. The improvement of rail punctuality can help to promote the modal shift from the more pollutant modes to the rail, which is one of the most environmental friendly transportation systems (Goverde 2005; Lackhove et al., 2011). Punctuality has been defined in literature as: "The ability to achieve a safe arrival at a destination to an advertised timetable" (Gylee 1994) or "a feature consisting in that a predefined vehicle arrives, departs or passes at a predefined point at a predefined time" (Rudincki 1997). As a consequence, the total delay is given by the difference between the scheduled time and the effective time (Mattsson, 2007) and it is a crucial topic in the daily operational business of any transportation company (Huisman et al., 2005). For example, the shared use of the same infrastructure by different railway services (high speed, freight transport and local service), with different origins and destinations, speeds and halting patterns, is probably the main reason of the propagation of delays throughout the network (Vromans et al., 2006). Moreover unreliability, and the consequent delay, happens when there are deviations from the official timetable, getting worse the customer level of service and inducing a probable modal shift (Rietveld et al., 2001; Olsson & Haugland, 2004; Freling et al., 2005).

The aims of the chapter are: (i) to propose a new classification of delay based on the link between motivation, causes and responsibility, on the basis of the literature review results; (ii) applying this classification, to better understand motivation and responsibility of the delay on a specific interregional Italian line. A panel data analysis with fixed effects has been performed; the model variables represent technical elements of the train (engine, weight, rank etc.) and other features of the journey (load factor, direction, seasonality, number of stops, etc.). The main research question is which factors positively or negatively affect the performance of a train journey, in terms of punctuality (difference, in minutes, from the effective arrival time and the scheduled one).

Moreover, a survival analysis (Jardine et al., 1989; Andersson & Björklund 2011; Andersson et al., 2012; Andersson et al., 2016) has been applied for the period 2013-2016 on the same railway line, in order to understand the survival rate of the analysed trains.

The chapter is structured as follows. The next section presents the rail passenger situation, the rate use and the different thresholds of delay used to identify the train performance in Italy and in other European countries. Subsequently, a literature review on punctuality and delay is provided and the major existing delay categories are identified. In section 4 a new delay classification is proposed, that is then used in the regression model described in paragraph 5. The following section describes the survival analysis by a theoretical point of view and applies it to the same Italian railway line, which has been considered in the regression model. The chapter ends with some concluding remarks.

2.2 Delay and use of rail in Italy: a European comparison

The Italian railway network is 17,000 kilometres long: the ratio between railway network and motorway network is higher than in Spain and similar, but lower, than in France (Policicchio 2007; RFI.it 2017).

Figure 2.1 Railway map of Italy (from RFI. Com)

Although there is a relevant number or railway lines in Italy compared to other European countries, the Italians travel by train far less than in Germany, France and the UK (Albalate et al., 2015). According to the most recent and available data (2014, from RMMSand ERADIS)[3]), the average value of the indicator rail kilometres per inhabitant is less than 1000 in UK, 1126 in Germany, 1359 in France and 804 in Italy (Cartmell, 2016). Even if in Austria, Sweden and Denmark people travels more by train than in Italy, in all other European country's trains are used less on average with respect to other transport modes (in particular, car), because railway is not capillary and in certain European ares the level of service is low.

In recent decades, Italy has hardly invested in new railway lines to create a high-speed and/or high capacity network, with the purpose to increase the quality and quantity of rail trips, making transport flows more sustainable (Banister 2000; Giuntini 2006; Bergantino et al., 2013). This network has the undoubted advantage to promote the shift of the demand for transport from road to rail, and the introduction of new quality standards also thanks to the pressure of new competitive operators (Curtis & Low 2013; Pendolaria 2016).

Although the user of short or medium distance rail transport services has different characteristics and needs than the high-speed customer, there is the need to improve the quality also of these services, in particular in terms of punctuality that is a key issue for commuting passengers (De Luca & Pagliara 2007). Due to the historical and geographical connotations of Italy, both high speed and "normal" railway services are fundamental components of the national rail system that involves about 21.3 million passengers every day (Trenitalia 2015) of which more than 5 million of commuters (Pendolaria 2016).

As regards delay, the latest Report on the quality of Trenitalia's services (2016) indicates that the percentage of all categories of trains that had more than one hour of delay was less than 1%. Moreover, in 2015 the 91.6% of medium and long-distance trains (so called Frecciarossa, Frecciargento, Frecciabianca, InterCity and InterCity Night) and 97.9% of regional trains were on time.

According to the study on the prices and quality of rail passenger services by Cartmell (2016), among the countries with large rail networks, in Germany and Italy the delays in long-distance trains are higher than in other countries. In both countries, less than 75% of the trains were punctual in 2014. However, the data on punctuality of the European railways are not perfectly comparable, because the delay threshold, in minutes, varies by the country according to the type of traffic and purchase modality. The punctuality threshold in Germany is lower than in Italy, particularly on long

[3] https://ec.europa.eu/transport/modes/rail/market/market_monitoring_en ; https://eradis.era.europa.eu/

distance services, as shown in the table 1. In fact, the Italian railway company (Rfi.com, 2018[4]) considers on time the passenger trains that arrive at destination with a delay lower than 15 minutes for long distance services (including interregional ones) and less than 5 minutes for short (regional) distance services. As regards freight trains, the punctuality threshold is based on 30 minutes. These thresholds are frequently higher than in other European countries.

Country	Regional Services	Long Distance Services
Austria	More than 5 minutes	More than 5 minutes
Denmark	More than 2 minutes and 29 seconds	More than 4 minutes and 59 seconds
France	More than 5 minutes and 59 seconds	from 5 to 15 minutes due to the category of the journey
Germany	More than 5 minutes and 59 seconds	More than 5 minutes and 59 seconds
Lithuania	More than 5 minutes	More than 5 minutes
Netherlands	More than 3 minutes	More than 5 minutes
Spain	from 3 to 10 minutes due to the category of the journey	from 5 to 10 minutes due to the category of the journey
Poland	More than 5 minutes	More than 5 minutes
United Kingdom	More than 5 minutes	More than 10 minutes
Italy	More than 5 minutes	More than 15 minutes

Table 2.1: Delay and threshold in Europe Sources: author's elaboration on various sources (2018).

2.3 Literature review: punctuality and delay in railway transportation

2.3.1 Punctuality and reliability definition

In the transport sector, focusing specifically on the rail sector, punctuality is an important indicator to understand if the planned travel time is optimal. Dealing with delays is a crucial issue in the daily operational business of any public and private transportation company (Schöbel 2009). Some studies (Harris & Godward 1992; Bates et al., 2001; Cavana et al., 2007) have shown that it is a critical element that companies need to take into account for managing their service and it is a measure of the operations' reliability and performance (Veiseth et al., 2007). In fact, deviations from scheduled time reduce the level of service (Dingler et al., 2010; Nagy & Csiszár 2015; Olsson & Haugland 2004).

Punctuality is a complex indicator and not only a simple parameter to be taken into account. From the railway point of view (supply side), it is useful to measure the service quality level and to understand if the infrastructure, even in bad condition, is able to guarantee the connections. From

[4] RFI, that is the company of FS group which manage the railway infrastructure, calculates the punctuality threshold for the traces purchased at least 5 working days in advance the date of utilization.

the passenger demand side, instead, punctuality is a fundamental element to plan a journey especially in the case of interchange of different transport modes (Nagy & Csiszár 2015). Landex (2008) argues that when a train is delayed, passengers are also late, and this can influence their life quality and their future transport modal choice. Carey and Carville (2003) underline that the structure and the physical organization of a railway station and the number of people waiting at a quay for a given train are factors that potentially affect the timeliness of travel.

In the literature, many definitions of punctuality are available. According to Gylee (1994), punctuality is the ability to achieve a safe arrival at a destination to an advertised timetable. Otherwise, Rudnicki (1997) defines punctuality as a measured value that is able to indicate if a given known vehicle arrives or departs at a specific point in a previously set time. Subsequently, Hansen (2001) defines the same concept as a percentage of railway journeys that arrive or depart in a specified station of a railway network no later than a specified time in minutes. Moreover, Olsson and Haugland (2004) describe train non-punctuality as a deviation, usually negative, from the defined timetable.

Veiseth et al., (2007) give a definition of punctuality similar to Hansen (2001), as the percentage of trains that arrive on time at their final destinations. However, this percentage is considered as a reductive indicator by Olsson and Haugland (2004) and by Bititci and Veiseth (2005) because some other useful data are hidden (such as the delay and the recovery time for an intermediate stop).

Mattsson (2007) uses a mathematical equation to define the concept of total delay based on the difference between the effective time and the minimum time scheduled. Noland and Polak (2002) focus their attention on travel time variability that is a measurement of the uncertainty of trip journey times in transportation, and introduce in this concept also delays, early arrivals and cancellations. According to Nystrom (2005), punctuality is an agreement between passengers and the company, one of the most important components of the measured quality of the service. Passengers put high expectations on the reliability of train schedule, which strongly influences the positive perception of the travel (Salkonen & Paavilainen 2010). Harris and Godward (1992) show that the reliability of the arrival time is often more important than the train rapidity.

The shared use of the same infrastructure by different railway services (high speed, regional, interregional and local service, long haul and freight at the same moment), with different origins and destinations, different speeds, and different halting patterns, is probably the main reason for the propagation of delays throughout the network (Vromans et al., 2006). However, the specific delay volume relationship is dependent on the traffic mix on a route (Dingler et al., 2009; Krueger 1999; Bronzini & Clarke 1985). Different train types have different operating characteristics influencing the total delay that a train experience. Heterogeneity in these train characteristics causes additional conflicts, increasing delays (Dingler et al., 2009; Pachl, 2002; Abril et al., 2008).

2.3.2 Categorization of the delay

In literature there are some authors sustaining that unreliability, and the consequent delay, happens when there are deviations from the official timetable (Bruinsma et al., 1999; Rietveld et al., 2001). Unscheduled delays can be caused by numerous events including: mechanical failures, malfunctioning infrastructure, weather conditions, excessive boarding times of passengers, accidents at highway-railroad grade crossings, etc. (Vromans et al., 2006; Carey 1999).

Delays may be divided into different categories, but the terminology differs among the authors. Regarding the size of delays, Glyee (1994) defines "primary delays" as the delays with the greatest impact, while "secondary delays" as delays that are a consequence of the primary ones. In this last case, the delay of a train spread to the others that are following, causing a phenomenon that is called "cascading effect" (Dingler et al., 2010). The terms primary and secondary delays are used differently in Norway: according to Veiseth et al. (2007), secondary delays indicate the delays caused by other delayed trains, while primary delays are caused directly by the train, not considering the influence of the other ones. Gibson et al., (2002) instead call exogenous delays the primary delays of Glyee (1994) and reactionary delays the secondary delays defined by Veiseth et al. (2007), but with more emphasis on the interaction between different train operators.

Carey (1999) underlines that there is a difference between exogenous delays and knock-on delays. The first ones are due to events such as failure of equipment or infrastructure, delays in passengers boarding or alighting and they are equivalent to the concept of secondary delays developed by Gylee (1994). The second ones are directly related to a failure of the train.

Higgins et al. (1995) classify the delay, combining different causes at the same moment. They identify three categories of delay:

- Track related delay: it occurs when a train have a slowdown caused by track problems or a sudden and unexpected stop (e.g. infrastructural problems).
- Train dependent delay: caused when a train is forced to slowdown in a line section for reasons other than track problems (e.g. locomotive failure).
- Terminal/scheduled stop delay: delay that happen in a scheduled stop and is related to loading/unloading, train connections, fuelling and crew problems.

Müller-Hannemann and Schnee (2009) focus their attention on the importance for passengers, but also for railway companies, to have a real-time information system that is able to up-to-date train status information and provide to a user valid timetable information in the presence of disturbances.

They decide to classify the delay, according to the different possible motivations: disruptions in the operational flows, accidents, malfunctioning or damaged equipment, construction work, repair work, and extreme weather conditions like snow and ice, floods, and landslides. In their analysis, they focus on the concept of real time information. The usefulness of immediate information is crucial for the passenger who is able to find alternatives to reach the destination. For example, in Germany, an online system manages every day 6 million of forecast messages about timetable changes and also the latest prediction of the current situation.

Another classification is provided by Nelson and O'Neill (2000). By analysing the U.S. railway lines in the period 1998-2000, they categorize the reasons of delay linked to its nature, identifying: (i) engineering causes (referred to tracks, structures, stations, signal and communication instruments), (ii) mechanical causes about the rolling stock and (iii) transportation causes regarding decisions of the railway manager, dispatching procedure. In addition, they define other specific factors related to delay that are construction work, problems related to passengers, extraordinary circumstances and cascade delays deriving from the circulation of freight trains.

Mechanical delay is a component that is common for any transport operators and is representative of a failure of a train component. Nelson and O'Neill (2000) found that the major causes in this case are an engine failure, braking system and coach components problems. Moreover, they highlight that 13% of the total delay is due to extraordinary events, such as weather conditions, vandalisms problems with vehicles at crossing lines and police interventions. The authors argue that passengers are not directly responsible for most of the delays, but they are a contributing factor. For example, a train could be delayed by the presence of an incremental extraordinary number of passengers deriving from a train suppression or by the waiting for delayed passengers by the train crew. The influence of the train stops in a railway station on the delay was also studied in deep by Harris (2015), Harris Mjøsund and Haugland (2013) and Harris and Andersson (2007). Analysing the dwell time, that is the whole process of train stop in station, they have made some measurement about the duration of delays in station stops that concern the entire process of boarding and alighting passengers.

A summary of the different types of delay classification provided by the literature can be found in Table 2.

Delay Classification	Scientific papers author(s)	Delay nature
Primary and secondary delay	Gylee, 1994	Circulation problems
Cascade delay	Dingler et al., 2010	Circulation problems
Exogenous and reactionary delays	Gibson et al., 2002	Circulation problems (linked to primary and secondary delay)
Exogenous delays and knock-on delays	Carey, 1999	Circulation problems (linked to primary and secondary delay)
Track related, dependent and terminal stop delays	Higgins et al., 1995	Dwell time, engine and infrastructure problems
Motivations of delay	Müller-Hannemann & Schnee 2009	On-time information to users
Engineering, mechanical, transportation and other extraordinary causes	Nelson & O'Neil 2000	Engine, train and infrastructure problems
Dwell time	Harris, 2015; Harris et al., 2013; Harris & Andersson 2007	Stopping time in a predetermined station

Table 2.2: Summary of the literature review on delay classification.

2.3.3 Other literature findings related to delay and punctuality

Olsson and Haugland (2004), using data on Norwegian railway (from January 2002 to Avril 2002) and the Pearson indicator, found a negative correlation between punctuality and the load factor of local trains. In fact, when the load factor is high in peak hours or days there is less punctuality, while in the non-working days and in non-commuting hours the punctuality is better. They analyse also the relation between punctuality and cancelled trains for the Oslo area, finding a positive correlation. In fact, given a certain railway infrastructure capacity, possible traffic problems are due to broken trains on the line (Burdett & Kozan 2006).

Infrastructure capacity, in terms of number of trains on a specific line in a predetermined time, is one of the elements that can influence a journey and its possible delay. According to some authors (Dingler et al., 2009; Pachl ,2002; Abril et al., 2005), the relationship between performance and infrastructure capacity is negative: as the number of trains increases, the average delay rises, worsening the performance. This relationship is clearly affected by the number of the tracks available on a specific line. Moreover, it is possible to have adjunctive delays in crossing times in a railway station with interchange binary located along a single-track line; in that case, the delay regards not only the train itself but also all the trains traveling along the line in a specific moment.

A possible solution to compensate (small) delays is represented by the recovery time. It is a procedure that add supplementary minutes to the total running. The recovery time is decided by the rail companies and differs according to the geographical location or country. Pachl (2002) distinguishes between regular and special recovery time: the first one indicates the supplementary time usually added to running time (as a percentage), while the second one is introduced when there are speed restrictions due to maintenance work (on track, line, powerline, signal, informatics components) or track malfunctions or problematic weather conditions.

According to Beyene (2012) and Kroon et al. (2014), since a temporary speed reduction can cause delay that the train is not able to make up during its journey, there is the need to reschedule the timetable on the lines that are involved in this reduction; otherwise a delay is caused. Moreover, the eventual deceleration zones that can be required by a speed reduction could cause a supplementary delay. Both speed limitations and the unavailability of a sufficient number of platforms for all the trains are conditions that can influence the dwell time and can raise the time for boarding and alighting passengers. In the case of unavailable platforms or maintenance work, the role of the circulation manager is very important, in reprogramming the traffic, using the computer systems. He has to apply operational priority rules, taking two important decisions of delay management: the “wait-depart decisions” and the “priority decisions”. The first one is about the choice to maintain or not a connection in case of delay, while the second one concerns the order in which a certain train is allowed to pass on a specific track (Dollevoet et. al., 2014). In other words, the normal scheduling timetable should be modified giving priority to the most important trains, according to the commercial agreements. These delay management decisions should be taken also in the case of limited capacity of the tracks, as studied by Ginkel and Schöbel (2007) and Schachtebeck and Schöbel (2010). In fact, if two or more trains use the same piece of infrastructure (single track or double track), a priority rule should be given to one of them.

2.4 New classification proposal

As underlined by the literature review, there is not a common view in defining and classifying the different types and determinants of the train delay. For this motivation the following paragraph is dedicate to a systematic organization of the concept of arrival delay with a classification referring to some insights from some of the works mentioned above and focusing on the delay causes and their responsibility. This new classification will be used in a regression model presented in the next section.

Five macro causes of the delay have been identified in Table 2.3. As regards the first one, the concept of delay due to circulation causes is directly linked to the concept of secondary delay expressed by Olsson and Haugland (2004), and the concept of exogenous delay described by Gibson in 2003. In this case the delay of the train is due to a delay of a preceding train. For example, the train B which follows the train A is forced to stand still outside the station, because the train A uses more time than planned for the boarding and alighting operations.

Causes of delay
Circulation problems
Train Failure
Infrastructure Failure
Preparation Delay
External Delay

Table 2.3: Classification of different delay causes. Source: author's elaboration.

The second cause of delay is the train failure: as for other types of vehicles it is possible that a train has a failure and is unable to resume his march (or it takes some time to be repaired on site). This type of failure can occur in the station of departure or during the journey. The possible causes may be represented by a failure of the locomotive, problems with a door of a wagon or a malfunction of some train components.

As regards the third cause, it is possible that the railway infrastructure has mechanical breakdowns (switches, tracks, power lines). This type of failure affects indirectly a train, that has to wait for a despatch order to continue the planned journey.

The preparation delay occurs when the trains (engine and/or coaches) are not ready at the starting station. The motivation is related to problems about the availability of the effective material due to failure or absence of the corresponding train, if the material does not arrive from the depot. It is possible that the train is delayed due to failure of the track or the electric line, but in this case is classified as a failure of the infrastructure.

The last delay category refers to the external causes, as explained by Nelson and O'Neill in 2000. For this kind of situations (e.g.: intervention of law enforcement, strikes, seismic and weather events, accidents not attributable to railway operators) the role of the railway operator is secondary, but it is important to classify and to analyze this typology to understand its incidence on the performance of a railway journey.

Each of these macro causes is linked to the identification of the responsibility source (excluding the external delay). The model that will be briefly presented in the next section relates to the Italian reality, where there are two organizations responsible for the delay:

- Rete Ferroviaria Italiana (RFI), that was established in July 2001 as the 'Infrastructure Company' of the State Railways Group in response to the Community Directive transposed by the Italian Government on the separation between the network operator and the transport services provider; it is responsible for delays due to circulation problems and infrastructure failure.

- Trenitalia S.p.A., that is a 100% owned subsidiary of State Railways, and is the leading Italian company for the management of both rail and passenger freight; it has responsibility for train failure and departure delay.

On the lines where other rail companies compete with Trenitalia, such as Italo-NTV firm, they can be also responsible for the second and fourth types of delay.

Moreover, in addition to above presented macro causes, in the regression model the concept of *physiological delay* has been included. This is a variable that has been introduced to check when there is a delay but there is not a precise motivation and refers to all the mini-causes that may occur during a trip, such as a temporary failure at a door or a slowdown due to previous trains, that are resolved quickly. This last classification is relevant for the model because can allow us to classify also minor delays that are not included in the above presented classification. In our case the physiological delay counts all the delays between 5 to 9 minutes, but it is possible to apply with different limits to another model. It is important to remark that in this model the delay is associated to a specific cause only when a railway journey has more than 9' of delay at the arrival point. This is due to the availability of our data; the rail operator has not provided the motivation for delay lower than 10 minutes. This model is adaptable to other realities with a variation of the range of the performance (related to the concept of delay of the rail operator of a specific country).

2.5 Regression model

2.5.1 Description of the model

The aim of the model is the validation of the proposed classification of delay and subsequently the analysis of the value and weight of the different delay determinants from a statistical point, using panel data. The regression model takes inspiration from the study provided by Harris and Godward (1992), who apply a similar kind of analysis to verify which factors would affect the delay of a generic train journey using UK data of the late 80'. They found that distance covered, and train length were statistically significant in determining punctuality. For them it would be realistic to expect the increase in delay to be proportionate to the route length.

The model here presented is applied to a well-defined sample of railway journeys in working days commuting hours (from 6.00 am to 9.00 am and from 16.00 pm to 20.00 pm) in the period 2013-2016. The data, which have been collected from the official web site www.viaggiatreno.it, in addition to the information provided by Trenitalia Long-Haul refer to 16 trains along the Milan-Genoa line (a total of 15,600 observations). The data concern the characteristics of the line, the trip and the train, considering also its performance in terms of time.

The normality of the performance data is confirmed and sustained by the analysis made in previous papers (Goverde et al., 2001; Murali et al., 2010).
The model that is used in this chapter is a panel data with fixed effect: a statistical model where the parameters are fixed or non-random quantities, and the single observations about n entities or individuals, or cross-sectional observations are described for two or more moments over time (day, months, years) (Hsiao, 2014).
In panel data, in which longitudinal observations for the same elements, for a fixed effect model exist, the dependent variable should be measured for each individual on at least two occasions and those measurements could be comparable. The term fixed effects estimator refers to an estimator for the coefficients in the regression model including those fixed effects (Allison, 2005; 2009).
Table 4 presents all the variables that are included in the complete model, specifying the typology and the related literature.

Variables		**References**	**Format**
Performance	This variable represents the final arrival time of the journey measured in minutes.	Harris & Goodward, 1992; Harris, 2007; Harris et al., 2013; Harris et al., 2015	Numerical, logarithm of the performance
Causes of delay	These variables are related to the motivation of the delay. There is a variables per categories.	Abril et al., 2005; Burdett & Kozan, 2006; Landex, 2008; Gibson et al., 2002; Olsson & Haugland 2004	binary-5 categories
ID_Rail	Number of train		Numerical
Model of locomotive	From official Trenitalia Data it was possible to derive the real engine for each train. The 3 locomotives are: e464, e444, e402.	Harris & Goodward, 1992; Trenitalia Libro composizioni servizi universali 2013-2016	binary-3 categories
Weight-Weight with brake-Rank	This Variable represent the weight of the train in tons.	Harris & Godward, 1992; Trenitalia Libro	Features of the journey (numerical and binary)

		composizioni servizi universali 2013-2016	
Load Factor	This variable represents the estimated load factor for each journey. The estimations are obtained from Trenitalia	Olsson & Haugland, 2004; Alwadood et al. 2012; Harris, 2007	Percentage
Costs	This Variable is related to the cost of a single trip in standard second Class. It is expressed in €.	Bergantino et al., 2013	numerical
Number of_Stops	Number of stops per journey per train. It is expressed in numbers.	Vromans et al., 2006; Harris, 2007; Harris et al., 2013; Harris et al., 2015	numerical
Travel Time	Expressed in minutes it is related to the planned travel time (official Trenitalia Timetable). It is expressed in minutes.	Harris & Godward 1992; Carey 1999; Bergantino et al., 2013;	numerical
Direction	This variable is about the effective relation of the journey (Genoa-Milan or Milan-Genoa)	Harris & Goodward, 1992; Olsson & Haugland 2004	binary
Morning_Evening	This variable is about the hour of the trip (Morning or Evening)	Olsson & Haugland, 2004; Skjæret, 2002	binary
Ownership	This variable represents the ownership of the train (Thello, Trenitalia, Trenitalia DPR)	Bentivogli & Panicara, 2012	binary-3 categories
Season	The season of the year related to the journey considered	Dobney et al., 2009; Olsson &Haugland, 2004	binary-4 categories
Day	The day related to the journey (From Monday to Friday)	Dobney et al., 2009; Olsson & Haugland, 2004	binary-5 categories
year-Date	This variable express the date of the trip.		Numerical
Speed Restriction	The variable assumes value 1 if there is a speed restriction on the track. This variable is unique for all the track, so assume the same value with 1 or more speed restriction	Beyene, 2012; Landex, 2008; Olsson & Haugland, 2004	Binary- 2 categories
Weather Conditions	The variable assumes value 1 if there is a	Dobney et al.,	Binary- 2

	meteo alert and 0 if there is not a meteo alert.	2009; Huisman & Boucherie, 2001; Mattsson, 2007	categories

Table 2.4: Regression variables. Source: Personal elaboration.

2.5.2 Regression results

The results of the regression (see Table 5) confirm that all the causes of delay, that are directly related to the logarithm of the performance, are statistically significant in relation with the train performance (with a p value <0.001). According to the coefficients, external causes (such as floods, suicides, fires, accidents at level) are the typology of delay that affect more the performance of the train, followed by train failure, and, with a similar coefficient, departure delay and infrastructure failure (electric line, rails, level passes). However, since the coefficients of these variables vary in a small range (1.20-1.15), the impact of these types of motivation on delay is similar. The circulation problems' influence on delay, indeed, is smaller. In fact, even if the circulation conflict occurs more frequently than the other causes, it causes minor disadvantages in terms of minutes of delay. The last cause that is represented by physiological delay has, logically, the smaller coefficient of the classification. This is due to the fact that, as explained above, in this category there are only delays from 5 to 9 minutes.

Variable	Coefficient	P-value	Literature
Constant	-12.641	0.055*	
Circulation	0.82912	0.00 ***	Verified
Train_failure	1.16354	0.00 ***	Verified
Infrastructure_failure	1.15508	0.00 ***	Verified
Preparation delay	1.15063	0.00 ***	Verified
External causes	1.20505	0.00 ***	Verified
Physiological delay	0.50107	0.00 ***	Verified
Weight_Brake	-1.12	0.01 ***	Not in literature
Load_Factor	0.49	0.00 ***	Verified
Costs	0.02	0.12	Not significant in this model
Travel_time	-0.03	0.00 ***	Verified

Morning or Evening	0.05	0.17	Not significant
Winter	-0.06	0.00 ***	In contrast with literature
Summer	-0.06	0.00 ***	Verified
Monday	0.03	0.02 **	Verified
Tuesday	0.03	0.16	Not Significant
Wednesday	0.02	0.19	Not significant
Friday	0.04	0.006 ***	Verified
Speed Restriction	0.077	0.09 **	Verified
Weather conditions	0.071	0.07 **	Verified
Additional information			
Mean Performance	0.45		
RMS Performance	0.60		
R^2 LSDV	0.73		
R^2 within	0.67		
Durbin-Watson	1.84		
Number of Observations	15684		

Table 2.5: Results of regression analysis with all the data (model 1) Source: Personal elaboration using Gretl (http://gretl.sourceforge.net/). Note: the variables not statistically significant and not relevant for the analysis are not in the table.

As regards the other determinants, confirming the findings of Olsson and Haugland (2004), Alwadood et al. (2012) and Harris (2007), high load factor increases delay, negatively influencing the train performance; in fact, the coefficient is statistically significant.

There is an inverse relationship between total travel time, which is dependent on the trip distance, and delay. The data show that the regional trains have a lower average delay compared to long-hauls trains with longer scheduled travel time.

The costs and morning-evening variables (MOR-EV, that indicates if the journey is done in the morning or in the evening) are not significant in terms of p-value. As regards winter season variable, the model results are in contrast with the findings of Olsson and Haugland (2004), who sustain that the delay increases in winter. Probably this is due to the characteristics of the line analyzed and the weather conditions of the considered regions (Lombardy and Liguria). In summer season indeed the delay decreases, although this is not supported by the literature.

As claimed by Dobney et al. (2009) and Olsson and Haugland (2004), in the initial and the ending working days of a week, Monday and Friday, the delay results greater.
Finally, the regression shows that both speed restrictions and weather conditions negatively affect train performance, confirming the findings of Beyene (2012) for the first variable and of Dobney et al. (2009), Huisman and Boucherie (2001), Mattsson (2007) for the second one.
In addition, other restricted models were developed, by dividing the data into different categories, according to the direction of the train (from North to South or *viceversa*) and to the departure time (morning or afternoon). The following table shows the resulting coefficients.

Variable	**Model 1: all data**	**Model 2: North-South direction**	**Model 3: South-North direction**	**Model 4: Departure time in afternoon**	**Model 5: Departure time in morning**
const	0.11 (***)	0.16 (***)	0.070 (***)	0.20 (***)	0.03 (***)
Circulation	0.83 (***)	0.78 (***)	0.88 (***)	0.78 (***)	0.73 (***)
Train_failure	1.16 (***)	1.10 (***)	1.22 (***)	1.11 (***)	0.82 (***)
Infrastructure_failure	1.15 (***)	1.14 (***)	1.17 (***)	1.06 (***)	0.91 (***)
Preparation delay	1.15 (***)	1.14 (***)	1.15(***)	1.13 (***)	0.89 (***)
External causes	1.21 (***)	1.17 (***)	1.24 (***)	1.13 (***)	0.87 (***)
Physiological delay	0.50 (***)	0.45 (***)	0.55 (***)	0.42 (***)	0.83 (***)
R^2	0.73	0.67	0.67	0.67	0.88

Table 2.6: Results of restricted models and comparison with model 1 (coefficients value) Source: Personal elaboration using Gretl (http://gretl.sourceforge.net/).

It is possible to observe that there are very small differences between the general model and the models considering only one direction. The results of model 4 and 5 are much more interesting: in the morning the variables infrastructure failure and departure delay are more relevant than the external causes variable and the other causes. The external causes are more important in afternoon trips. The weight of the physiological delay is higher in the morning than in the other cases.
The R square is similar for the first three sub-models while it is much higher for the morning trips model.

2.6 Survival Analysis

2.6.1 Definition of survival analysis and censoring

The survival analysis is a statistical method to analyze the expected duration of time until a specific event happens. It may be applied to different issues, for example in the epidemiological area, the event of interest may be the death of a patient or the relapse following a disease or the response of a patient to a specific treatment. In general, in the survival analysis literature, death or failure, is considered the "event of interest". It is also called “reliability analysis” in engineering, “duration analysis” in economics, and “event history analysis” in sociology (Miller. 2011; Kleinbaum & Klein, 2010; Cleves, 2008).

The first step in a survival analysis is the calculation of "survival time", as the difference between the time to event occurred and the time of entry into the study of a statistical unit and it is typically a positive number (Despa, 2010). According to the general theory and concepts of survival analysis and model estimation (Kiefer 1988; Lancaster 1990; Klein and Moeschberger, 2005), it is possible to underline that:

- survival functions generate a hazard function for a consumer i, that describes the probability of defeat at time t, that is indicated as $h_i(t)$.
- The hazard function can be transformed into a survival function, which represents the probability S_i (t) that a consumer survives at time t conditioned to the fact that it is "alive" at t-1 time, that is $S_i (t) = (S_i (t-1) \times 1-h_i (t))$, con $S_i (1)=1$
- S(t) is constant in the time interval between two events. S(t) is a step function that changes its value only if the event happens.
- Time to event: The time between the subject's entry into the study until a particular "outcome".

In this technique, some units of analysis are censured, i.e. removed from the observation before failure, if for a certain period of time there are no information, or when they leave the study, or if the study ends before the outcome of interest is revealed. They are counted as "alive" for the time they were followed in the study. Furthermore, it is important to remember that dropouts are related to outcomes and treatment and they can distort the results.

There are two different types of censoring: left and right. Left censoring occurs when an observation is below a certain value, while right censoring when it is above a certain value, but in both cases the exact value in unknown.

Examples of censored observations are (Klein & Moeschberger, 2005):

- End of study
- Inability to follow the subject
- the minimum time t until a subject "survived".

There are several fields in which it is possible to use and analyze data with this technique (health, mechanical, railway). It is important to underline that the data distribution is not normal but exponential, Weibull and log normal distribution, as described in Table 6.

Distribution	S(t) Survival function
Exponential distribution	$e^{-\lambda t}$
Weibull distribution	$e^{-\lambda t^{\gamma}}$
Log normal distribution	$1-\phi\left(\frac{\ln(t)-\mu}{\sigma}\right)$

Table 2.7: Survival Analysis Distribution. Sources : Miller, 2011; Carlin & Louis, 1997; Cox & Oakes, 1984. Note: ϕ is the cumulative function of the normal distribution.

2.6.2 Applications of the survival analysis to the railway sector

To the best of our knowledge, in literature only few applications of the survival analysis to the railway field can be found. The aims of these applications are very different than those of our analysis, because they do not concern the rail delay issue. Jardine et al., (1989) used survival analysis to determine the risk of failure of diesel locomotives in Canada within the maintenance-related repair cost process. In their paper, they have decided to concentrate their attention on checking the Weibull form of the hazard function. They apply the failure time concept to the components of train equipment which have a well-defined point of failure after a length of time. Moreover, they consider some censored data that are determined when the engine has a motor change for another reason (e.g. a scheduled overhaul), or when "failure" has still not occurred before the end of the observation period.

Grube-Carvers and Patterson (2015) use survival analysis to test the relationship between urban rapid rail transit and the beginning of gentrification in the three largest cities of Canada.

More recently, Andersson et al., (2016) used survival analysis to estimate the cost of renewal of railway tracks. They used a sample of censored data containing nearly 1,300 observations on the Swedish main railway lines. They use a Weibull distribution to understand the failure time and develop a regression models to estimate the deterioration elasticities for total tonnage as well as for passenger and freight tonnages separately.

2.6.3 Application of survival analysis to Milan-Genoa railway line

The survival analysis has been applied to 15,684 train data relating to the Milano-Genoa line (equally divided in both directions) in the period 2013-2016 only in working days. The failure event is represented by the suppression of the train, that consequently does not arrive at the destination. The data censored to the right is represented by trains that did not have the cancellation, because they have not final destination in Genoa; in fact, there is a number of journeys that finishes in other destinations such as Ventimiglia/Nice Ville (West) or La Spezia/Livorno (East). It is important to

underline that the right censoring is not present in the South-North direction since all the trains have their final destination in central Milan.
The objective of this analysis is to test the data and verified the results with the declared percentage of the quality reports produced in the same years by Trenitalia 2013, 2014, 2015, 2016). In these documents there are data about trains arrived to a destination and the percentage of cancellations.
The spatial survival analysis (Ibrahim et al., 2005; Grube-Cavers & Patterson, 2015) can be very useful to check if there are any points (e.g. climbs, mountains) that can cause train failure. This analysis is useful also from a forecast point of view as it is possible, through estimates, to hypothesize what percentage of trains will arrive at their destination. Due to the data availability it is possible to understand the exact position of the train when there is the event (suppression) from a temporal and geographical point of view. Although this sample is not representative of the entire national railway system, the results of the analysis is even confirmed by the data provided by Trenitalia in its quality reports. In fact, as showed in Figure 1, in all the models the survival rate is close to 99% and Trenitalia declares that more than the 98% of the analysed trains arrived at destination. It should be pointed out, therefore, that the arrival is not related to the average train delay.
Stata software was used to perform this analysis with the STS function (Cleves, 2008; Lambert & Royston, 2009).

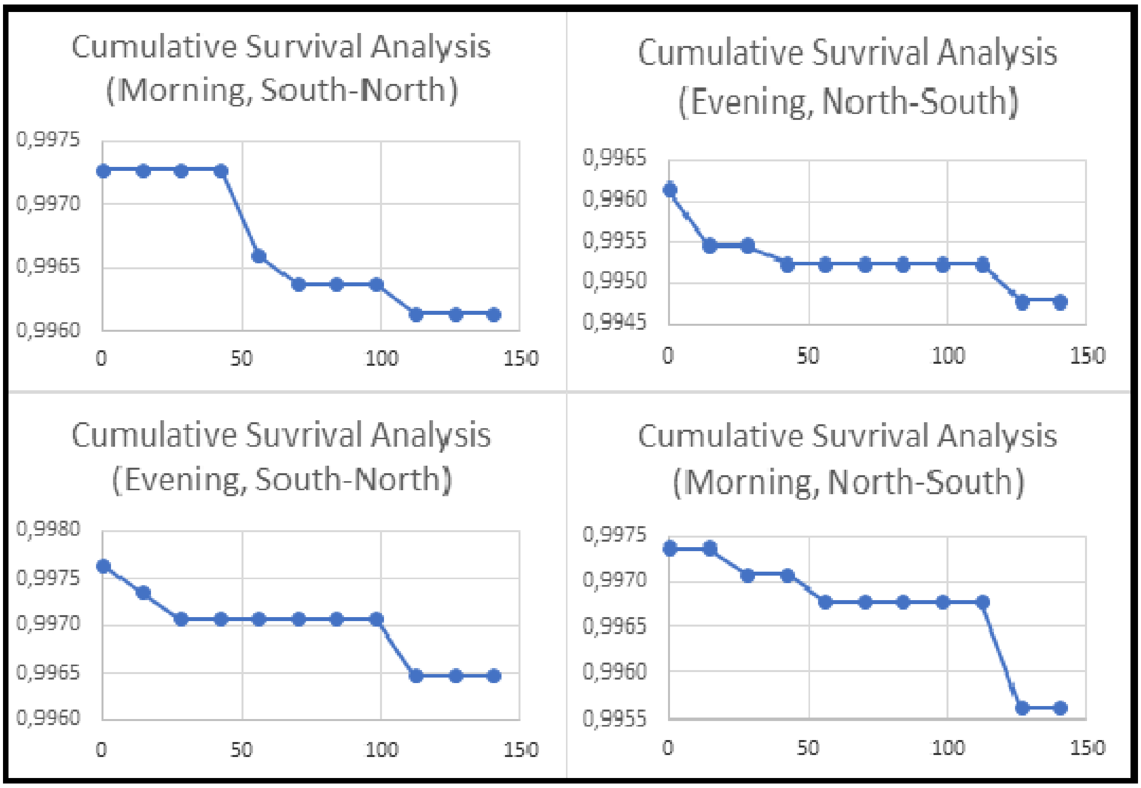

Figure 2.2: Survival Analysis 2013-2016. Source: Personal Elaboration using Stata and Excel on official data from Viaggiatreno.com.

2.7 Conclusions

One of the most challenging goal at present is to make more sustainable the growing passengers flows, rebalancing the modal shift in favor of train, that is less pollutant and energy consuming than car. Since the value of travel time in transport modal choice is often more important than the price, the issue of train punctuality is of key importance. Understanding the most frequent delay causes and their relative weight, compared to the others, can help the rail companies in identifying the most effective strategies to improve punctuality, positively affecting the choices of the travelers.

The present chapter gives a contribution to the existing literature in different ways. First, since there is not a common view in defining and classifying the different types and determinants of the train delay, a systemic classification of delay causes, and its responsibility is proposed and developed on the basis of the results of the literature review.

Second, it is the first analysis on the delay determinants performed in Italy, where there is a specific railway system, with different characteristics than other European countries, in the use, investments and also in the definition of the thresholds considered to identify if a train is on time or not. This analysis has been developed by using panel data regression models, focusing on an important railway line of Northern Italy, connecting the most important Italian economic city (Milan) with another urban area (Genoa) in which a key port is located. The regression analysis includes more variables than the majority of the other works on this issue, indicating which are the main causes of train delays, generally confirming the results of previous works but also determining the importance of new factors, such as the concept of the delay responsibility and the opportunity to apply the model also to other realities (this last factor is obviously subject to data availability), giving a weight to each determinant for the considered line.

Third, the chapter applies – to the best of our knowledge – for the first time the technique of survival analysis to determine the probability of train arrival at the destination on the same line. The resulting survival rate is confirmed by the empirical observations made by the railway company, Trenitalia, in its quality reports, suggesting the statistically goodness of the analyzed sample.

In the future it would be interesting to extend both the econometric and survival analysis to other lines or, if the railway operator will be available to provide information (since today this was not possible), to the whole Italian railway system, making comparison between different lines, regions and periods of time. Another possible application may concern the railway systems of other countries. Finally, another possible step would be the consideration of the concept of seasonality in the survival analysis, checking if the number of trains, that arrive to a destination, differs according to the travel season (Dobney et al., 2009; Olsson and Haugland, 2004).

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Chapter 3
Commuting to university: habits, propensity to change and public transport service evaluation. A case of an Italian polycentric university

3.1 Introduction

The increasing traffic flows, which characterize all the urban areas, strongly car-based, causing accidents, air pollution, noise and energy consumption - as described in chapter one - are one of the most important issues of the sustainable urban development. Urgent solutions are required to improve the citizens quality of life, by encouraging the use of alternative systems than private vehicles. There is the need, in particular, to affect the behavior of systematic mobility that is mainly composed by commuting to work or to school. The chapter focuses on this type of travelers, exploring the case study of a medium size Italian University: University of Insubria (Uninsubria). It is a public university founded in 1998, that is located in the North-Western part of Italy and has two main poles, Varese and Como, which attract a growing number of students and a third minor site in Busto Arsizio (Varese).

Each university pole is an important attractor node that causes both positive and negative impacts on the area where it is located; only a shared mobility strategy, involving both academic body and local policymakers, could positively affect the level of livability of the city.

The aim of the chapter is to analyze the commuting habits of students, professors and administrative staff from house to work, using the data of a survey performed at the University of Insubria in November 2017 (about 2,800 observations). The results of the analysis could give a relevant contribution to understand the current mobility dynamics and to design possible solutions able to orient the commuters towards sustainable transport modes.

In particular, the research questions are:

(i) does the alleged car-dominance in commuting habits characterize all the Uninsubria poles or are there differences? (ii) which are the main drivers that affect the user's modal choice?; (iii) from a policy perspective, how do commuters, who use public services in the two main poles (Varese, Como), evaluate this service?; (iv) which are the attitudes of the involved community to change the transport modes, reducing the use of personal car and taking over all the potential barriers?

From a methodological point of view, both descriptive statistics and an econometric model is applied. A multinomial logit approach is used to analyze the commuters' habits and the propensity to change the modal choice, while the pairwise Z-test statistics is applied to check if there are any differences between the two main sites of the University in choosing the public transport services.

The chapter is structured as follows: in the first part it is illustrated the theoretical framework on commuting to work and commuting to university and the link with sustainability. Subsequently the survey is described through its main elements, highlighting the research questions and using the descriptive statistics to present the sample. In the second part of the chapter the econometric analysis (multinomial logit) is presented, aimed at identifying the most significant variables that determines the modal choice in the commuting process home to work. Moreover, in the section 3.6 it is provided the comparative analysis of the public transit and finally, section 3.7 presents the analysis of the propensity to the modal change versus greener sustainable transport solutions.

3.2 Literature review

3.2.1 Sustainable commuting: habits and propensity towards a behavioral change

As described in chapter one, sustainability should be understood as a continuous process, which requires the need to combine the three fundamental and inseparable dimensions of development: environmental, economic and social (Sharpley & Telfer 2015; Adams, 2008; Kates et al., 2005). These concepts are strongly connected with the urban environment and its features such as the characteristic of mobility. The model of commuting is changing and moving every day to go to work - or for other reasons of systematic mobility - becomes more difficult. In fact, the average length of journeys tends to increase, attesting now an average of over 25 km (Isfort, 2016). A precise monitoring of the profiles and the dynamics of commuting, possibly focused on a local scale, allows the policymaker to understand the needs of the demand and to organize more balanced policies on the supply side. In the recent years local governments are seeking effective ways to promote sustainable commuting for reducing energy consumption and improving commuters' experience (Willamowski et al., 2014). Sustainable commuter traffic will contribute to an improvement of the living environment of the inhabitants of the region. Although the notion of sustainable commuting may not necessarily be a contradiction in terms, the road to achieve this goal may not be as easy and straight (Shaw & Gallent, 1999; Coleman, 2000; Rietveld & Daniel, 2004).
One of the possible resistances to a modality change is surely represented by the behavioral aspects, in particular the predominance of some specific habits which guide the modal choice (Paez & Whalen, 2010). In particular, consolidated habits reduce people's perceptions of different modal alternatives, negatively affecting also the predictive ability of mathematics-based models, based on the assumption of perfect rationality of travelers. Bounded rationality should be introduced in the analysis (Shannon et al., 2006). Moreover, the use of commuting information to increase the level of knowledge and the promotion of more awareness among commuters on the availability of

sustainable forms of transport could be one of the keys for varying travel decisions (Shaw & Gallent, 1999).

In literature there are many studies focusing on the different factors influencing modal changes, that often are external to the transport scope (e.g. a change of residence) (Klockner, 2004; Stanbridge et al., 2004). Ouellette and Wood (1998) sustain that a key event, such as changing jobs or passing the driving test, can affect breaking habits: a change of habitual behavior and an increase in consciousness of the decisions.

According to a Eurobarometer survey conducted in 2011, consumers affirm, generally, that they are available to change their habits to reduce CO2 emissions. In the 66% of cases, motorists say that they are willing to accept a compromise regarding the size of the car, in order to reduce emissions. A part of them (62%) declare the same concept also for small distances related to common daily actions. Finally, the 60% affirm that they are available to pay a surplus price for the car if this can help the reduction of emissions. Moreover, in that survey, the clear majority (71%) of motorists think that public transport is less comfortable than cars and a similar percentage (72%) affirm that there is a problem of lack of connections to reach a destination.

The successive Eurobarometer survey (2015) investigated the possible modality change to green alternatives, trying to understand which are the features and the elements that can limit the use of cars and motorbikes. It emerged that frequency and the geographical coverage of the services, and the price of tickets are important elements. Besides, it is important to remark that about 20% of the participants affirm that nothing would encourage them to use public transport more often.

However, since the quality of the public transport services is generally rated unsatisfactory, the public decision-maker should allocate more resources for the upgrading of services (and networks) and for the modernization of rolling stock. But, also transport providers should improve the quality of services and adapt better their characteristics to the demand and its segments' needs.

Several studies have explained that there are a lot of factors (such as availability of seats, comfort, safety and security, cleanliness) that determine the perception of the quality of public services (Redman et al., 2013; Bilişik et al., 2013; Eriksson, 2011; Shaaban & Kim 2016). Poudenx (2008) and Goyal (2003) argue that frequent monitoring of commuter's opinion can be effective to improve the service and to increase the number of users. If the service is considered positive, an increasing number of people are encouraged to use it. Focusing on costs it emerges, from the literature, that travel time and ticketing costs are, in descending order, important aspects that can motivate commuters to choose public transport (Cantwell et al., 2009). Furthermore, an integrated tariff system (ITS, Integrated Tariff Systems), possibly together with a good quality of services can make some change the on the user's behaviour in favour of public transportations (Abrate et al., 2009).

A high population density in a given geographical area can both support the development of a public transport service of higher quality and encourage a greater number of walkers and bikers (Hickman & Banister, 2005), especially in case of existence of direct routes for pedestrians and cyclists (Williams & Dair, 2007). Moreover, it is advisable to discourage private vehicle traffic in urban centres through a fair mix of dissuasive private traffic measures (LTZ, pedestrian areas, park pricing, road pricing, etc.) (Buchanan, 2015). It is important to reduce the time spent on the whole trip, avoiding that the traffic congestion of the "last mile" nullify the improvement achieved up to the access to the city centre (Liu et al., 2012; Shaleen & Chan, 2016).

Gatersleben & Uzzell (2007) have focused their attention on examining cognitive evaluations for the use of private cars and public transport and on the stress of commuter's related to drive a private mean or use public transport. For Steg et al. (2001) and Steg (2005) the emotional and psychological motivations should be considered, in fact when commuters are questioned on the motivations of their choice, they would tend rationalize their behaviour, not considering all the characteristics that are important for the modal choice. Moreover, the vehicle can also satisfy the need for self-affirmation by emphasizing the social position. Reasons such as health, respect for the environment and low costs are a determinant element for walking and biking (Hopkinson & Wardman, 1996). Joireman et al. (2004) and Matthies et al. (2002) underline the relation between the use of sustainable modes of transport and the environmental, social and personal motivations.

3.2.2 Commuting to university

A University or a college is a pole of attraction of students and workers, with different working hours and travel frequency and it contributes in various ways to the demand of local and regional travel. Therefore, a good knowledge of the preferences and the usual travel modes of university commuters could be useful to orientate sustainable mobility policies.

In literature it is possible to find a huge number of authors that, over the years, focus their attention on the usual displacements of students and high education students and workers, trying to understand travel behavior and the stability of the choices over time.

Some studies have underlined the relationship between the commuting choice and the house re-location choice during the academic period (living in the city where the university is located): high travel time for commuting increases the likelihood of opting for domiciliation rather than commuting (Rotaris, Danielis & Rosato, 2011) or influences the attractiveness for students to live near the university of attendance (e.g., Zhou, 2012; Limanond et al., 2011; Ubillos & Sainz, 2004).

Other studies have concentrated the attention on the relation between the university users' modal choice and the availability of a specific transport service to achieve the university (rail, low-cost air transport service, car sharing, etc.). For example, Henke (2017), focused its attention on rail transport. Students (and workers) that use this modality have usually to cover medium-long distances with a frequency from 2 to 5 times per week. In many cases the distance between home and the university, although long, is not encouraging the students and the workers to rent a room near the university for economic, logistics, behavioural or cultural reasons.

Cascetta et al. (2013) and Cascetta and Cartenì (2014a; 2014b) have estimated the quality and the accessibility of the rail transport and its influence on users' choice, using data from a survey at the University of Naples Federico Secondo. The results show that in terms of perceived utility, travelling from a station far 900 metres from home is equivalent to travel every day a distance greater than 28 km to reach the university.

Some authors have considered the influence of the presence of low cost companies on the level accessibility to universities. As sustained by Román and Martín (2014), air transportation has boosted the accessibility for people that decide to study and work in different regions, moreover this can conduct to create positive externalities for the destination area (Carlino et al., 2007) and attracting students from outside (Gunesh, 2017). Cattaneo et al. (2016) found that the evolution of transport services has decreased the negative effect of the distance and augmented the chances to choose among more different universities by increasing university accessibility. In their work they use a sample of 75 universities and 48 airports on a period of 10 years investigating this relation on a sample made by first year students that live more than 300 km to the attended university.

Morever, Danielis et al. (2016) have estimated the potential demand of carsharing by university commuters. They have elaborated a model that take into account within the commuter's needs and behaviour psychological costs\benefits (e.g. the pleasure of owning a car, value of the pleasure of owning a car, the pleasure of being a CS user).

Other studies concern modal choices (Delmelle and Delmelle, 2012) and activity travel patterns of university or college students (Chen, 2012). The two papers are referred to the relation between individuals and sustainable mobility during the different seasons of the year also with focuses on specific categories of subjects. Other works by Paez and Whalen (2010) and Shannon et al. (2006) try to explain the choice of different modes of transportation and the potential availability to change in terms of cultural factors. The results of the different studies are quite different. This is certainly due to several factors such as location and position of the university in comparison to the city center and/or the public hub of transportation and the presence or not of infrastructure able to support large volumes of commuters (Rodriguez & Joo, 2004; Delmelle & Delmelle, 2012; Lovejoy & Handy 2011). A better understanding of the travel behavior of students, who tend to use more frequently modes of commuting different than car, can generate valuable information on factors that can help sustain the habit of active transport (Whalen et al., 2013).

3.3. Data, survey and research questions

The University of Insubria is an attractive pole that generates, during the day, a relevant number of journeys, with different means of transport. The high number of users involved in the three poles of this university makes a flow of daily journeys, with different features, that make necessary to carry out an analysis to improve the current transportation system and to increase the accessibility in the three involved academic sites. To obtain a whole overview of the typical travels of students, professors and the technical-administrative staff, a survey was conducted to create a cooperation meeting table between the operators of shared mobility, local administration and the University. The purpose of the survey has been addressed to a deeper and more intrinsic analysis about the features of the trips, the characteristic of the commuters, the number of means of transport used linked with some concept of sustainable commuting such as the use of systems of Sharing Mobility. The online survey was carried out in the period that goes from the 13th to the 23th November 2017 and it was provided via a Google Forms' online platform.

The aim is to identify the travel habits of the university commuters, trying to answer to the following four research questions:

- RQ1: Does the alleged car-dominance in commuting habits apply for Uninsubria poles?
- RQ2: What are the main drivers of modal choice to/from Uninsubria?
- RQ3: From a policy perspective, how commuters who travel to different poles (Varese, Como) give value to alternative more environmental friendly modes?
- RQ4: Which is the travelers' propensity to shift to more environmental friendly transport modes (collective and sharing mobility)?

To understand the main drivers that affect the modal choice, a multinomial logit approach has been applied to the data after a procedure of geographical clustering.

Instead for answering to the other questions, descriptive statistics has been used, taking into consideration also the geographical position of the different university sites.

Finally, the pairwise z test is used to compare the evaluation given by the users to the public transportation services that are available in Como and Varese.

3.3.1 Structure of the survey

The questionnaire is made up of 82 total questions (see the annex 1); respondents were asked to describe the entire commuting trip, specifying the modality, the travel time and other useful characteristics. Additionally, respondents were asked to rate their satisfaction levels (for their principal means of transport) and to evaluate the public transport services (if used, with a Likert scale). The survey also gathered other information about respondents such as travel and mode preferences, socio-demographic characteristics and the use of the sharing mobility services.

More in depth, the survey is made by four main sections:

- Personal data: in this section, the interviewee is asked to indicate its personal information (sex, age, level of study and the role).
- Home-university trips: in this section, the respondent is asked to answer questions aimed to understand the characteristics of the usual travel.
- Means of transport generally used: the questions in this section are mainly aimed to understand the reasons that determinate the choice of transport of the user. These questions mainly differ according to the level of sustainability of the traveller habit in choosing the main transport mode. In the case of an unsustainable choice (car, motorbike), the interviewee is asked to indicate the average time taken for the journey made by that only means of transport; where his/her private vehicle is parked; what are the reasons for choosing that particular means of transport; what are the conditions that would cause the user to stop using it anymore and, above all, which other means of transport the user would choose if he/she were obliged to change; finally, if the choice of transport varies according to the season. Otherwise, in the case of a sustainable choice, a further distinction of questions exists depending on whether the user indicates 1) the city bus, extra-urban bus or train, 2) the bicycle or to go by foot. In the first case, the interviewee is asked to indicate the average time taken for the journey on that means, the characteristics of the trip and to evaluate the public service. In the second case, the interviewee is asked to indicate also the average time taken to travel between home and university, the motivation related to this travel decision and the eventual change when the weather is bad.
- Sharing Mobility: the last part, dispensed to all users, focuses the attention on the use of carpooling and bike sharing, and the shuttle service offered by the University for students, professors and technical and administrative staff of the Varese site.

3.3.2 The sample

The population of the University of Insubria, at the date of the survey, was composed of about 11,320 people: more than 10,000 students, 493 professors (including also some collaborators) and 320 persons in the technical-administrative staff, which are mainly concentrated in Varese (Table 3.1).

The sample is composed by 2,795 valid data, i.e. approximately 24% of the total university population. The 60% is represented by male and the 40% is represented by female. The majority has an age between 18 and 24, since the higher rate of respondents that are students (Figure 3.1).

Role	Busto A.	Como	Varese	Total
Students	59	2661	7787	10507
T.A. Staff	6	91	223	320
Professors	12	264	217	493
Total	**77**	**3016**	**8227**	**11320**

Table 3.1 Distribution of the population of the University of Insubria by cathegory and location (author's elaboration).

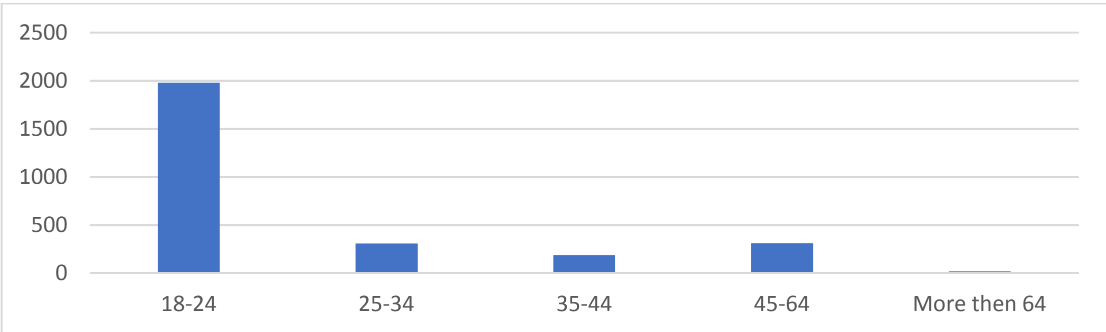

Figure 3.1 Age of the sample (author's elaboration).

City	Students	Professors	T. A. Staff
Varese	21%	62%	67%
Como	23%	15%	64%
Busto Arsizio	17%	68%	67%

Table 3.2 Sample distribution by category and destination (author's elaboration).

Table 3.2 shows the distribution of the sample by category and by academic sites, that is in line with the population distribution. The rate of students and T.A. staff that have participate to the survey is similar in three academic sites, while the number of the professors is high in Varese and Busto

Arsizio, but much lower in Como. The academic sites of Como, in fact, have a higher level of accessibility by train and are closer to the city center. It should be said, however, that this last data could be not totally adherent to the reality because many professors teach in more than one site, independently from the location of their Department (the majority of the departments are located in Varese). Nevertheless, the percentage of respondents for different categories is higher than 60% thus denoting a high interest about the mobility issue.

3.4 Results of the empirical analysis

3.4.1 Commuters' habits: descriptive statistics

The sample includes both single-mode commuters and multiple-mode commuters. Tables 3.3 and 3.4 summarize their transport modal choice in relation to the trip distance. Table 3.3, related to the use of only one means of transportation, shows that the car is the most used means for any distance, confirming the hypothesis of the University's strong car dominance. For commuters that use more than one vehicle, the distance influences the choice. In fact, as explained in Table 3.4, the urban bus is the most used if the distances is less than 3 km, while in the distance classes over 11 km the train is the first option.

Distance	Car	Motorbike	Train	Urban bus	Extra-urban bus	Bicycle	Other	N° of Observations
<3 km	52.60%	9.60%	0%	29.80%	0%	7.90%	0	114
3-10 km	77.20%	3.70%	0.80%	15,9%	0%	1.70%	0.60%	347
11-30 km	91%	0.90%	2.10%	1.20%	4.60%	0.10%	0	719
31-60 km	84.6	1.50%	10.30%	0%	3.10%	0.3	0.3	389
> 60 km	97.8	2.20%	0%	0%	0%	0	0	93

Table 3.3 Transport modal share by distance for unimodal commuters (author's elaboration).

Distance	Car	Motorbike	Train	Urban bus	Extra-urban bus	Bicycle	Other	N° of Observations
<3 km	31.60%	0.00%	5%	57.90%	0%	5.30%	0.00%	19
3-10 km	23.90%	1.10%	21.70%	34.80%	19%	0.00%	0.00%	92
11-30 km	16%	0.90%	54.00%	3.00%	25.90%	0.30%	0.00%	326
31-60 km	8.10%	0.00%	82.20%	0%	9.30%	0.00%	0.50%	432
> 60 km	3.80%	0.00%	93%	0%	2%	0.80%	0.80%	132

Table 3.4 Transport modal share by distance for multimodal commuters (author's elaboration)

Since the University of Insubria is polycentric, it is necessary to check if there are any significant differences in commuting to Varese than to Como and Busto Arsizio. The following three tables (3.5, 3.6, 3.7) help in comparing some main travel and trip characteristics, including the modal choice.

Variable	Students	Professors	T.A. Staff
Age (mean)	23,76	51,5	47,09
Gender	M (58%)	F (56.29%)	M (74%)
Frequency (n. days/week)	3,9	3,6	4,7
Main transport means (including foot)	Car/Motorbike (63.36%)	Car/Motorbike (76.82%)	Car/Motorbike (78.38%)
Number of means	1,55	1,32	1,12
Trip duration (min.)	46	46	32
Distance	28 km	40 km	17 km
Monthly cost for transport	€ 68	€ 78,45	€ 64,36
Incidence of transport costs on income (%)	No Income (57.8%)	Less than 5% (46.3%)	Between 5% and 10% (35%)

Table 3.5 Principal traveler and trip features: Varese.

Variable	Students	Professors	T.A. Staff
Age (mean)	23,49	50	45,63
Gender	M (69%)	F (60.32%)	M (62%)
Frequency (n. days/week)	4.1	3.5	4.98
Main transport means	Rail (34.67%)	Rail (46%)	Car/Motorbike(77.6%)
Number of means (including foot)	1,65	1,57	1
Trip duration (min.)	47	52	29
Distance	24,5 km	52 km	12 km
Monthly cost for transport	€ 68,82	€ 77,51	€ 58,63
Incidence of transport costs on income (%)	No Income (54.4%)	Less than 5% (55.5%)	N.A. (34.5%)

Table 3.6 Principal traveler and trip features: Como.

Variable	Students	Professors	T.A. Staff
Age (mean)	24,6	52,5	54,5
Gender	M (73%)	M (75%)	M (75%)
Frequency (n. days/week)	4,6	4,8	4,87
Main transport means	Rail (53%)	Rail (63%)	Car/Motorbike (75%)
Number of means (including foot)	1,86	1,87	1,5
Trip duration (min.)	51	57	28
Distance	26,2 km	41,1 km	13,5 km
Monthly cost for transport	€ 80,56	€103,31	€ 62,75
Incidence of transport costs on income (%)	No Income (47%)	Less than 5% (50%)	Between 5% and 10% (50%)

Table 3.7 Principal traveler and trip features: Busto Arsizio.

Variable	age	distance	start_time	end_tim	minutes	int_stop	freq	cost	n_means
Mean	27.7	27.27	8.19	16.55	44.91	0.27	4	67.8	1.53
Std Dev.	10.9	21.71	1.83	1.85	22.04	0.6	1.4	36.7	0.92
Max	68.5	231	16.3	20	75	2	6	120	4
Min	22	0.6	5.3	12	7	0	0.5	0	0

Table 3.8 Descriptive statistics on the sample characteristics

It is possible to notice that as regards age, frequency, average number of vehicles used, trip duration and incurred costs , there are no significant differences between the two main poles, Varese and Como while the frequency is higher in Busto Arsizio. It should also be noted that the average expenditure for students and teachers is much higher in Busto Arsizio than in the other two poles.

A very interesting factor is represented by the main means of transport which in the case of Vareseis the car for all the considered categories. In the other two sites, meanwhile, it is the train for professor and students and the car/motorbike for the T.A. staff. As a consequence, the level of sustainability of commuting flows to/from Como and Busto Arsizio is higher. This is confirmed by Figure 3.2, that shows all the transport modes used comparing the two most important university sites. Considering all the users together, the percentage of use of car in Varese is almost two times in comparison with Como, where train is predominant. This is probably due to the geographic position of the sites and the different level of accessibility of the two cities.

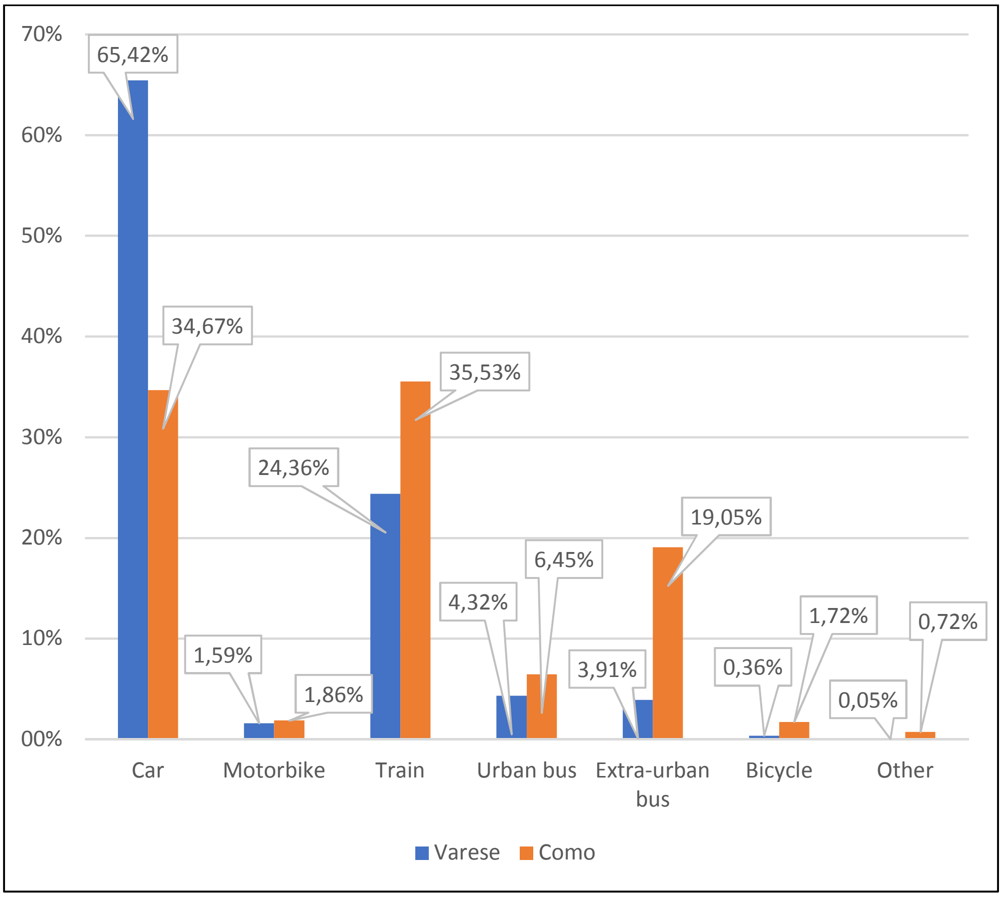

Figure 3.2 Commuting Modes.

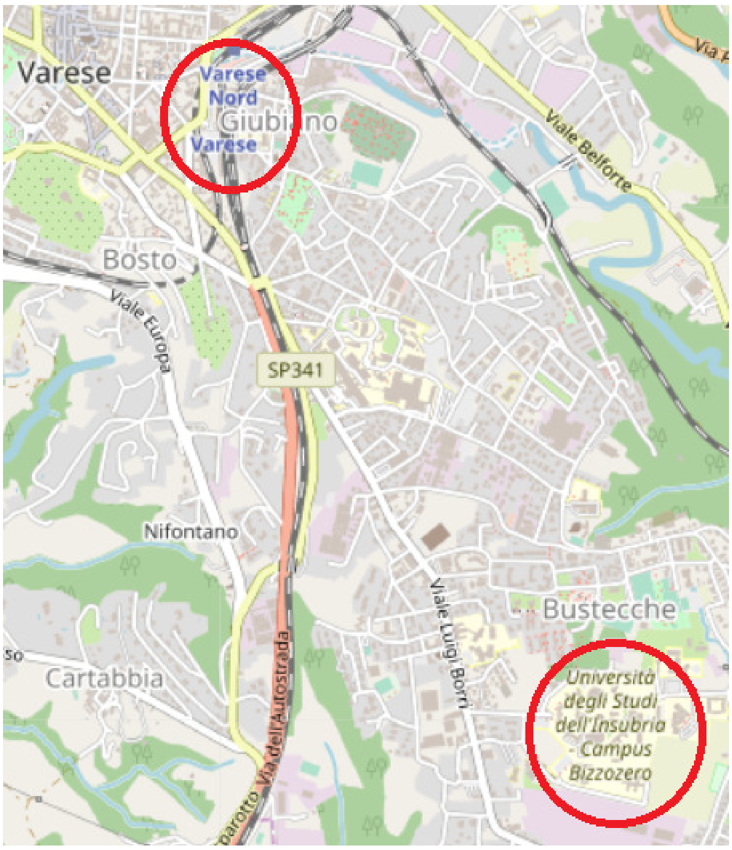

Figure 3.3 Location of university sites on plan of Varese.

In the center of Varese there are only few administrative offices, while the campus, which attracts all the students, is in a peripheral neighborhood (Bizzozero), far from the railway stations, that can be reached by two lines of local urban buses (that have not a relevant number of rides during the rush hours). Moreover, the campus of Bizzozero offers a large free parking, which is probably an incentive for the use of the car.

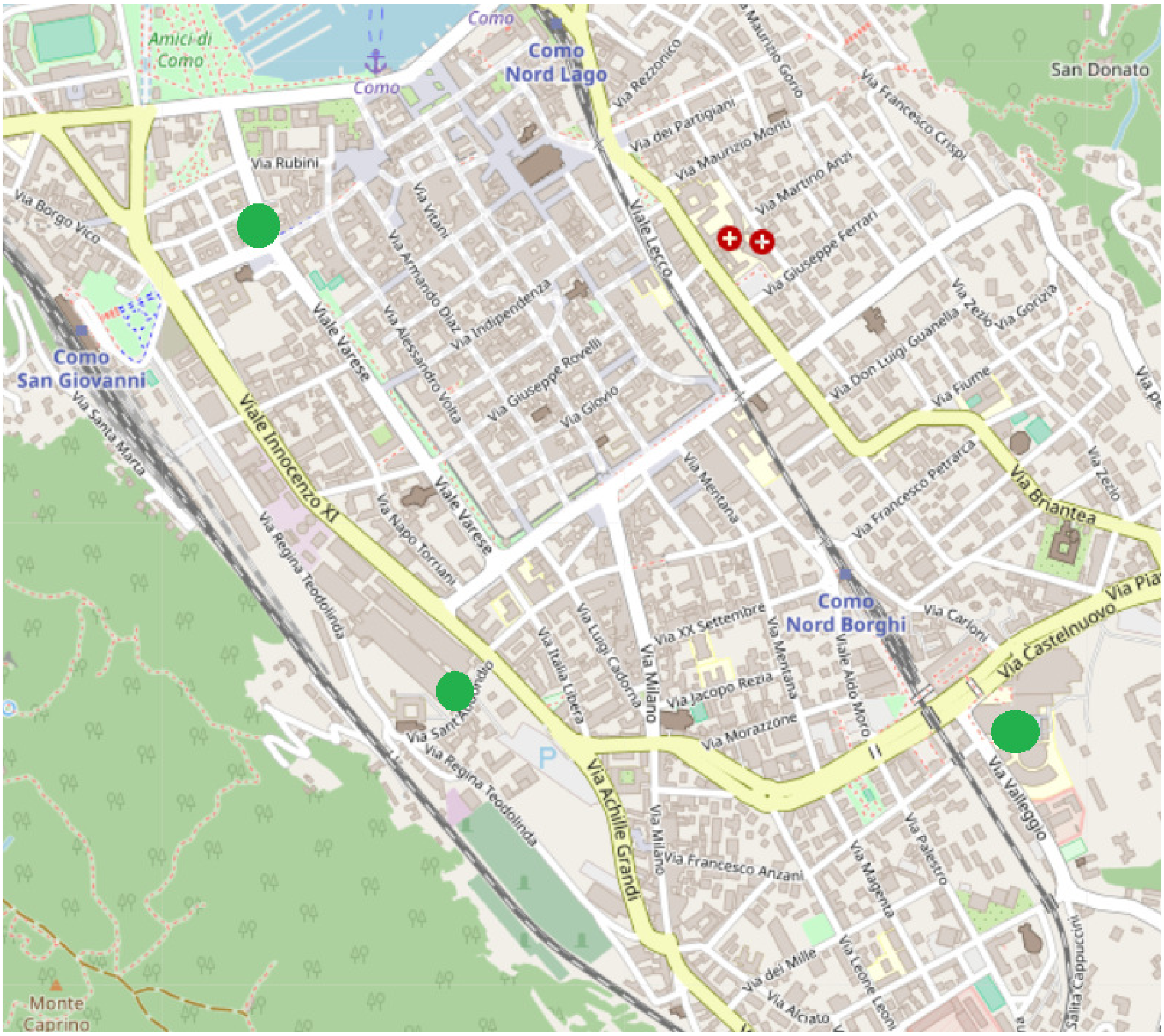

Figure 3.4 Location of university sites on plan of Como.

In Como there is not a unique campus for the lectures but there are more sites situated near the center of the city and the parking places are limited (or they are reserved to technical staff /professors). The green points on the map of figure 3.4 indicate the location of these academic sites.

City	Before 6:00	6:00-7:00	7:01-8:00	8:01-9:00	9:01-11:00	11:01-16:00	Over 16:00
Varese	1.09%	13.12%	33.66%	37.48%	8.96%	3.61%	2.08%
Como	1.35%	13.46%	33.11%	34.45%	10.23%	7.00%	0.40%
Busto Arsizio	0.00%	7.41%	44.44%	48.15%	0.00%	0.00%	0.00%

Table 3.9 Distribution of the commuting flows by arrival time.

City	Before 13:00	13:00-15:00	15:01-17:00	17:01-19:00	Over 19:00
Varese	3.56%	18.66%	29.36%	43.12%	5.30%
Como	3.74%	15.51%	33.69%	44.79%	2.27%
Busto Arsizio	0.00%	3.70%	29.63%	66.67%	0.00%

Table 3.10 Distribution of the commuting flows by return time.

The rush hours are concentrated between 7 and 9 a.m. and 17.00 and 19 p.m.. It is important to underline that in Varese a part-time course is active (lessons from 6 to 9 pm) and this can explain the small percentage of people that arrive at the pole after 4 pm.

From this scenario emerges a situation with similarities and differences within the same university. It is clear that the presence of structures in too different geographical locations gives rise to different needs for the involved users. Moreover, the descriptive analysis brings out the "car dominance" as regards the territory of Varese, by partially accepting RQ1. The situation could have improvements and changes through policies studied involving all the possible interest subjects (political / institutional, university and transport actors).

3.4.2 The determinants of modal choice: an econometric approach

The above descriptive statistics have disclosed some variables that might affect the university users' commuting choice.A widely adopted approach to investigate the factors explaining the modal commuting choices is represented by the logit models (Marcucci, 2011; Zhou, 2012; Whalen et al., 2013; Kotoula et al., 2017; Danaf et al., 2014; Cascetta, 2013; Scaccia & Marcucci, 2010; Danielis, 2005). Discrete choice models are routinely used in transportation research to parameterize utility functions for the alternatives based on revealed preferences and explanatory factors (Whalen et al., 2013). Among these methods, the multinomial logit model (MNL) is the most commonly used discrete choice framework where the probability of choice is calculated without the use of numerical integration or simulation methods (i.e., closed-form model). In case of travel modes choices, it also allows to estimate the impact of different physical or individual factors such as travel time, distance and costs on a given mode choice. Beyond early texts dealing with the MNL models (including McFadden, 1976, 1980 and Ben-Akiva & Lerman, 1985), many authors have used this model to study the mode choice of students and factors affecting it (Zhou, 2012; Müller et al., 2008). In our case, the probability that the ith university user would choose the jth commuting choice is given by $P_{ij} = Pr(U_{ij} > U_{ik})$, where $k \neq j$, with Uij being the maximum utility achievable for user i choosing the mode j. The related utility model is thus defined as follows:

$$U_{ij} = \alpha + \beta_j x_i + \varepsilon_{ij}$$

where β_j is a vector of coefficients of each of the explanatory variables x_i and different mode choices are grouped together to consider similar means, that is, j = Rail (train), Road_C (local and extra-urban bus) and Road_S (car, motorbike). If the white noises ε_{ij} are independent and identically distributed according to the type-1 extreme value log Weibull distribution (Zhou, 2012; Greene, 2000), the MNL can be formulated as:

$$P_{ij} = \frac{\exp(\beta_j x_i)}{\sum \exp(\beta_j x_i)}$$

where β_j are estimated by maximizing a log likelihood function. In fact, the independent errors of MNL models imply the independence of irrelevant alternatives (IIA) assumption. Basically, this requires that an individual's evaluation of an alternative relative to another alternative should not change if a third (irrelevant) alternative is added or dropped to the analysis.[5] In our context, this means that we need to assume that different mode choices, such as driving-alone and using public transit are independent of one another (Ewing et al., 2004; McFadden, 1980). Hence, separating mode choices related to different travel habits (for instance, collective vs. individual means on the road) allows to soften the drawbacks of the IIA assumption.[6] Moreover, commuting habits are bundled considering varying environmental effects, ranging from low-impact (train), middle-impact (bus, car-pooling) and high-impact means (car, motorbike) in order to evaluate how users' choices might have further effects on sustainability. In this study, explanatory variables (x_i) include: quantitative data (age, frequency, minutes, costs) and categorical variables (user type: students, faculty, TA staff; residence/starting point: VA, CO, OTHER; poles/destination point: Varese, Como; ownership of private cars; car-pooling attitude; past and/or present use of the university shuttle bus (active in the Varese campus only).[7]

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[5] See Cameron and Trivedi (2005) for a more detailed discussion of the formulations of the MNL models.

[6] Specific tests will confirm this approach as described in the section x.

[7] Residence dummy: respondents are clustered using administrative data (ISTAT and law 59/97) to account for proximity-effects among users. In this phase the residence dummy is represented with three main clusters that are CO (that means: people who live in Como and nearly cities) VA (that means: people who live in Como and nearly cities) and OTHER (that means: people who don't live neither Como or Varese and nearly cities). In this way there is a scenario with people who live in the two main cities where there is the university and people who live in other towns.)

3.4.3 Results

In order to analyse the survey data, three MNL models have been developed, as shown in Table 3.12. It is important to remember that, for all the models, the reference group is the private car. The first model (labelled as MNL1) includes the entire sample (Varese and Como, 2,586 observations) and basically it would be useful to check whether destination-based effects keep alive when considering the whole sample. The second model (MNL2) only concerns the pole of Varese (1,914 observations) while the last model (MNL3) is about the habits of users reaching the Como site (672 observations). By considering different sub-samples, our aim is two-fold. First, from a mobility management perspective, we would point out determinants of modal choice that are sensitive to university poles' location. As briefly explained above, the two sites in Varese and Como indeed face very different mobility issues as the former pole is in a suburban area of the city (about 3 km far from the railway stations) while the latter one is in the nearby of the city center of Como (as in Figures 3.3 and 3.4).

Variables	**Information**	**Description**
Age	Quantitavive variable	Age of the respondent
Car_own	Categorical Variable	Ownership of a private car (Yes or No)
Car_pooling	Categorical Variable	Attitude to Car Pooling (Yes or No)
Cost	Quantitavive variable	Monthly Cost for transport
Frequency	Quantitavive variable	Number of commuting days per week
Minutes	Quantitavive variable	Average minutes of the typical journey
Shuttle_bus	Categorical Variable	Use of the shuttle bus (Yes or No)
Staff	Categorical Variable	User type, Ref group Faculty
Student	Categorical Variable	User type, Ref group Faculty
VA	Categorical Variable	Starting point, Ref Group CO
Varese	Categorical Variable	Destination point, Ref Group Como
OTHER	Categorical Variable	Starting point, Ref Group CO

Table 3.11 MNL Variable description.

	MNL1: Aggregate (Pseudo R2: 0.3608)		**MNL2**: Varese (Pseudo R2: 0.4103)		**MNL3**: Como (Pseudo R2: 0.2410)	
VARIABLES	*Rail*	*Road_C*	*Rail*	*Road_C*	*Rail*	*Road_C*
Age	-0.0532***	-0.0481***	-0.078***	-0.058***	-0.0231	-0.0276
	(0.0126)	(0.0150)	(0.0173)	(0.0198)	(0.0187)	(0.0224)
Minutes	0.0620***	0.0334***	0.0735***	0.0363***	0.0457***	0.0314***
	(0.00407)	(0.00431)	(0.00532)	(0.00589)	(0.00684)	(0.00736)
Frequency	0.193***	0.290***	0.159**	0.269***	0.248***	0.344***
	(0.0517)	(0.0556)	(0.0639)	(0.0694)	(0.0911)	(0.0983)
Cost	-0.00889***	-0.0218***	-0.0071**	-0.023***	-0.013***	-0.0177***
	(0.00232)	(0.00253)	(0.00280)	(0.00314)	(0.00438)	(0.00462)
Staff	-0.526	0.475	0.302	0.583	-2.594***	0.553
	(0.424)	(0.510)	(0.512)	(0.585)	(0.873)	(1.194)
Student	-0.379	0.649	-0.883	-0.166	-0.0638	2.546**
	(0.410)	(0.583)	(0.556)	(0.712)	(0.593)	(1.204)
Car_own	-3.630***	-3.856***	-3.733***	-4.119***	-3.011***	-3.280***
	(0.248)	(0.244)	(0.297)	(0.292)	(0.461)	(0.462)
Shuttle_bus			1.463***	1.022***		
			(0.162)	(0.180)		
Car_pooling	-0.672***	-0.00465	-0.684***	0.319*	-0.760***	-0.542**
	(0.135)	(0.141)	(0.164)	(0.179)	(0.243)	(0.246)
VA	0.655	0.852***	-0.692**	0.886***		
	(0.406)	(0.260)	(0.338)	(0.238)		
OTHER	1.894***	0.0819			1.398***	-0.137
	(0.329)	(0.225)			(0.382)	(0.307)
Varese	-1.668***	-1.864***				
	(0.155)	(0.168)				
Constant	0.354	2.432**	0.943	1.663	0.269	-0.366
	(0.834)	(0.988)	(1.056)	(1.253)	(1.223)	(1.713)
Observations	2,586	2,586	1,914	1,914	672	672

Table 3.12 Multinomial Logit Models (rReference group for all the models: private ca and motorbike – Road_Sr).

Starting our analysis from MNL2 and MNL3, these two distinct models would explain the effect of the selected variables on the marginal utility of mode choice such as public and/or collective transportation on railway and roads (Rail and Road_C) with respect to the (baseline) individual transportation on roads (Road_S). Regarding to the socio-economic characteristics of users, the coefficients of Cost and Car_own are highly significant and with negative sign across both the MNL2 and MNL3 models, meaning that both a higher incidence of travel expenses on monthly budget and the availability of households' private cars are factors that decrease the utility associated to train or collective means to reach the university poles. However, it is easy to notice how the elasticity of the demand for collective means with respect to train is much higher in Varese (utility loss equal to 0.01605) than in Como (0.0041). Not very surprisingly, this means that an increase in travel costs relatively reduces the utility of users commuting by city or extra-urban buses (including car-poolers) to the suburban pole of Uninsubria. Controlling for the cost incidence of daily travels, in a similar way, the magnitude of the utility loss associated to either train or collective means is larger when considering Varese as the destination point and users who own a household's private cars. In this case, people who commute to Como show a relative larger incentive to not use private cars (even if available). Overall, both these effects are confirmed when considering the whole sample (as in the MNL1 model).

Regarding to university users' age and role, instead, the first feature seems to negatively matter only for people commuting to Varese when considering alternative modes with respect to private cars or motorbikes (Rail = -0.0789; Road_C = -0.0576). In other words, comfort and auto-dependence are associated to ageing users in case of suburban university pole as destination, whereas on average those aspects seem to not matter when city-centre poles are considered (i.e., the distance between railway or bus station and university is typically smaller). By contrast, when considering faculty as the baseline role, only in Como the fact to be a staff member or a student (full-time or part-time undergraduates and PhD students) is statistically significant. Being a staff member (technical and administrative employee) is associated to a reduction of train usage (Rail = -2.594), while the student status implies an increasing usage of road collective means (Road_C = +2.546). In this case, as the Como pole is less car-dominant than that in Varese, more effects of different modes emerge, whereas any type of users reaching Varese is not sensitive to own university role. Obviously, the above results tell about a car-dominance associated to the selected socio-economic characteristics that is overall present at Uninsubria, regardless the fact that either suburban (Varese) or city-centre (Como) poles are considered. Notably, this effect cannot be detected by the aggregate MNL1 model, where related coefficients are not significant. However, by segmenting users in different destinations, in this case the university mobility manager could assess commuting issues accordingly, i.e., in Como staff members must be given incentive to commute by train, whereas the students' preference for road collective means must be preserved (or improved, if possible).

With respect to travel-time characteristics, both increasing Minutes and Frequency variables positively impact on the utility of commuting by more sustainable means of transport (i.e., train, city or extra-urban bus, car-pooling) in the MNL2 and MNL3 models. About travelling times (expressed by the variable Minutes), the option Rail has a higher coefficient than Road_C, and the other way around occurs for Frequency. When commuting to the suburban pole (Varese), the trip duration has a stronger positive relationship with the commuters' choice of the train as main means of transport (Rail = 0.0735), that is, the railway service is chosen for longer distance than the bus system. This fact may suggest, in fact, to focus on users living at a far distance from the Varese pole to improve the usage of low-impact means such as trains. This effect still applies to the Como case, but at a smaller extent (Rail = 0.0457). Moreover, if we consider the impact of past/current recourse to the university shuttle bus (available in the Varese pole only), it is easy to notice that this service could improve more the utility of users who commute by train (Rail = 1.463) than those using road collective modes (Road_C = 1.022). As regards the frequency of travels made by different users, the results suggest to improved road collective means either in Varese or Como for people who commute more times during the week. Ceteris paribus, even in case of suburban pole, the preference for city or extra-urban buses and being a car passenger (Road_C = 0.269) can be explained by the fact that overall bus services provide a better supply, especially in terms of regularity and number of transits at peak hours. What is more, the willingness to apply for prospective organized forms of car-pooling provided by Uninsubria (captured by the dummy variable Car_pooling) tells about a subtle substitution effect between single-motorized modes (car as driver, motorbike) and more sustainable means. Having car-pooling experiences (that is, commuting by car as driver and/or passenger) or being willing to change current habits towards road sharing mobility solutions is a behavioural feature which seems a prerogative of users commuting by car or motorbike towards Uninsubria sites (Rail and Road_C coefficients are significant and negative). In other words, car-pooling is potentially alternative to solely drive a car or ride a motorbike and thus may increase the sustainability of auto-dependent users. A notable exception is, in fact, the positive relationship between users willing to be car-poolers and the choice of road collective means in Varese. As already told, in this case the superior supply of transit service provided by buses in suburban areas of Varese could explain the substitute effect between the propensity for car-pooling and the usage of road collective modes (Road_C = 0.319).

Turning to the origin-effect (investigated by using geographical clusters), we first consider the Varese pole (MNL2 model) and how commuting choices are affected by the users' residence. By setting people travelling to Varese from extra-urban clusters (including the province of Como and other towns at a radius distance of more than 7-8 km) as the baseline, when considering users within the urban cluster (labelled with the dummy variable VA) choosing the train as main mode reduces the utility (Rail = -0.692), while on average using road collective means increases it (Road_C = 0.886). By contrast, in the MNL3 model, we set users who live in the Como cluster (at a radius distance of less than 10-12 km from the city centre) as the baseline. When considering people coming from outer clusters (including who lives in the province of Varese and/or in towns from different areas), shifting from using private cars or motorbike to train considerably increases the utility of commuting (Rail = 1.398), whereas a change towards road collective means has no statistically significant utility improvement.

3.5 Predicted Probabilities

Through the predicted probabilities calculation, that is an accurate estimate of the likelihood of detecting the species at a given site (Pearce and Ferrier, 2000), it is possible to verify which is the most probable combination between commuting modes, origin of the trip and final destination. As previously explained, the analysis is based on a clustered geographical system that divided areas both for the origin of the journey (Varese, Como or Other) and for the final destination (VA & CO).

	RAIL	**ROAD_C**	**ROAD_S**
COMMUTING MODES (aggregate)	**Predicted probability**	**Predicted probability**	**Predicted probability**
CO#Como	0.122***	0.436***	0.443***
	(0.0326)	(0.0470)	(0.0481)
CO#Varese	0.0430***	0.127***	0.830***
	(0.0132)	(0.0253)	(0.0307)
OTHER#Como	0.469***	0.275***	0.257***
	(0.0288)	(0.0247)	(0.0241)
OTHER#Varese	0.228***	0.110***	0.662***
	(0.0166)	(0.0109)	(0.0195)
VA#Como	0.138***	0.602***	0.261***
	(0.0297)	(0.0466)	(0.0408)
VA#Varese	0.0683***	0.246***	0.686***
	(0.0159)	(0.0296)	(0.0347)
Observations	2,586	1,914	672

Table 3.13 Predicted Probabilities.

The analysis shows that the train is the most probable means for people who come from outside the two cities and decide to go to the Como sites, secondly people coming from the cluster other and have Varese as their final destination. This is reasonable because the train is used by commuters who move over long distances and do not live in the two cities. The collective transport (Road_C) is the most probable used for people living in Varese who have Como as their final destination, surprisingly we find a strong difference between VA#Varese and CO# Como, this means that the use of the urban bus in Como is more probable respect that in Varese.

Finally, for the Road_S category there are some interesting results due to the fact that the greatest probabilities are about people coming from Como to Varese (while it is very low the probability of people from Varese that go to Como, maybe even given the number not so relevant of subjects that make this journey and the above mentioned parking problems) and denotes a strong dominance of the car (as was already evident from the descriptive analysis on the predominance of the same). In fact, both those who come from OTHER who arrive in Varese (VA) have very high predicted odds results. All this can be explained by the ease of parking and the high number of people using the car to go to the Varese main sites (Bizzozero).

3.6 Public transit evaluation: a comparative analysis

Another aspect of the analysis is based on the users' score about the transport choice motivation and the evaluation of public transport services of the cities of Varese and Como. This analysis considers all the respondents of Como and Varese that have chosen public transportation as their principal vehicle. The three means, involved in this analysis, are Urban Bus, Inter Urban Bus and Train to be evaluated with Likert scales from 0 to 3.

The following graphs present the results of this analysis.

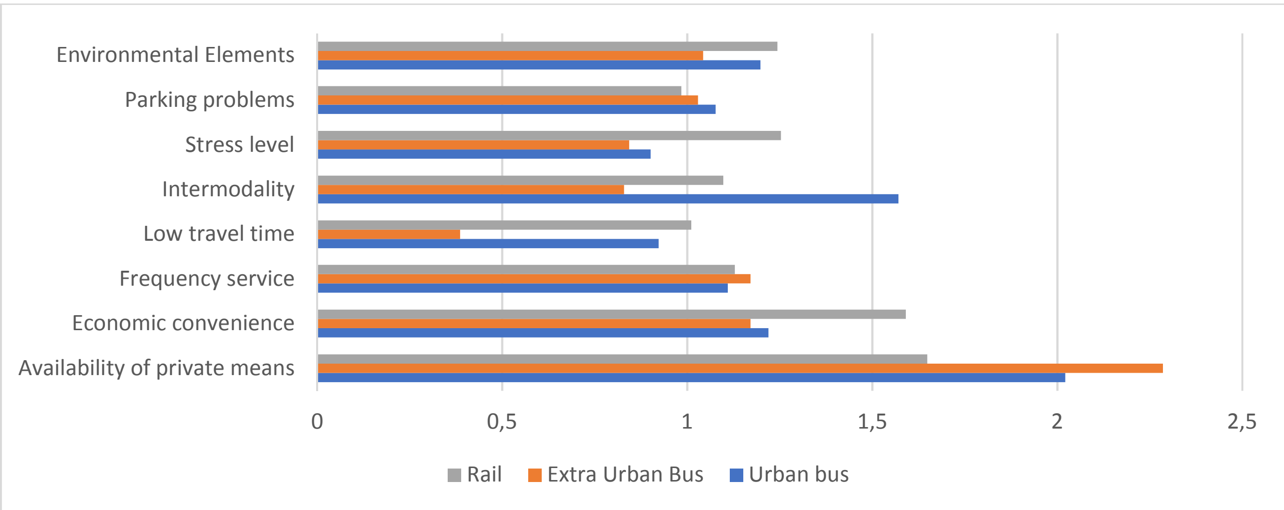

Figure 3.5 Motivations of transport choice in Varese.

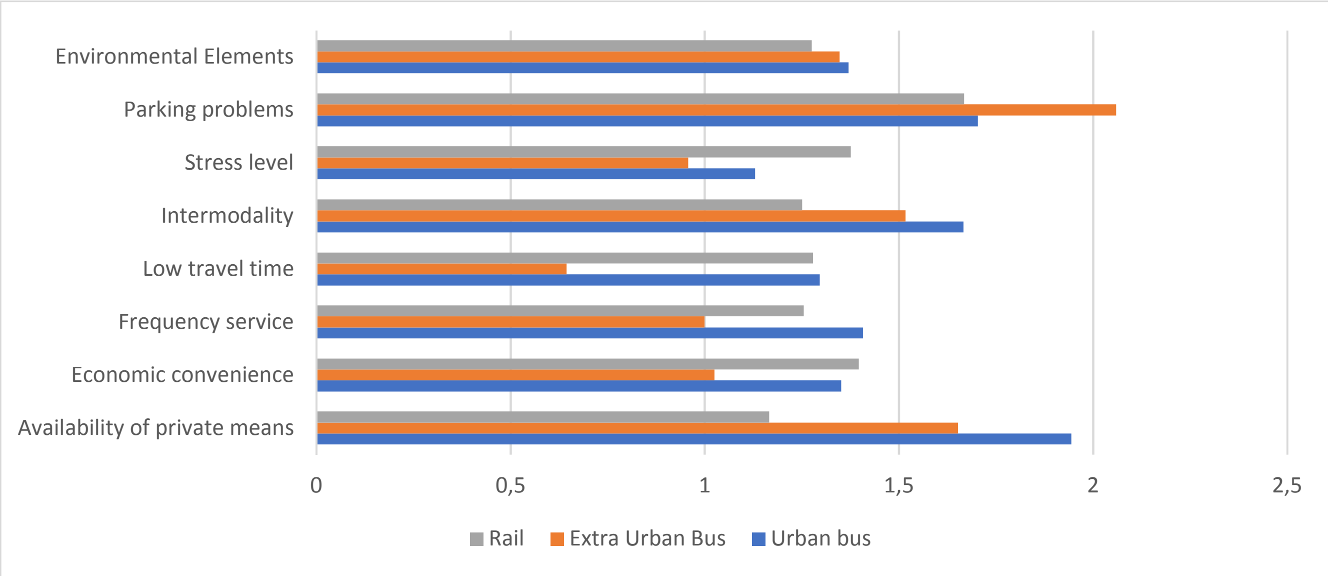

Figure 3.6 Motivations of transport choice in Como.

As for the determinants of the service, it emerges that the lack of availability of a private vehicle and parking problems, as far as Como is concerned, are the most relevant elements that emerge from this descriptive analysis. It should also be noted that stress level and low travel time are common determinants for all the users involved in the two university poles.

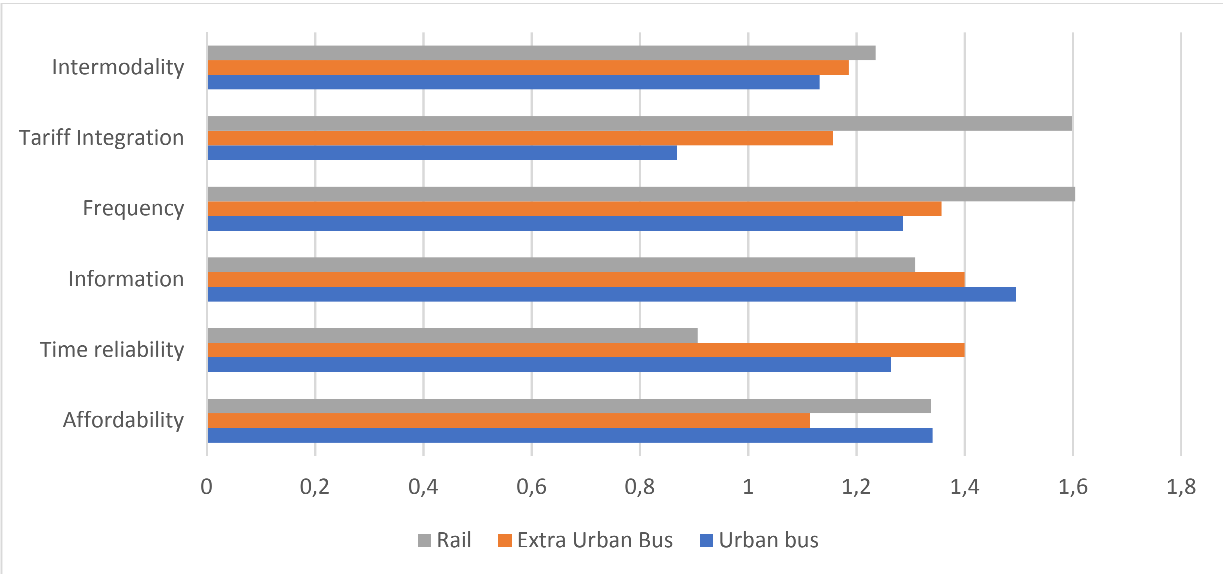

Figure 3.7 Evaluation of public transport services in Varese.

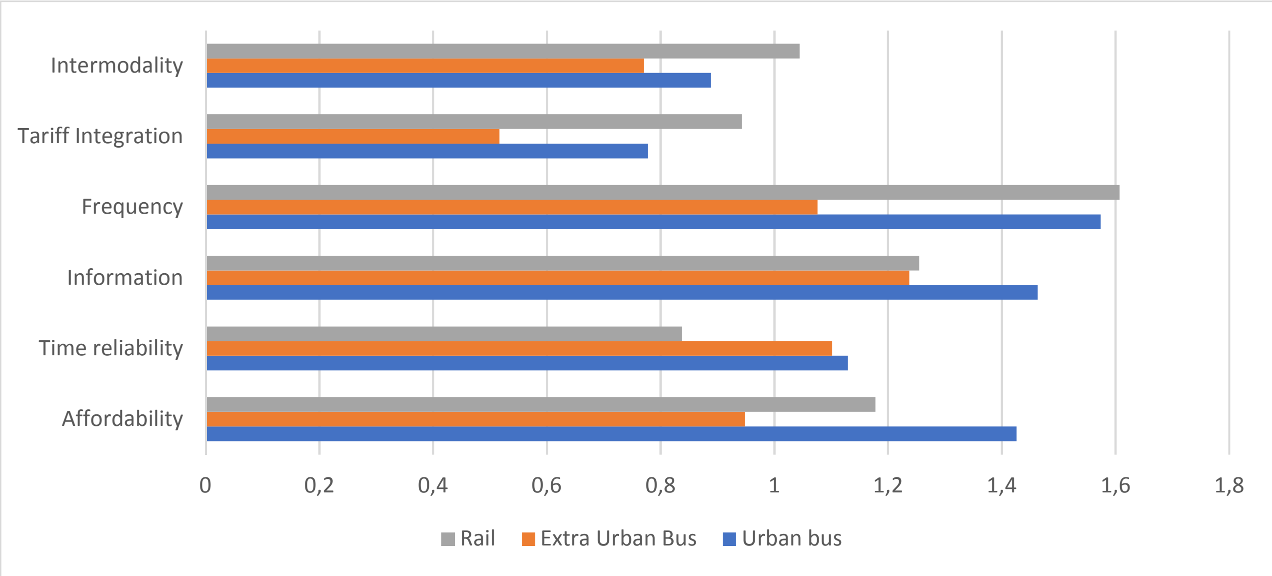

Figure 3.8 Evaluation of public transport services in Como

The judgment of the service and the scores linked to it show low values (almost all <1.5) and a low train punctuality (with a score <1 for Varese). In this regard we find a good frequency with problems of intermodality (score below 1). To evaluate the possible different evaluation between users of the two different cities it was decided to use the pairwise test tool.

In a paired sample t-test, each element is measured two times, and results as a pair of observations. Usual applications of this test include case-control studies or repeated-measures designs.

Such as other statistical instruments, the paired sample t-test has two hypotheses, (null and alternative). The null hypothesis presumes that the true mean difference between the paired samples is zero. With this model, all observable differences are explained by random variation. Contrariwise, the alternative hypothesis assumes that the true mean difference between the samples is not equal to zero. The alternative hypothesis has different forms and depend to the expected outcome, in fact it is possible to have a one tail test or a two tails hypothesis if there is not a precise direction but only a difference and its power increase if the test is one tail (Faliva & Zoia, 2004; Faliva & Venini, 2000; Paruolo, 1999). In this case the interest is to check the score of the motivations that drives the users of one of the three means of transport to verify if there are differences between the two considered cities. The second step is to reply the same test on the questions related to the evaluation of the services. To analyse these results, we start from the assumption that the evaluation of users is similar, and the individual has the same preferences and capability to evaluate the questions (Armstrong, 1987; Gob et al., 2007).

The paired sample *t*-test hypotheses are formally defined below:

H0: $\mu_d = 0$ where μ_d is the difference between Como and Varese
H1: $\mu_d \neq 0$ (two-tailed) where μ_d is the difference between Como and Varese

	URBAN BUS	INTER-URBAN BUS	TRAIN
Motivation	**Test (Como – Varese)**	**Test (Como – Varese)**	**Test (Como – Varese)**
	Sample: Como=45 ; Varese=84	Sample: Como= 133 ; Varese= 76	Sample: Como=247 ; Varese=450
Availability of private means	-1.23	-3.34***	-5.10***
Economic convenience	1.40	-1.39	-2.51**
Frequency service	2.20**	-1.04	1.78
Low travel time	2.15**	2.82**	3.46***
Intermodality	1.89 *	4.41***	1.67
Stress level	1.39	0.78	1.47
Parking problems	4.73***	6.16***	7.43***
Environmental elements	1.93*	1.84	0.39
Evaluation			
Affordability	1.54	-1.98*	-2.39**
Time reliability	-0.39	-2.93***	-1.13
Information	0.10	-1.47	-0.82
Frequency	1.84*	-2.06**	0.05
Tariff Integration	-0.47	-4.39***	-8.31***
Intermodality	-1.15	-3.30***	-2.65**

Table 3.14 Results of the paired sample t-test.

The different assessment between public transport between Como and Varese emerges in many of its aspects and for this motivation RQ3 is partially accepted.

Regarding the urban bus we note how the frequency is evaluated in a positive way in Como and there is a strong difference with the Varese evaluation's. So, it is possible that the commuters of Como use the bus because it has a better frequency. The extra-urban bus has much more complex results, in fact the availability of private vehicles is absolutely in favor of Varese. Moreover, in the part dedicated to the evaluation a statistically significant situation emerges, and in favor of Varese, with regard to frequency and time reliability. The train is relevant (for the Varese side) in the variables related to the availability of private vehicles and economic convenience. Furthermore, as far as the evaluation section is concerned, affordability is relevant. The analysis of the last two means of transport (inter-urban bus and train) shows a similarity about the concept of tariff integration. In fact, for respondents, this variable is very relevant and the results outlines a strong significance. This is determined by the fact that, to reach the main pole (Bizzozero), it is highly probable to use more than one mean of public transportation. A significant variable for all three vehicles is the parking availability. The strong use of the private vehicle in Varese, connected with the evaluations of public transport and the lack of availability of parking places in the Como offices, underlines the difficulties encountered in the land of Como. The result is statistically significant, at 1% for all three-public transport means. It is important to underline that the use of public transportation, in Como, is high due to the position, in the center of the city, of the university poles. There are no particular differences in the score related to the motivation regarding the environmental impact, the level of perceived stress and the frequency of the service. Finally, the evaluation of the information does not present any differences between the two poles.

3.7 Bike Sharing and Car Pooling: Propensity for a Change?

As explained in the previous paragraphs the methodology used for analyzing the data has provided descriptive and econometric results. Moreover, another aim of the survey was to verify the propensity about the modal change versus an ecofriendly way (for people that affirmed that use car or motorbike as their main vehicle in the commuting process from home to work). The propensity to change was analyzed making a distinction between the availability to adopt the Public transportation, the bicycle or the carpooling as an alternative of the private vehicle. Subsequently there were some questions related to inquire the conditions that can favored the behavioral and modal change in relation with possible constraints and problems. This made possible to understand which are the possible actions to implement that increase the chances of success. Finally, some questions related to Carpooling and bike sharing were provided to the respondents.

In the following graph it is possible to analyze the motivations that influence a possible modal change from the use of the car to a fewer polluting means. Considering the Varese side, it can be noted that the most relevant factors are the cost and the improvement of local public transport, this is coherent with the position of the Bizzozero campus. In the central site and hospital offices, some users report that there are no reasons to avoid the use of the car. From the side of Como, as already stated above, the situation and geographical location is different. For this reason, the motivation and propensity for change is different than in Varese. But, also in this location it is possible to find some similarities that can be reconducted to the economic motivations. It is interesting to point out that there were no explicit questions related to the improvement of public transport, but a percentage of users from both cities has included the motivation for a possible modal change.

Finally, we can conclude emphasizing the high propensity to change comes from users of the Campus Bizzozero (where the improvement of local transport could be relevant) and in general this propensity is higher in Varese than Como.

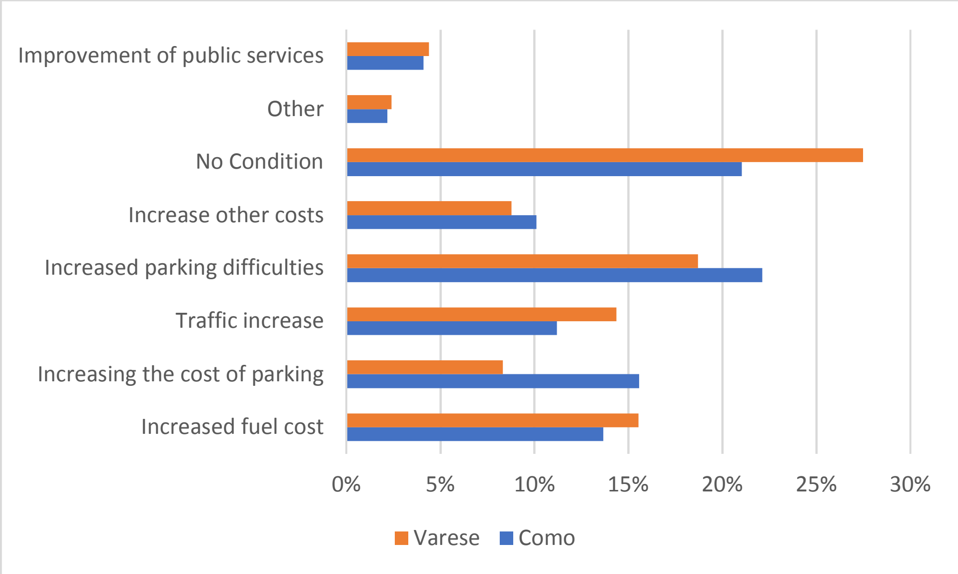

Figure 3.9 Motivations for a eco- change.

In the modal change section, were asked some questions, to the entire sample (excluding people who have declared that use a bike or walking), about the use of Bike Sharing and Car Pooling.

3.7.1 Car Pooling

The results are summarized in the following table:

Car Pooling			
City	Yes	No	Favorable
Varese	44%	17%	39%
Como	30%	26%	45%
Role	Yes	No	Favorable
Student	45%	15%	40%
Professor	22%	36%	42%
T.A. Staff	17%	39%	43%

Table 3.15 Car Pooling Data.

Regarding to the carpooling, has emerged that, considering the two main poles without any distinction by role, there is a strong difference between the number of users in Como and Varese that have already used almost one time this share green modality; a possible motivation related to these results could be the different use of the car in the two cities. Considering the roles of the respondents, the percentage of users who would be favorable to the use of this means of transport is very similar, but there are strong differences between actual users: students use currently this opportunity more than professors and administrative staff.

3.7.2 Bike Sharing

The term bike sharing (from the English bike "bicycle" and the verb to share "share") represent a form of transport based on the collective use of one or more bicycles. Unlike the rental, these services include a fleet of vehicles that can be used for short periods, that can be represented by time or kilometers (Shaheen et al., 2013; Manzi & Saibene, 2018; Marshall et al., 2016; Bush, 2012; Ricci, 2015; Zhang et al., 2015).

The municipal bike sharing is present in the three considered cities, each of them has different elements offering this service to occasional users or subscribers. As for car sharing, there were some questions related to people that use (occasional or continuous) bike sharing and, for those who do not use it at the moment, which are the conditions that they consider relevant to became active actors for this modal change.

Bike Sharing	**Yes**	**No**	**In the future**
Varese	4%	56%	40%
Como	7%	48%	46%

Table 3.16 Bike Sharing Data.

Conditions to favour the use of bike sharing	
Element	Evaluation score (In Percentage)
Availability of cycle paths	70%
Availability of pedal assisted bicycles	37%
Number of bicycles available	73%
Better traffic condition	67%
Economic Convenience	77%
Weather conditions	83%

Table 3.17 Bike Sharing Conditions.

The survey showed that the use of bike sharing is a niche element for the analyzed sample. Only 4% in Varese and 7% in Como use it at least occasionally. The future propensity score for using this sharing means could be more than the 40% for both cities. The components that can favor the use of bike sharing that are considered relevant from users are the weather conditions, the economic factors and the availability of bicycles in the stalls to be used on dedicated routes.

Considering the fourth research question (RQ4) it is partially clear that the modal sustainable change will be a relevant step to be implemented with some difficulties, first of all the resistance to change of the users. There is a theoretical propensity that is showed by the users but also a huge number of factors that should be implemented by the local authorities in cooperation with the University.

3.8 Conclusions

The attention to sustainability has increased significantly in recent years and it has become a theme broadly debated at all social and political levels. On all fronts it is comprehensible that the defense of nature and the growth of human activities should not be considered in a separate and exclusive way, but some synergistic elements of the same process could be able to plan actions and performances that allow the actors to increase the constructive effects on a territory.

The first important result to underline is represented by the answer rate of the survey. More than 11,500 is the number of the people who are part of the university (of its three sites in Varese, Como and Busto Arsizio) and the replies were 2,800 people (25% of the entire sample). The University of Insubria, from the data collected, confirms to be a strong pole of attraction, where actors constantly participate in university life although with some differences among the three poles.

The duration of the journeys is, on average, between 31 and 60 minutes for all three Insubria sites and all the outward trips, on average, begin between 7:00 and 9:00, while the return journey starts between 17:00 and 19:00, without any distinction between the different locations

A more optimistic situation, from a sustainability point of view, is revealed from those who claim to use more than one means of transport for the entire home-university journey (40% of the sample): in that case, the more used means of transportation is, in 68% of the cases, the train, which is associated with the use of city buses (to reach the station from home, or to reach the university headquarters starting from the train station), while walking and bike are used for short trips.

The commuters who use only one mean of transport are obviously not sustainable: 84% of them use the car.

As regards the sustainability of commuters' flows, there are relevant differences between the dtwo main academic poles. From one hand, in Como the car is marginal thanks to the countless possibilities of public transport and from the other hand, Varese, where there is a very strong car dominance.

Regarding carpooling, it emerges that it is a feasible alternative to solely drive a car or ride a motorbike and thus may increase the sustainability of auto-dependent users.

Since there are significant geographical differences between the two poles, the synergy between local authorities and the central government of the university is of fundamental importance in order to develop policies for sustainable commuting, such as bike sharing or carpooling. The latter solutions are still less useds, but there is a high propensity to adopt them in the future. The development of safe lanes and cycle paths and the adoption of an institutional app for the carpooling / pooling could help in acheveing this result. Finally, it is important to point out, before moving on to the future developments that, at the time of the questionnaire submission, the Varese-Mendrisio railway (with branches for Como - Bellinzona and Immensee) was not active, as it came into operation at the beginning of 2018 (VareseNews, 2018); moreover, recently the private company OFO has decided to withdraw from the city of Varese (Prealpina, 2018) the entire bike park reserved for bike sharing. These two changes are certainly to be taken into account for future surveys and for the development of a sustainable mobility policy in the territory, involving the entire population of the three poles.

The results of the study, therefore, are a good starting point to allow the mobility manager of University of Insubria to suggest some possible interventions. This manager is in charge to optimize the home-work travel of employees, trying to reduce the use of private cars in favor of transport solutions with low environmental impact (mainly public transport, cycling and carpooling). The analyzes carried out on the mobility habits of employees and the actions identified to achieve the pre-established goals constitute the base for the Home-Work Travel Plan.

Finally, considering the not negligible percentage of users who declare themselves unwilling to no longer use their private vehicle, it would be useful to invest in the dissemination of more information about the consequences of their modal choices and the benefits of using active and sustainable mobility. for individual and collective well-being. In conclusion, the results of the study are a good starting point to allow the university and local authorities to intervene in a more targeted way to increase the sustainability of home-university travel.

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Chapter 4
Concluding remarks

The focus on sustainability has strongly increased its importance in recent decades, and it is become a topic broadly debated by both scholars and policymakers. It is logical that the protection of nature and the development of human activities should be considered a unique process made up of some steps that are separate, mutually exclusive but synergic. This process should be able to outline actions and behaviors to increase the positive effects on a territory.

To summarize, the focus must be on increasing the awareness of the need to change current lifestyles, if we really want to alleviate the effects of the irresponsible management of regions and cities on the generations to come. Moreover, the awareness that a system of growth and production based on excess will not lead to viable scenarios is obvious and does not struggle to find consensus. It is much more complicated to find the same consensus when discussing the need to change the mechanisms of economic progress and the lifestyles of individuals (Latouche, 2010). Instead, as an indicator of the environmental weight of our "ecological footprint" lifestyle, the results are not sustainable as well as being far from exhibiting universal equality. The ecological debt will not stop growing unless the paths undertaken so far are modified (Pollard et al, 2010).

In order to follow and increment the level of sustainability in the transport sector, it is important to observe and implement some steps. First of all, the concept of intermodality is a possible lever of change: without a transportation system that allow commuters and people to program a journey, using public transportation or sustainable forms of transportation with an acceptable timeline, it will be very difficult to reduce the number of cars.

In this process regional and metropolitan public authorities are suitable to provide unitary guidelines, to orientate all the involved actors and local municipalities. Moreover, it should be implemented a strong program of technological investments in ecological transport infrastructure and local services that can convince commuters to make a modal shift in a sustainable way.

Finally, the urban space management policies should over time include guidelines for urban development planning for public transport ("transit oriented") and, in the short term, widespread solutions of traffic such as low speed zones, protections to pedestrians and cyclists.

Moreover, considering the focus of this thesis, one of the most challenging goal of this period is to make more sustainable the rising passengers flows, to rebalance the modal shift in favor of sustainable means of transportation that are less pollutant than the private car or motorbike. Surely, one relevant factor is the value of travel time in transport modal choice that it is often more important than the price and is a key element to push travelers to favor certain kinds of sustainable means of transportation.

The first chapter presents an analysis of the most relevant data from Italy and Europe about mobility, modal share and environmental impact. Subsequently, there is a review of sustainable mobility literature and some strategies to carry out this concept. Finally, some sustainable transport modes such as carpooling, bike and car sharing and long-distance buses, are examined in deep to underline their features and the impacts on the communities.

The second chapter is related to the railway sector to identify the elements that are directly connected with the arrival performance of a railway journey.

The issue of arrival time, and obviuously the concept of delay, is related with the railway transportation sector. This is directly linked with the most recurrent delay causes with their relative percentages that could be helpuf, for the rail companies, to identify some strategies to improve journey's punctuality. One contribution of this chapter is the new classification of the determinants of the train delay that considers the responsibility of the actors involved (RFI, Trenitalia). This classification differs from other classifications that have been already developed by other authors in which concepts such as primary delay and secondary delay (Gylee, 1994) or exogenous delays and knock-on delays (Carey, 1999) group a huge number of factors, hiding some peculiarities with a consequent loss of information. Moreover, this classification, based on the responsibility, is the base for a regression model, showing a scenario that places the causes of the delays in order of importance and, consequently, also proposes possible solutions. It is clear that the actors involved have little power with regard to external causes such as floods, earthquakes or accidents in which they are not directly involved but can act on relevant factors such as train or line failures.

For this reason, it emerges from the research results that only through strong maintenance and planning, with the purchase of new trains and the improvement traffic management, the rail performance will be upgraded. In the last part of the second chapter, the survival analysis basically confirms the findings of Trenitalia on all the Italian railway lines. For this motivation it could be interesting, in the near future, to extend the same analysis to a wide database that contains also other data from some Italian (or foreign) railway lines. In this way a wide analysis should be provided to make a comparison between the effective different reasons that causes delay on railway lines. The same database could be useful to implement a wide survival analysis also to understand, for example, if the seasonality effect has some consequences on the effective arrival of a train in a predetermined destination.

The objectives of the last chapter are related to understand the dominant transport mode in the Uninsubria reality and to verify the different commuting habits of the two main poles. Moreover, another relevant focus is related to the sustainable mobility approach and the propensity to some green transport alternatives such as car pooling and bike sharing.

Referring to the home-school commuting trips, as explained in the chapter three, the overall picture that emerges from the data of the survey and according to the main theoretical findings, shows that a considerable population that is not properly advised in the sustainability field. This is demonstrated not only by the choices of the means adopted, but also by the answers that emerged from the survey and the interviews; it is clear that not all the commuters have a willingness to change the means of transport in favor of a more sustainable choice. The population of Insubria considers comfort and convenience as the main reasons to choose the principal means of transport. The results of the analyses, however, are a good point to orientate the University of Insubria in identifying the best strategies to reduce the individual use of the car and increase the use of sustainable alternative means. Finally, the analysis underlines that there are significant differences between the two main academic poles, due to different geographical locations of the university sites in the cities and a subsequent difficulty in reaching the Varese campus using public transport, in comparison with Como (where the sites are located in the city center). Considering separately the results, the users of Como seem more environmental friendly than the users of Varese and this is a challenge to improve the sensibility to the sustainable transportation of this pole. Probably, only with the implementation of a car-pooling application and the improvement of the local bus transportation system, this pole will be more virtuous from the environmental point of view.

At the end of this work, it is possible to shortly mention other elements that could help in improving the sustainability of mobility in the future. One key element that could encourage commuters to use alternative means than their car is certainly the tariff integration (Reis & Macario, 2015; Abrate et al., 2009). This is an element already effective in some Italian regional realities (e.g. Lombardy) but not yet common throughout our country. Considering the long term, the tariff integration should be extended to all regional services, directly or indirectly connected to public transport. Users should have access to a single payment instrument (e.g. smart card, mobile app…), accessing both to public transport and sharing mobility, as well as any other services connected to transport (e.g. parking lots, shops, structure to charge electric vehicles, etc.). Sharing mobility is a change in the paradigm of mobility that requires gradual interventions, because it affects the cultural domain (Danielis et al., 2016). However, the transition from an own vehicle to a sharing vehicle is increasing successfully in the last period also in Italy. Applying the concept of intermodality, the shared vehicles could be used mainly for the access to collective transportation or to complete the last part of a journey (last mile).

Moreover, the use of different types of electric vehicles, the diffusion of ICT and some new business models should be the basis for the creation of innovative forms of mobility that will be a link between sharing mobility and collective transportation. The sharing system should follow three innovative elements to be sustainable (Casals et al., 2016):

- Easy access, for all users, to a set of mobility services consisting of different kinds of vehicles, from the motor vehicle to the e-bike;
- functioning in strict conjunction with collective transport
- based on zero emission vehicles

Another futuristic evolution of mobility regards the use of innovative transportation vehicles, gradually shifting from traditional vehicles, to electric (medium-term) and automatic (long-term) vehicles (Konig & Neumayr, 2017). In particular, various automatic transport systems will have a strong integration with long-range systems (trains, large electric buses) and medium-range ones (automatic non-individual vehicles). All the means will be used in an adaptive manner and according to specific needs.

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Postfazione in lingua italiana

La tesi ha lo scopo di approfondire il concetto della mobilità sostenibile di passeggeri da un punto di vista teorico ed empirico, quest'ultimo aspetto analizzato attraverso l'uso di dati provenienti da realtà italiane. Il primo caso riguarda il comparto ferroviario, che, come noto, è la modalità di trasporto più sostenibile per i viaggi a medio-lungo raggio. In particolare, viene analizzato il problema del ritardo, fattore che impatta sulle prestazioni del treno e, indirettamente, anche sulle scelte degli utenti, i quali sono spinti a preferire l'automobile, poichè garantisce maggiore puntualità. Il secondo caso riguarda gli spostamenti casa-lavoro da/per un'università italiana policentrica di medie dimensioni: l'Università dell'Insubria.

In particolare, la tesi è composta da tre capitoli. Il primo è dedicato a definire, da un punto di vista teorico, il concetto di mobilità sostenibile e la sua evoluzione. Esso contiene una serie di dati europei ed italiani sulla crescita e sulle variazioni nel corso del tempo dei flussi di trasporto passeggeri, la scelta modale e le esternalità negative prodotte. È importante ricordare che la mobilità assume un ruolo centrale nel sistema sociale e rappresenta un fattore fondamentale per lo sviluppo socioeconomico sia a livello globale che locale. Considerando le implicazioni economiche, essa influenza il commercio internazionale, la crescita economica di un paese e lo spostamento delle persone e delle merci all'interno di un territorio, determinando l'accessibilità e migliorando la qualità della vita dei cittadini. Per l'implementazione di questi aspetti sono decisive le politiche di trasporto, con risvolti ambientali e sociali, volte alla riduzione delle emissioni inquinanti. Non ultimo la questione legata alla congestione stradale ed all'efficienza dei mezzi pubblici, anch'essi devono essere legati a politiche di coesione sociale, sviluppo urbano e sicurezza. Il capitolo presenta un'analisi dei dati europei e italiani su: mobilità, quota modale e impatto sull'ambiente. Successivamente, viene definita la mobilità sostenibile e vengono delineate, brevemente, alcune strategie per implementarla; infine, sono esaminate le nuove forme di mobilità sostenibile come il carpooling, il *bike* e *car sharing* e il bus a lunga percorrenza, sottolineandone le caratteristiche, gli aspetti positivi e le eventuali problematiche.

Il secondo capitolo è relativo all'analisi delle prestazioni di una linea ferroviaria italiana a media distanza (Milano-Genova). Il sistema ferroviario assume un ruolo strategico nell'economia della gran parte dei territori con una rete infrastrutturale sviluppata. Esso ha la capacità di trasportare ogni giorno milioni di passeggeri e beni del valore di milioni di dollari/euro dal luogo di origine a quello di destinazione. In molti lavori scientifici e documenti empirici il comparto ferroviario, grazie alle basse emissioni di CO_2, rappresenta una modalità di trasporto ecologica e sicura ed è apprezzato per la sua elevata efficienza energetica. Uno dei problemi più comuni e frequenti di questa modalità di trasporto è il ritardo, il quale influenza negativamente la scelta modale dei viaggiatori. Lo scopo del capitolo è duplice: in primo luogo fornisce una revisione critica della letteratura sulle categorie di ritardo come punto di partenza per lo sviluppo di una nuova classificazione dello stesso basata sul legame tra motivazioni, cause e responsabilità. In secondo luogo, applicando questa classificazione, viene eseguita un'analisi dei dati raccolti per comprendere la motivazione e la responsabilità del ritardo su un'importante linea ferroviaria interregionale italiana. I risultati descrivono una situazione nella quale le cause esterne, i problemi tecnici ed il guasto infrastrutturale, per quanto riguarda i dati analizzati, sono gli elementi più significativi. Le prime sono difficilmente prevedibili ed ipotizzabili, riguardano eventi naturali come alluvioni e terremoti oppure incidenti sulla linea dovuti ad attori esterni (incidenti tra autoveicoli e treno oppure tentativi di suicidio). Il tecnico al treno o il guasto infrastrutturale, invece, potrebbero essere limitati e controllati attraverso una maggiore manutenzione degli apparati del treno stesso o della linea. Nella classificazione è stato introdotto il ritardo "fisiologico", ovvero quello derivante da una serie di piccole concause che non possono essere attribuite ad una specifica classificazione poiché esse si possono verificare frequentemente e, prese singolarmente, non inficiano la prestazione ferroviaria in maniera rilevante. Inoltre, nella parte finale del capitolo, è utilizzata la tecnica dell'analisi di sopravvivenza per valutare la probabilità di guasto di un treno e per stimare la percentuale di corse che arrivano alla destinazione finale. Il terzo capitolo è relativo all'analisi delle dinamiche del pendolarismo casa-lavoro da/per un'università italiana policentrica di medie dimensioni, l'Università dell'Insubria. Queste analisi consentono di fornire un quadro della situazione attuale, mettendo a disposizione dei policymakers informazioni utili per individuare le misure più efficaci per un miglioramento della mobilità sostenibile. Il lavoro si basa sull'analisi dei dati raccolti attraverso un sondaggio (Insubria Mobility Survey) svolto presso l'Università degli Studi dell'Insubria (Uninsubria) nel novembre 2017 (circa 2.800 osservazioni), riguardante le abitudini in termini di pendolarismo di studenti, professori e personale amministrativo nel percorso casa-lavoro. Uninsubria è un'università statale italiana fondata nel 1998, localizzata nella parte nord-occidentale dell'Italia, in Lombardia (Provincie di Varese e Como) e ha due poli principali, Varese e Como ed un polo secondario di piccola dimensione, Busto Arsizio. È necessario innanzitutto sottolineare che un polo universitario produce, nell'area in cui è situato, impatti positivi e negativi e solamente strategie condivise da tutti gli attori possono influire positivamente sul livello di vivibilità del territorio. Lo scopo è di fornire un contributo rilevante riferito alle attuali dinamiche di *commuting* per poter sviluppare proposte e soluzioni in grado di orientare la domanda di mobilità verso modalità di trasporto sostenibili. In particolare, gli obiettivi del capitolo sono: (i) capire, attraverso elaborazioni statistico-descritte, se la presunta "*car dominance*" nelle abitudini di pendolarismo degli utenti si applica a tutti i poli dell'Università; (ii) verificare quali sono i driver principali che influenzano la scelta modale dell'utente, utilizzando un'analisi econometrica basata su un modello logit multinomiale. Successivamente (iii), dal punto di vista delle policy, vengono confrontati i risultati delle valutazioni degli utenti relativamente alle caratteristiche principali del servizio di trasporto pubblico di Como e Varese utilizzando il metodo dei test d'ipotesi. Infine, (iv) vengono analizzati i dati relativi all'utilizzo attuale e futuro ed alla propensione all'utilizzo di forme di mobilità condivisa e sostenibile nelle tre città oggetto d'indagine. Nell'analisi sono sviluppati diversi modelli di tipo logit multinomiale legati ai dati dei due poli principali, per stimare le determinanti della scelta modale in funzione del livello di sostenibilità del mezzo utilizzato. Si distinguono, quindi, tre categorie: trasporto individuale, - trasporto collettivo su gomma e trasporto ferroviario con dati aggregati in cluster geografici per luogo di provenienza dei pendolari. I risultati denotano una situazione molto differenziata tra i poli, infatti nel campus di Varese è presente una percentuale molto elevata di car-users, grazie al fatto che i flussi si concentrano nella sede decentrata (campus universitario collocato nel quartiere periferico di Bizzozero), ove vi sono anche possibilità abbastanza ampie di parcheggio. Nella città di Como, data la centralità delle sedi, il mezzo di trasporto pubblico è usato in modo prevalente. Tale scelta è motivata soprattutto da un lato in termini di ridotte tempistiche di viaggio (il servizio è valutato più positivamente rispetto a Varese) e dall'altro lato, dalla forte difficoltà di parcheggio nelle sedi che scoraggia l'utilizzo dell'automobile. Considerando separatamente i dati legati alla sostenibilità dei due poli principali, gli utenti di Como sembrano più sensibili alle tematiche ambientali rispetto agli utenti di Varese. Questa rappresenta certamente una sfida volta a spostare l'attenzione degli utenti varesini verso degli spostamenti più sostenibili cercando di renderli meno dipendenti da mezzi privati ed inquinanti. Probabilmente, per quanto riguarda quest'ultimo polo, solo attraverso l'implementazione di un'applicazione di carpooling ed il miglioramento del sistema di trasporto pubblico locale, si potranno ottenere dei miglioramenti considerevoli dal punto di vista della mobilità sostenibile.

Annex 1
Insubria Mobility Survey

Indagine sugli spostamenti casa - Università. Questionario per personale e studenti dell'Università degli Studi dell'Insubria

Questa indagine è stata promossa e condotta dal Mobility Manager dell'Università degli Studi dell'Insubria. L'obiettivo principale dell'indagine è quello di raccogliere informazioni sulle abitudini di spostamento degli utenti (docenti, personale e studenti) della nostra Università e sul grado di accessibilità delle diverse sedi universitarie, al fine di identificare alcune linee di azione strategiche volte a migliorare la mobilità quotidiana di ciascuno, anche dal punto di vista della sua sostenibilità.

*Campo obbligatorio

Informazioni anagrafiche

1. **Età** *

Contrassegna solo un ovale.

- 18-24
- 25-34
- 35-44
- 45-64
- Oltre

2. **Sesso** *

Contrassegna solo un ovale.

- M
- F

3. **Grado di Formazione Scolastica** *

Contrassegna solo un ovale.

- Licenza media inferiore
- Diploma
- Laurea
- Master Post Laurea
- Dottorato di ricerca

4. **Qualifica** *

Contrassegna solo un ovale.

- Studente a tempo pieno *Passa alla domanda 5.*
- Studente Lavoratore *Passa alla domanda 5.*
- Dottorando *Passa alla domanda 8.*
- Assegnista di Ricerca - Borsista *Passa alla domanda 9.*
- Docente *Passa alla domanda 9.*
- Personale Tecnico Amministrativo *Passa alla domanda 9.*
- Altro: ______________________ *Passa alla domanda 9.*

5. **A quale corso di laurea è iscritto?** *
Contrassegna solo un ovale.
- Triennale *Passa alla domanda 6.*
- Magistrale o Ciclo unico *Passa alla domanda 7.*

Laurea Triennale

6. **Qual è la denominazione del corso di laurea frequentato?** *
Contrassegna solo un ovale.
- Biotecnologie
- Chimica e chimica industriale
- Economia e management
- Educazione professionale
- Fisica
- Fisioterapia
- Igiene dentale
- Infermieristica
- Informatica
- Ingegneria per la sicurezza del lavoro e dell'ambiente
- Matematica
- Ostetricia
- Scienze biologiche
- Scienze motorie
- Scienze del turismo
- Scienze dell'ambiente e della natura
- Scienze della comunicazione
- Scienze della mediazione interlinguistica e interculturale
- Tecniche di fisiopatologia cardiocircolatoria e perfusione cardiovascolare
- Altro: ____________________

Passa alla domanda 9.

Laurea Magistrale o a Ciclo Unico

7. **Qual è la denominazione del corso di laurea frequentato?** *
Contrassegna solo un ovale.

- Biomedical Sciences
- Biotecnologie molecolari e industriali
- Chimica
- Economia, diritto e finanza d'impresa
- Fisica
- Global entrepreneurship economics and management
- Informatica
- Lingue moderne per la comunicazione e la cooperazione internazionale
- Matematica
- Scienze ambientali
- Scienze e tecniche della comunicazione
- Giurisprudenza
- Medicina e chirurgia
- Odontoiatria e protesi dentaria
- Altro: ____________________

Passa alla domanda 9.

Dottorato

8. **A quale corso di dottorato è iscritto?** *
Contrassegna solo un ovale.

- Scienze della vita e biotecnologie
- Diritto e scienze umane
- Fisica e astrofisica
- Informatica e matematica del calcolo
- Medicina clinica e sperimentale e Medical Humanities
- Medicina sperimentale e traslazionale
- Metodi e modelli per le decisioni economiche
- Scienze chimiche e ambientali
- Altro: ____________________

Passa alla domanda 9.

Spostamenti casa - Università

9. **Qual è il Comune dal quale parte abitualmente per recarsi in Università?** *
Inserire il nome, per esteso, del Comune di partenza

____

10. **Qual è la prevalente destinazione dello spostamento casa - Università?** *
Scegliere la sede di studio e/o lavoro nella quale viene passata la maggior parte del tempo
Contrassegna solo un ovale.

- Varese - Campus Bizzozzero
- Varese - Ospedale di Circolo
- Varese - Via Ravasi
- Varese - Via Mazzini
- Varese - Villa Toeplitz
- Varese - Via Piatti
- Varese - Ospedale Filippo del Ponte
- Como - Chiostro di S.Abbondio
- Como - Via Bossi
- Como - Via Castelnuovo
- Como - Via Cavallotti
- Como - Via Natta
- Como - Via Valleggio
- Busto Arsizio - Via A.Da Giussano
- Busto Arsizio- Villa Manara

11. **Abitualmente, in quale fascia oraria inizia il suo spostamento casa - Università?** *
Contrassegna solo un ovale.

- Prima delle 6.00
- 6.00 - 7.00
- 7.01 - 8.00
- 8.01 - 9.00
- 9.01 - 11.00
- 11.01- 16.00
- Oltre le 16.00

12. **Abitualmente, in quale fascia oraria lascia l'Università?** *
Contrassegna solo un ovale.

- Prima delle 13.00
- 13.00 - 15.00
- 15.01 - 17.00
- 17.01 - 19.00
- Oltre le 19.00

13. **Mediamente, quanti minuti impiega nello spostamento casa - Università?** *
Contrassegna solo un ovale.

- Meno di 10 minuti
- Tra 11 e 20 minuti
- Tra 21 e 30 minuti
- Tra 31 e 60 minuti
- Oltre 60 minuti

14. **Nel corso del suo spostamento casa - Università, effettua abitualmente delle fermate intermedie per esigenze personali e/o familiari (es., accompagnare i figli a scuola, fare la spesa, fare altre commissioni, ecc.)?** *
Contrassegna solo un ovale.

- NO
- SI, solo all'andata
- SI, solo al ritorno
- SI, sia all'andata che al ritorno

15. **Mediamente, nel periodo settembre - giugno, con quale frequenza percorre la tratta casa - Università?** *
Contrassegna solo un ovale.

- Meno di 1 volta alla settimana (es., studenti non frequentanti, personale tecnico in telelavoro, etc.)
- 1 volta alla settimana
- 2-3 volte a settimana
- 4-5 volte a settimana
- Oltre le 5 volte a settimana

16. **A quanto ammonta la sua spesa media mensile per gli spostamenti casa - Università?** *
Contrassegna solo un ovale.

- Non sostengo alcuna spesa
- Meno di 30€
- Tra 31€ e 50€
- Tra 51€ e 100€
- Oltre i 100€

17. **Qual è l'incidenza media percentuale del costo dello spostamento casa - Università sulla sua disponibilità di reddito mensile?** *
Contrassegna solo un ovale.

- Non ho reddito (es., sono uno studente non lavoratore)
- Meno del 5%
- Tra il 5% ed il 10%
- Oltre il 10%
- Non so/non rispondo

18. **A prescindere dal suo utilizzo o meno, per gli spostamenti casa - Università avrebbe abitualmente la disponibilità di un veicolo motorizzato (automobile, motocicletta/ciclomotore/scooter)?** *
Esempio: mezzi di proprietà personale e/o familiare
Contrassegna solo un ovale.

- SI, sempre
- SI, saltuariamente
- NO

Mezzi di trasporto

19. **Abitualmente, quanti mezzi di trasporto utilizza per lo spostamento casa - Università, includendo i tragitti a piedi per più di 5 minuti?** *
Contrassegna solo un ovale.

- Nessuno *Passa alla domanda 73.*
- 1 *Passa alla domanda 20.*
- 2 *Passa alla domanda 21.*
- 3 *Passa alla domanda 23.*
- più di 3 *Passa alla domanda 25.*

Utilizzo di 1 mezzo di trasporto

20. **Quale mezzo di trasporto utilizza?** *
Contrassegna solo un ovale.

- Nessuno, vado a piedi *Passa alla domanda 73.*
- Bicicletta *Passa alla domanda 66.*
- Motocicletta/Ciclomotore/Scooter *Passa alla domanda 40.*
- Automobile (come conducente) *Passa alla domanda 27.*
- Automobile (come passeggero) *Passa alla domanda 34.*
- Bus Urbano/Metropolitana/Tram *Passa alla domanda 47.*
- Bus Extra Urbano *Passa alla domanda 54.*
- Treno *Passa alla domanda 60.*
- Altro (Esempio: Traghetto, Battello, Funicolare) *Passa alla domanda 72.*

Utilizzo di 2 mezzi di trasporto

21. **Quali mezzi utilizza?** *
Contrassegna solo un ovale per riga.

	A piedi (per più di 5 minuti)	Bicicletta	Motocicletta, Ciclomotore, Scooter	Automobile	Bus Urbano, Metropolitana, Tram	Bus Extra Urbano	Treno	Altro (Traghetto, Battello, Funicolare)
1°mezzo								
2°mezzo								

22. **In quale Comune effettua il cambio tra i 2 mezzi di trasporto?** *

____

Passa alla domanda 26.

Utilizzo di 3 mezzi di trasporto

23. **Quali mezzi utilizza?** *

Contrassegna solo un ovale per riga.

	A piedi (per più di 5 minuti)	Bicicletta	Motocicletta, Ciclomotore, Scooter	Automobile	Bus Urbano, Metropolitana, Tram	Bus Extra Urbano	Treno	Altro (Traghetto, Battello, Funicolare)
1°mezzo								
2°mezzo								
3°mezzo								

24. **In quali Comuni effettua i cambi tra i 3 mezzi di trasporto?** *

Inserire i Comuni in ordine temporale, separati da una virgola (es.: Milano, Bergamo)

Passa alla domanda 26.

Utilizzo di più di 3 mezzi di trasporto

25. **Quali mezzi utilizza?**

Seleziona tutte le voci applicabili.

	A piedi (per più di 5 minuti)	Bicicletta	Motocicletta, Ciclomotore, Scooter	Automobile	Bus Urbano, Metropolitana, Tram	Bus Extra Urbano	Treno	Altro (Traghetto, Battello, Funicolare)
1°mezzo								
2°mezzo								
3°mezzo								
4°mezzo								
5°mezzo								
6°mezzo								

Passa alla domanda 26.

Qual è il suo principale mezzo di trasporto per lo spostamento casa - Università?

Scegliere il mezzo che copre la distanza maggiore, espressa in km

26. *

Contrassegna solo un ovale.

- Nessuno, vado a piedi *Passa alla domanda 73.*
- Bicicletta *Passa alla domanda 66.*
- Motocicletta/Ciclomotore/Scooter *Passa alla domanda 40.*
- Automobile (come conducente) *Passa alla domanda 27.*
- Automobile (come passeggero) *Passa alla domanda 34.*
- Autobus Urbano *Passa alla domanda 47.*
- Autobus Extraurbano *Passa alla domanda 54.*
- Treno *Passa alla domanda 60.*
- Altro (Traghetto, Battello, Funicolare) *Passa alla domanda 72.*

Automobile (come conducente)

27. **Mediamente, quanti minuti impiega per la sola tratta percorsa in automobile? ***
Contrassegna solo un ovale.

- Meno di 10 minuti
- Tra 11 e 20 minuti
- Tra 21 e 30 minuti
- Tra 31 e 60 minuti
- Oltre 60 minuti

28. **Che tipo di automobile utilizza abitualmente? ***
Contrassegna solo un ovale.

- Benzina
- Diesel
- Ibrida (benzina + elettrica)
- GPL
- Metano
- Elettrica

29. **Per quali motivi utilizza l'automobile? ***
Inserire un valore da 0 a 3 che indichi il peso di ciascuna delle seguenti motivazioni (0 = non influente --> 3 = altamente influente)
Contrassegna solo un ovale per riga.

	0	1	2	3
Non esistono mezzi pubblici diretti o non esistono mezzi pubblici				
Inadeguato livello del servizio pubblico (bassa frequenza delle corse, mezzi affollati, etc.)				
Convenienza economica				
Durata del viaggio (tempi ridotti)				
Preferenza per viaggi in solitudine e/o maggiore comfort				
Sicurezza personale				

30. **Arrivato a destinazione, dove parcheggia abitualmente l'automobile ? ***
Contrassegna solo un ovale.

- Parcheggio interno dell'università
- Sosta su strada a pagamento
- Sosta su strada gratuita
- Altro: ____________________

31. **Ha difficoltà a trovare parcheggio nelle vicinanze dell'Università? ***
Contrassegna solo un ovale.

- SI, sempre
- SI, a volte
- NO

32. **Quali sono le condizioni che la spingerebbero a non utilizzare più l'automobile o a ridurne drasticamente l'utilizzo?** *

Scegliere al massimo 3 condizioni

Seleziona tutte le voci applicabili.

- [ ] Aumento del costo del carburante
- [ ] Aumento del costo del parcheggio
- [ ] Aumento di altri costi legati all'utilizzo dell'automobile (es., tariffe autostradali, ticket di ingresso in area urbana)
- [ ] Aumento delle difficoltà di parcheggio
- [ ] Aumento del traffico
- [ ] Nessuna condizione (continuerei ad utilizzare l'automobile)
- [ ] Altro: ______________________

33. **In primavera e/o estate oppure quando le condizioni meteorologiche lo consentono, modifica le sue abitudini di spostamento casa - Università?** *

Contrassegna solo un ovale.

- ( ) NO
- ( ) SI, utilizzo una bicicletta privata
- ( ) SI, utilizzo una bicicletta pubblica in condivisione (servizio di bike sharing)
- ( ) SI, utilizzo la motocicletta/il ciclomotore/lo scooter
- ( ) SI, mi muovo a piedi

Passa alla domanda 39.

Automobile (come passeggero)

34. **Mediamente, quanti minuti impiega per la sola tratta percorsa in automobile?** *

Contrassegna solo un ovale.

- ( ) Meno di 10 minuti
- ( ) Tra 11 e 20 minuti
- ( ) Tra 21 e 30 minuti
- ( ) Tra 31 e 60 minuti
- ( ) Oltre 60 minuti

35. **Per quali motivi utilizza l'automobile come passeggero?** *

Inserire un valore da 0 a 3 per ciascuna motivazione (0 = non influente --> 3 = altamente influente)

Contrassegna solo un ovale per riga.

	0	1	2	3
Non esistono mezzi pubblici diretti o non esistono mezzi pubblici	( )	( )	( )	( )
Inadeguato livello del servizio pubblico (bassa frequenza delle corse, mezzi affollati, etc.)	( )	( )	( )	( )
Non ho a disposizione alcun mezzo di proprietà	( )	( )	( )	( )
Durata del viaggio (tempi ridotti)	( )	( )	( )	( )
Preferenza per viaggi in compagnia	( )	( )	( )	( )
Convenienza economica (es., condivisione dei costi)	( )	( )	( )	( )

36. **Arrivato a destinazione, dove viene parcheggiata abitualmente l'automobile ?** *
Contrassegna solo un ovale.

- Parcheggio interno dell'università
- Sosta su strada a pagamento
- Sosta su strada gratuita
- Altro: ______________________

37. **Avete difficoltà a trovare parcheggio nelle vicinanze dell'Università?** *
Contrassegna solo un ovale.

- SI, sempre
- SI, a volte
- NO

38. **In primavera e/o estate oppure quando le condizioni meteorologiche lo consentono, modifica le sue abitudini di spostamento casa - Università?** *
Contrassegna solo un ovale.

- NO
- SI, utilizzo una bicicletta privata
- SI, utilizzo una bicicletta pubblica in condivisione (servizio di bike sharing)
- SI, utilizzo la motocicletta /il ciclomotore / lo scooter
- SI, mi muovo a piedi

Passa alla domanda 39.

39. **Se fosse costretto a scegliere una modalità alternativa all'automobile per i suoi spostamenti casa - Università, quale mezzo di trasporto sarebbe più propenso ad utilizzare?** *
Considerare il mezzo che andrebbe a coprire la tratta più lunga nello spostamento casa - Università
Contrassegna solo un ovale.

- Motocicletta/Ciclomotore/Scooter *Passa alla domanda 74.*
- Bicicletta Privata *Passa alla domanda 74.*
- Bike Sharing *Passa alla domanda 74.*
- Autobus Extraurbano *Passa alla domanda 74.*
- Autobus Urbano *Passa alla domanda 74.*
- Treno *Passa alla domanda 74.*
- Altro: ______________________ *Passa alla domanda 74.*

Passa alla domanda 74.

Motocicletta/Ciclomotore/Scooter

40. **Mediamente, quanti minuti impiega per percorrere la sola tratta in motocicletta/ciclomotore/scooter?** *
Contrassegna solo un ovale.

- Meno di 10 minuti
- Tra 11 e 20 minuti
- Tra 21 e 30 minuti
- Tra 31 e 60 minuti
- Oltre 60 minuti

41. **Per quali motivi utilizza il mezzo motocicletta/ciclomotore/scooter?** *

Inserire un valore da 0 a 3 che indichi il peso di ciascuna delle seguenti motivazioni (0 = non influente -> 3 = altamente influente)

Contrassegna solo un ovale per riga.

	0	1	2	3
Non esistono mezzi pubblici diretti o non esistono mezzi pubblici	◯	◯	◯	◯
Inadeguato livello del servizio pubblico (bassa frequenza delle corse, mezzi affollati, ecc.)	◯	◯	◯	◯
Convenienza economica	◯	◯	◯	◯
Durata del viaggio (tempi ridotti)	◯	◯	◯	◯
Preferenza per viaggi in solitudine e/o maggiore comfort	◯	◯	◯	◯
Sicurezza personale	◯	◯	◯	◯

42. **Arrivato a destinazione, dove parcheggia il mezzo motocicletta/ciclomotore/scooter?** *

Contrassegna solo un ovale.

- ◯ Parcheggio interno dell'Università
- ◯ Sosta su strada a pagamento
- ◯ Sosta su strada gratuita
- ◯ Altro: ____________________

43. **Ha difficoltà a trovare parcheggio nelle vicinanze dell'Università?** *

Contrassegna solo un ovale.

- ◯ SI, sempre
- ◯ SI, a volte
- ◯ NO

44. **Quali sono le condizioni che la spingerebbero a non utilizzare più un motoveicolo o a ridurne drasticamente l'utilizzo?** *

Scegliere al massimo 3 condizioni

Seleziona tutte le voci applicabili.

- ☐ Aumento del costo del carburante
- ☐ Aumento del costo del parcheggio
- ☐ Aumento di altri costi legati all'utilizzo del motoveicolo (es., tariffe autostradali, ticket di ingresso in area urbana)
- ☐ Aumento delle difficoltà di parcheggio
- ☐ Aumento del traffico
- ☐ Nessuna condizione (continuerei ad utilizzare il motoveicolo)
- ☐ Altro: ____________________

45. **In autunno e/o inverno, oppure quando le condizioni meteorologiche sono proibitive, modifica le sue abitudini di spostamento nel tratto casa - Università? ***
Contrassegna solo un ovale.

- NO
- SI, utilizzo l'auto come guidatore
- SI, utilizzo l'auto come passeggero
- SI, utilizzo il bus urbano
- SI, utilizzo il bus extraurbano
- SI, utilizzo il treno
- SI, utilizzo un altro mezzo diverso da quelli sopra indicati

Passa alla domanda 46.

46. **In riferimento allo spostamento casa - Università, dovendo scegliere una modalità alternativa, quale mezzo di trasporto sareste più propensi ad utilizzare al posto del motoveicolo? ***
Considerare il mezzo che andrebbe a coprire la tratta più lunga nello spostamento casa - Università
Contrassegna solo un ovale.

- Automobile come conducente *Passa alla domanda 74.*
- Automobile come passeggero *Passa alla domanda 74.*
- Bicicletta privata *Passa alla domanda 74.*
- Bike Sharing *Passa alla domanda 74.*
- Autobus Extraurbano *Passa alla domanda 74.*
- Autobus Urbano *Passa alla domanda 74.*
- Treno *Passa alla domanda 74.*
- Altro: ______________________ *Passa alla domanda 74.*

Passa alla domanda 74.

Autobus Urbano

47. **Mediamente, quanti minuti impiega per la sola tratta percorsa con l'autobus urbano? ***
Contrassegna solo un ovale.

- Meno di 10 minuti
- Tra 11 e 20 minuti
- Tra 21 e 30 minuti
- Tra 31 e 60 minuti
- Oltre 60 minuti

48. **Quanti minuti impiega, mediamente, per effettuare il tragitto da casa verso la fermata dell'autobus urbano? ***
Contrassegna solo un ovale.

- Meno di 5 minuti
- Tra 5 e 10 minuti
- Tra 11 e 15 minuti
- Oltre 15 minuti

49. **Mediamente, con quale frequenza passa l'autobus urbano che la porta in Università?** *
Contrassegna solo un ovale.

- Meno di 5 minuti
- Tra 5 e 10 minuti
- Tra 10 e 15 minuti
- Tra 15 e 20 minuti
- Oltre 20 minuti

50. **Per quale motivo utilizza l'autobus urbano?** *
Inserire un valore da 0 a 3 che indichi il peso di ciascuna delle seguenti motivazioni (0 = non influente --> 3 = altamente influente)
Contrassegna solo un ovale per riga.

	0	1	2	3
Mancata disponibilità di un mezzo privato				
Convenienza (basse tariffe)				
Livello del servizio adeguato (frequenza delle corse, vicinanza alle fermate)				
Durata del viaggio (tempi ridotti)				
Collegamento diretto (assenza di cambi)				
Maggiore comfort (minore stress, possibilità di lavoro/riposo, etc.)				
Carenza o difficoltà di parcheggio di mezzi privati vicino all'Università				
Rispetto e tutela dell'ambiente (es., qualità dell'aria)				

51. **Esprima un giudizio sulle diverse caratteristiche della linea di autobus urbano che utilizza per gli spostamenti casa - Università** *
Inserire un valore da 0 a 3 per ciascuna caratteristica del servizio (0 = insoddisfacente --> 3 = pienamente soddisfacente)
Contrassegna solo un ovale per riga.

	0	1	2	3
Convenienza economica				
Puntualità				
Informazione su orari e modifiche				
Frequenza delle corse				
Integrazione tariffaria con altri mezzi pubblici (es., treno, bus extraurbani, bike sharing)				
Comodità nel cambio con altri mezzi (es., coincidenze, parcheggi di interscambio)				

52. **Possiede un abbonamento per il servizio pubblico di autobus urbano?** *
Contrassegna solo un ovale.

- SI
- NO *Passa alla domanda 74.*

Passa alla domanda 53.

53. **Il suo abbonamento prevede l'integrazione tariffaria con altri mezzi del servizio pubblico?** *
Contrassegna solo un ovale.

- NO
- SI, ma solo con il treno
- SI, ma solo con l'autobus extraurbano
- SI, sia con il treno che con l'autobus extraurbano
- Non ne sono a conoscenza

Passa alla domanda 74.

Autobus Extraurbano

54. **Mediamente, quanti minuti impiega per la sola tratta percorsa con l'autobus extraurbano?** *
Contrassegna solo un ovale.

- Meno di 10 minuti
- Tra 11 e 20 minuti
- Tra 21 e 30 minuti
- Tra 31 e 60 minuti
- Oltre 60 minuti

55. **Quanti minuti impiega, mediamente, per effettuare il tragitto da casa verso la fermata dell'autobus extraurbano?** *
Contrassegna solo un ovale.

- Meno di 5 minuti
- Tra 5 e 10 minuti
- Tra 11 e 15 minuti
- Oltre 15 minuti

56. **Per quale motivo utilizza l'autobus extraurbano?** *
Inserire un valore da 0 a 3 che indichi il peso di ciascuna delle seguenti motivazioni (0 = non influente --> 3 = altamente influente)
Contrassegna solo un ovale per riga.

	0	1	2	3
Mancata disponibilità di un mezzo privato				
Convenienza (basse tariffe)				
Livello del servizio adeguato (frequenza delle corse, vicinanza alle fermate)				
Durata del viaggio (tempi ridotti)				
Collegamento diretto (assenza di cambi)				
Maggiore comfort (minore stress, possibilità di lavoro/riposo, etc.)				
Carenza o difficoltà di parcheggio di mezzi privati vicino all'Università				
Rispetto e tutela dell'ambiente (es., qualità dell'aria)				

57. **Esprima un giudizio sulle diverse caratteristiche della linea di autobus extraurbano che utilizza per gli spostamenti casa - Università** *

Inserire un valore da 0 a 3 per ciascuna caratteristica del servizio (0 = insoddisfacente --> 3 = pienamente soddisfacente)

Contrassegna solo un ovale per riga.

	0	1	2	3
Convenienza economica				
Puntualità				
Informazione su orari e modifiche				
Frequenza delle corse				
Integrazione tariffaria con altri mezzi pubblici (es., treno, autobus urbani, bike sharing)				
Comodità nel cambio con altri mezzi (es., coincidenze, parcheggi di interscambio)				

58. **Possiede un abbonamento per il servizio pubblico di autobus extraurbano?** *

Contrassegna solo un ovale.

- SI
- NO *Passa alla domanda 74.*

Passa alla domanda 59.

59. **Il suo abbonamento prevede l'integrazione tariffaria con altri mezzi del servizio pubblico?** *

Contrassegna solo un ovale.

- NO
- SI, ma solo con il treno
- SI, ma solo con l'autobus urbano
- SI, sia con il treno che con l'autobus urbano
- Non ne sono a conoscenza

Passa alla domanda 74.

Treno

60. **Mediamente, quanti minuti impiega per la sola tratta percorsa con il treno?** *

Contrassegna solo un ovale.

- Meno di 10 minuti
- Tra 10 e 20 minuti
- Tra 21 e 30 minuti
- Tra 31 e 60 minuti
- Oltre 60 minuti

61. **Quanti minuti impiega, mediamente, per effettuare il tragitto da casa verso la stazione ferroviaria?** *

Contrassegna solo un ovale.

- Meno di 5 minuti
- Tra 5 e 10 minuti
- Tra 11 e 15 minuti
- Oltre 15 minuti

62. **Per quale motivo utilizza il treno?** *

Inserire un valore da 0 a 3 che indichi il peso di ciascuna delle seguenti motivazioni (0 = non influente --> 3 = altamente influente)

Contrassegna solo un ovale per riga.

	0	1	2	3
Mancata disponibilità di un mezzo privato				
Convenienza (basse tariffe)				
Livello del servizio adeguato (frequenza dei viaggi, vicinanza alla stazione)				
Durata del viaggio (tempi ridotti)				
Collegamento diretto (assenza di cambi)				
Maggiore comfort (minore stress, possibilità di lavoro/riposo, etc.)				
Carenza o difficoltà di parcheggio di mezzi privati vicino all'Università				
Rispetto e tutela dell'ambiente (es., qualità dell'aria)				

63. **Esprima un giudizio sulle diverse caratteristiche della linea ferroviaria che utilizza per gli spostamenti casa - Università** *

Inserire un valore da 0 a 3 per ciascuna caratteristica del servizio (0 = insoddisfacente --> 3 = pienamente soddisfacente)

Contrassegna solo un ovale per riga.

	0	1	2	3
Convenienza economica				
Puntualità				
Informazione su orari e modifiche				
Frequenza dei viaggi				
Integrazione tariffaria con altri mezzi pubblici (es., autobus urbani ed extraurbani, bike sharing)				
Comodità nel cambio con altri mezzi (es., coincidenze, parcheggi di interscambio)				

64. **Possiede un abbonamento per il servizio ferroviario?** *

Contrassegna solo un ovale.

- SI
- NO *Passa alla domanda 74.*

Passa alla domanda 65.

65. **Il suo abbonamento prevede l'integrazione tariffaria con altri mezzi del servizio pubblico?** *

Contrassegna solo un ovale.

- NO
- SI, ma solo con l'autobus urbano
- SI, ma solo con l'autobus extraurbano
- SI, sia con l'autobus urbano che extraurbano
- Non ne sono a conoscenza

Passa alla domanda 74.

Bicicletta

66. **Mediamente, quanti minuti impiega per la sola tratta percorsa con la bicicletta?** *
Contrassegna solo un ovale.

- Meno di 10 minuti
- Tra 10 e 20 minuti
- Tra 21 e 30 minuti
- Oltre 30 minuti

67. **Quanto influiscono i seguenti aspetti sulla sua scelta di utilizzo della bicicletta?** *
Inserire un valore da 0 a 3 per ciascun aspetto considerato (0 = non influente --> 3 = altamente influente)
Contrassegna solo un ovale per riga.

	0	1	2	3
Mancata disponibilità di un mezzo privato motorizzato (es., automobile, motocicletta/ciclomotore/scooter)				
Inadeguatezza del servizio di trasporto pubblico				
Convenienza economica				
Carenza o difficoltà di parcheggio di mezzi privati vicino all'Università				
Durata del viaggio (tempi ridotti)				
Preferenza per viaggi in solitudine				
Salute psico-fisica				
Piacere personale e/o passione				
Rispetto e tutela dell'ambiente (es., qualità dell'aria)				

68. **In autunno e/o inverno oppure quando le condizioni meteorologiche sono proibitive, modifica le sue abitudini di spostamento casa - Università?** *
Contrassegna solo un ovale.

- NO
- SI, utilizzo l'auto come guidatore
- SI, utilizzo l'auto come passeggero
- SI, utilizzo l'autobus urbano
- SI, utilizzo l'autobus extraurbano
- SI, utilizzo il treno
- SI, utilizzo un altro mezzo diverso da quelli sopra indicati

69. **Negli spostamenti casa - Università, che tipo di bicicletta utilizza?** *
Contrassegna solo un ovale.

- Privata *Passa alla domanda 74.*
- Privata con pedalata assistita *Passa alla domanda 74.*
- Pubblica in condivisione (bike sharing) *Passa alla domanda 70.*

Bike Sharing

70. **Da quanto tempo è abbonato al servizio di bike sharing?** *

Contrassegna solo un ovale.

- Meno di 1 anno
- Tra 1 e 2 anni
- Tra 2 e 3 anni
- Più di 3 anni
- Non ho un abbonamento, lo utilizzo saltuariamente

71. **Esprima un giudizio sulle diverse caratteristiche del bike sharing di Varese/Como/Busto Arsizio** *

Inserire un valore da 0 a 3 per ciascuna caratteristica del servizio (0 = insoddisfacente --> 3 = pienamente soddisfacente)

Contrassegna solo un ovale per riga.

	0	1	2	3
Costo dell'abbonamento				
Numero delle biciclette in ciascuno stallo				
Adeguatezza delle biciclette (qualità del mezzo, manutenzione, etc.)				
Localizzazione degli stalli				
Qualità del servizio (modalità di iscrizione, servizio clienti)				
Comodità nel cambio con altri mezzi (es., distanza fra stalli e stazioni ferroviarie e/o fermate degli autobus)				
Il livello del comfort della bicicletta				
Il numero di piste ciclabili presenti in città				
La sicurezza delle piste ciclabili				
La sicurezza delle zone dei ricoveri / stalli delle biciclette				

Passa alla domanda 79.

Altro mezzo di trasporto

In questa parte del questionario viene richiesto all'utente di descrivere brevemente il percorso casa - Università ed il mezzo utilizzato.

72. **Descrivere brevemente il mezzo utilizzato, la tratta percorsa, la frequenza settimanale con la quale effettua lo spostamento casa - Università e i relativi costi sostenuti. Se lo ritiene opportuno, inoltre, può lasciare un suo indirizzo e-mail in modo che venga contattato per approfondire la conoscenza sulla sua esperienza di viaggio. Grazie!** *

Passa alla domanda 74.

Non utilizzo alcun mezzo di trasporto

73. **Descrivere brevemente le principali motivazioni che la spingono a non utilizzare alcun mezzo di trasporto (es., distanza ridotta tra abitazione ed Università, etc.)** *

Passa alla domanda 76.

Car Pooling

Il CAR POOLING è una modalità di trasporto che consiste nella condivisione di automobili private tra un gruppo di persone: un automobilista mette a disposizione i posti liberi sulla propria automobile con o senza un contributo alle spese

74. **Sarebbe disposto a condividere lo spostamento casa - Università e i relativi costi con altri colleghi/compagni come conducente o passeggero di un'automobile?** *

Contrassegna solo un ovale.

- SI, lo faccio già abitualmente *Passa alla domanda 76.*
- SI, è già capitato qualche volta *Passa alla domanda 75.*
- SI, ma ancora non lo faccio *Passa alla domanda 75.*
- NO *Passa alla domanda 76.*

Passa alla domanda 75.

75. **A quali condizioni sarebbe disposto a condividere il viaggio abitualmente o frequentemente con colleghi/compagni?** *

Scegliere al massimo 3 alternative

Seleziona tutte le voci applicabili.

- Se fosse disponibile un sistema organizzativo dell'Università che consentisse di mettersi in contatto con i colleghi/compagni che hanno le stesse esigenze di percorso e tempi
- Se i tempi di spostamento non fossero superiori a quelli attuali
- Se nell'Università fossero a disposizione parcheggi riservati per chi sfrutta il carpooling
- Solo con conoscenti
- Solo a condizione di non guidare
- Se consentisse di risparmiare sui costi di viaggio

Bike Sharing

Il bike sharing è un sistema di condivisione di biciclette pubbliche per brevi spostamenti cittadini

76. **Nelle diverse sedi di Uninsubria (Varese, Como, Busto Arsizio) è disponibile un servizio di bike sharing cittadino. Lo ha mai utilizzato?** *

Contrassegna solo un ovale.

- SI, a volte per gli spostamenti casa-università *Passa alla domanda 70.*
- SI, a volte per altri spostamenti *Passa alla domanda 70.*
- NO *Passa alla domanda 77.*
- Non conosco questo tipo di servizio *Passa alla domanda 77.*

77. **Pur non avendone ancora fatto ricorso, sarebbe in qualche modo disposto ad utilizzare il servizio di bike sharing?** *

Contrassegna solo un ovale.

- SI *Passa alla domanda 78.*
- NO *Passa alla domanda 79.*

78. **Sotto quali condizioni sarebbe disposto a utilizzare il servizio di bike sharing?** *

Inserire un valore da 0 a 3 che indichi il peso di ciascuna delle seguenti condizioni (0 = non influente --> 3 = altamente influente)

Contrassegna solo un ovale per riga.

	0	1	2	3
Condizioni metereologiche favorevoli				
Convenienza economica (basso costo dell'abbonamento)				
Minore traffico sulle strade cittadine				
Adeguata dotazione di biciclette nei diversi stalli				
Esistenza di biciclette a pedalata assistita				
Esistenza di piste ciclabili				

Servizio Bus Navetta Uninsubria

Servizio attivo solo per la sede di Varese. Il servizio bus navetta, fornito a titolo gratuito dall'Università degli Studi dell'Insubria è riservato a studenti, docenti e personale tecnico-amministrativo dell'Ateneo (http://www4.uninsubria.it/on-line/home/naviga-per-tema/servizi/navetta.html)

79. **Ha mai utilizzato il servizio bus navetta di Uninsubria, esistente nella sola sede di Varese?** *

Contrassegna solo un ovale.

- SI, lo utilizzo regolarmente *Passa alla domanda 81.*
- SI, lo utilizzo saltuariamente *Passa alla domanda 81.*
- SI, l'ho utilizzato in passato (ma ora non più) *Passa alla domanda 80.*
- NO *Passa alla domanda 80.*

80. **Per quali motivi non utilizza più o non ha mai utilizzato il servizio bus navetta della sede di Varese?** *

Scegliere al massimo 3 motivazioni

Seleziona tutte le voci applicabili.

- [ ] La sede universitaria in cui studio/lavoro (Como e/o Busto Arsizio) non è servita dal bus navetta
- [ ] Non vi è sufficiente disponibilità di posti per ogni corsa
- [ ] Orari non compatibili con le mie esigenze di spostamento
- [ ] Preferisco utilizzare il mezzo di trasporto abituale

Passa alla domanda 82.

81. **Esprima un giudizio sulle diverse caratteristiche del servizio bus navetta Uninsubria esistente nella sede di Varese** *

Inserire un valore da 0 a 3 per ciascuna caratteristica del servizio (0 = insoddisfacente --> 3 = pienamente soddisfacente)

Contrassegna solo un ovale per riga.

	0	1	2	3
Puntualità				
Orari delle partenze				
Informazione su orari e modifiche				
Frequenza dei viaggi				
Numero di posti a disposizione per ogni corsa				

Conclusione

Grazie per aver partecipato alla nostra indagine!!

Ai sensi dell'art. 13 D.Lgs. 196/03, i dati da lei forniti verranno usati esclusivamente ad uso statistico e la loro divulgazione avverrà solo in forma aggregata, in modo da non poterne fare alcun riferimento personale.

Per ulteriori informazioni sul sondaggio, la preghiamo di contattare il referente al seguente indirizzo mail: elena.maggi@uninsubria.it

82. **Se desidera, può lasciarci un commento finale nello spazio sottostante**

83. **Clicca qui per inviare il sondaggio!** *

Contrassegna solo un ovale.

FINE! *Interrompi la compilazione del modulo.*