

Smart City, Sustainable Mobility, Home-Work Mobility: Data Analysis and Actions

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Abstract. The paper deals with the issue related to the home-work mobility of the employees. This issue is very important because many employees have similar working hours, starting at the same hour and finishing at the same hour. The result is a significant increase of traffic congestion and pollution in these hours. Similar situation occurs for students who have to go to school or go home. The previous cases coexist very often and are related each other. The aim of this paper is to present the results of a survey about the home-work mobility of the municipality employees of three medium cities located in the South of Italy. It results that the car is the privileged vehicle for the home-work transfer, independently from the costs of the transfer and from the time needed to reach the nearest stop of public transport vehicle. In a relevant number of cases the car is also the essential vehicle, because of intermediate mandatory stops or to the need to limit the transfer time. In these cases, the use of an electrical car could be an effective solution to join the need to use a car with the need to limit the pollution.

Keywords

Smart City, Sustainable mobility, Home-work mobility, Electrical vehicles

1. Introduction

Mobility in urban areas is strongly constrained, i.e., by traffic and inefficient (private and/or public) transportation. These inefficiencies lead to congestion, pollution, noise, increased energy consumption, and the associated economic losses. For instance, in the USA, congestion wastes a massive amount of time, fuel, and money. i.e., 1.9 billion gallons of wasted fuel, 4.8 billion hours of extra time, and 101 billion dollars of delay and fuel cost [1]. In the EU, congestion costs 1% of the total GDP annually [2]. According to recent studies [3], [4], the transportation sector alone accounts for 25% and 32% of the total carbon dioxide (CO₂) emissions in Europe and in the USA, respectively. Virtually all of the energy consumed in this end-use sector came from petroleum products [4]. More specifically, in the EU road transportation is responsible for 71% of the total transport share in total emissions as stated in [5] and has clearly represented the dominant mode of transport over the past few decades. One aggravating factor is the ever-increasing traffic levels that have neutralized the average emission reduction per vehicle obtained due to the design of more efficient vehicles [6]. Most of times the home-work mobility represents a criticism from the urban traffic point

of view. Then we carried out a study about the home-work mobility of the employees of the municipalities of three medium cities located in the South of Italy: Barletta, Andria, Trani. This study is constituted by two parts for each city. The former regards the **data analysis** of the questionnaire completed by the employees; the latter reports possible **actions** to change the standard habits of the home-work mobility in order to use less polluting transportations.

2. Data analysis and proposed actions

The questionnaire was administered to the municipal employees of the three cities of the province BAT (Barletta, Andria, Trani) and consists of the following main sections:

1. Report and working hours.
2. Journeys to and from work, with particular attention to the case where the user uses the car.
3. Means of transport preferred as alternative to the one already used.

The purpose of the questionnaire is to create a database of current modes of travel to and from work, of any critical situation that favors one mode (eg. the private car) over another (eg. public bus), of possible actions that could change the current choices, etc.

Fig. 1 shows, for the three municipalities involved, the total number of employees and the number of employees available to respond to the questionnaire. For the City of Barletta participated 195 employees of 292 (67%), for the City of Andria 192 employees of 416 (46%), for the city of Trani 86 employees of 135 (64%).

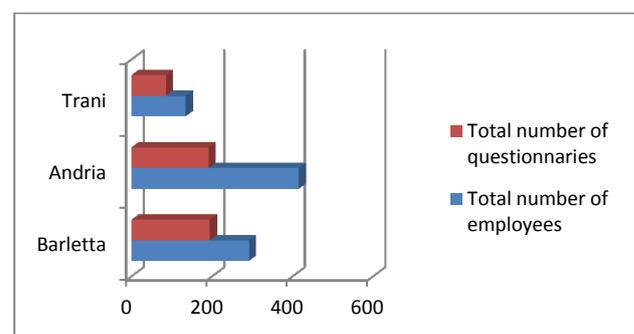


Fig. 1. Number of employees, survey participants.

A. Municipality of Barletta

The number of municipal employees totalled 292, of which 97 (33%) was not available to respond to the questionnaire. Of the remaining 195 questionnaires (67% of total) 14 were partially empty, 173 employees are residents of Barletta (representing approximately 90% of the dataset available).

The first analysis concerns the mode of travel from home to work. Fig. 2 shows the number of employees for each type, which shows that the *private car as driver* is the main means of transport, followed by mode *afoot*. Very low is the use of public transport, especially the train (typically used by staff outside-seat), being very low number of employees off-seat. Compared to the other two cities, in Barletta there are also employees who use bikes/motorcycles, type virtually absent among the employees of the other two municipalities. The use of the private car (driver + passenger) represents about 49% of the mode of travel.

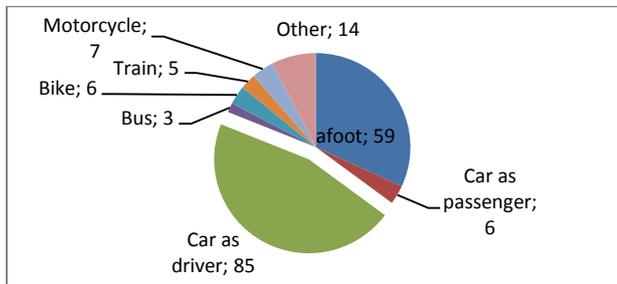


Fig. 2. Modes of travel to and from work for employees of the City of Barletta

This probably also takes account of the fact that as many as 64 employees (of the 85) have a private parking space in their house, which, in addition to being a head start from home, avoids the parking problem to return from work. Furthermore, over 80% of employees declared to take advantage of free parking, when it reaches the workplace, 10% use the car park of the place of work or paid parking on public land. The sum of all the values do not reach the number of questionnaires, as some employees have not given any indication of the means of transport. This situation will also occur for other times.

Another analysis concerned the time needed to reach the bus transportation mode closest to own home. Fig. 3 shows the time needed to reach the nearest bus stop, taking into account the mobility mode currently used.

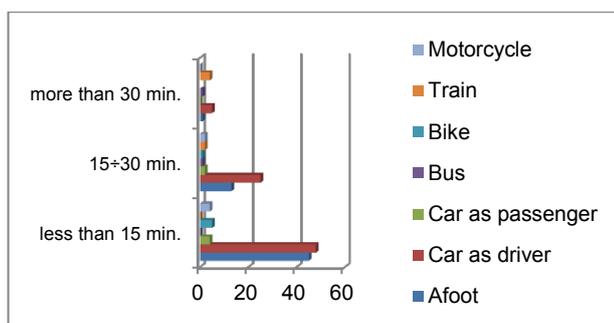


Fig. 3. Time to reach the stop nearest to your home for the employees of the City of Barletta

For times less than 15 minutes, the *car as driver* is the first option for the journey from home to work, followed by mode *afoot*. These two modes of travel account for about 95% of the mode of travel. Exceeded the 15 minutes needed to reach the nearest stop of an alternative means, the mode *car as driver* is the most widely used, by covering only 50% of the sample, followed by mode *afoot* with about 20%. The set of alternative means covers about 10% of the options chosen by the employees. Some employees do not respond.

Similarly, it appears that the income of the employee does not influence the decision on the means of transport to and from work; in fact the private car is mainly used by employees, whatever the income range of belonging, thus showing a low correlation between their income and the means used (Fig. 4).

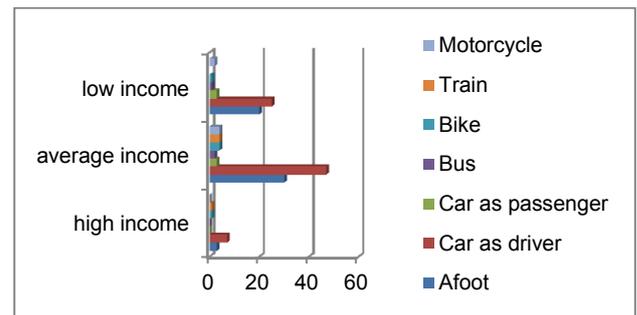


Fig. 4. Income of the employees of the City of Barletta according to the method chosen for the home-work

Finally, only 37 out of 195 state employees have to do shifts in the intermediate and from work, typically to accompany (or resume) children in sole or assistance to elderly or disabled parents or commissions. Almost all of the 37 employees use their car, even if they do occasionally intermediate displacements. Whereas the private car is used by 91 employees, this implies that about 50 employees use this medium to the only way to work, regardless of the distance and the time required to travel the distance. The fact that 8 (of 195) employees use the *car as a passenger* shows that less than 4% of employees use the car-pooling for commuting. Another analysis in the economic aspect is directly related to displacement. Fig. 5 shows the distribution of employees according to the monthly cost incurred for moving. 40% of employees bears a cost of less than 50 €, 46% spend between € 50 and € 100, the remaining 14% at a cost of more than € 100/month and some of these more than 150 €/month.

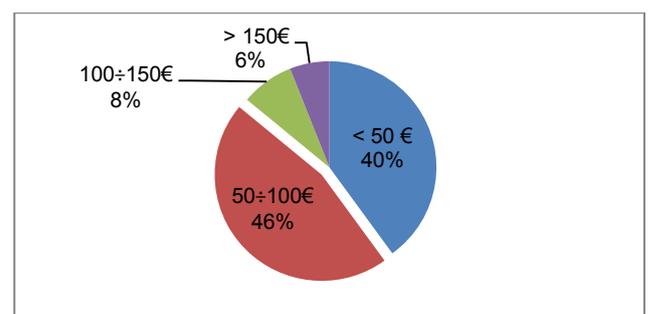


Fig. 5. Monthly cost incurred by the employees of the City of Barletta for the home-work

Exploding the graph of Fig. 5, Fig. 6 shows that the mode of transportation *car as passenger* and *motorcycle* are the only ones with lower costs contained in 100 € / month. This graph, however, should be read together with that of the previous Fig. 3, which shows that the number of employees who use their own car is a substantial majority, then remedial work on this method is more effective than the other.

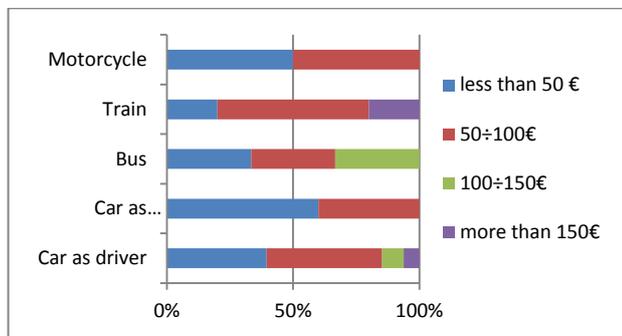


Fig. 6. Distribution of transport modes as a function of the costs incurred by the employees of the City of Barletta

As the private car is the means of transport most widely used by the employees, we have analysed the reasons for this choice. For 86% of the employees, the motivation lies in the aspects that affect the need to minimize the time spent traveling to and from work (excessive travel time, lack of direct connection, intermittent connections); only 4% believed that the use of public transport is not an economic alternative.

Given the previous result, it is asked to employees under what conditions they would be willing to use public transport. The results (Fig. 7), highlight the critical issues related to the ability to reach the workplace in certain times (10%) and short (18%) and at convenient times (40%). 22% of employees would not use anyway public transport; for some of them the choice is linked to other needs that are not compatible with the public transportation.

Options other than public transport (Fig. 8) have been also evaluated. Car-pooling (already used by some employees) is not considered as a possible alternative by 45% of employees who use the car, while 31% would consider it, if it would not result in a time dilation and 8% if there were reserved parking space.

The bike-sharing is considered as a possible alternative by 56% of employees self-equipped (Fig. 9), provided that there are stalls equipped (25%), best and safe bike paths (23%) and public bike rental (8%). The remaining 44% does not evaluate this possibility in any case.

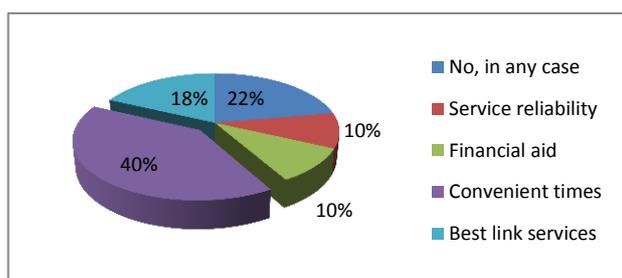


Fig. 7. Conditions of the employees of the City of Barletta to use public transport

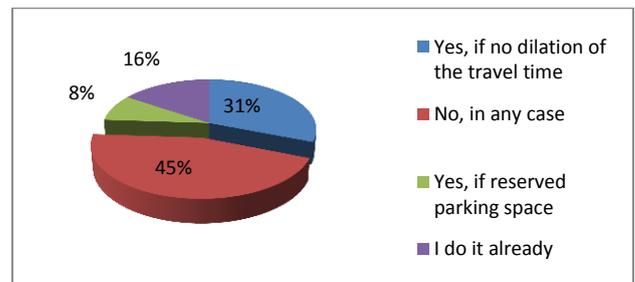


Fig. 8. Conditions of the employees of the City of Barletta to use the car-pooling

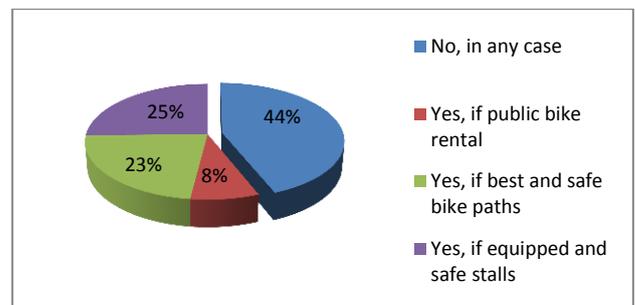


Fig. 9. Conditions of the employees of the City of Barletta to use the bike-sharing

B. Municipality of Andria

The number of municipality employees totaled 416, of which 224 (54%) was not available to respond to the questionnaire. The completed questionnaires were 192 (46%), of which 173 employees resident in Andria.

The first analysis concerns the mode of travel from home to work. Fig. 10 shows the number of employees for each type, which shows that the *private car as driver* is the main means of transport, followed by mode *afoot*. Very low is the use of public transport, especially the train (typically used by staff outside-seat), being very low number of employees off-seat. The use of the private car (driver + passenger) represents about 56% of the mode of travel. This probably also takes account of the fact that 71 employees (90 with own car) have a private parking space in their house, which, in addition to being a head start from home, avoid the parking problem to return from work. Furthermore, all employees say they benefit from free parking, when they reach the workplace.

Another analysis concerned the time needed to reach the bus transportation mode closest to own home. Fig. 11 shows the time needed to reach the nearest bus stop, taking into account the mobility mode currently used.

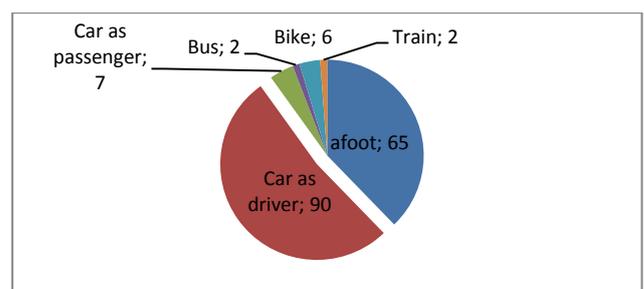


Fig. 10. Modes of travel to and from work for employees of the City of Andria

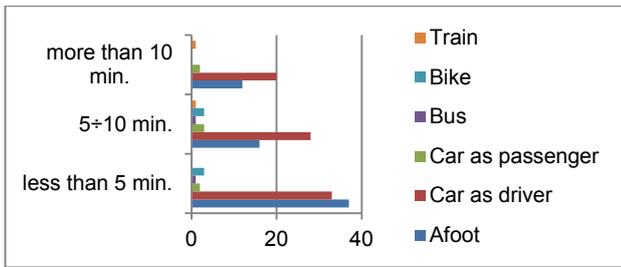


Fig. 11. Time to reach the stop nearest to your home for the employees of the City of Andria

It turns out that only time less than 5 minutes, the mode *afoot* is the first option for the journey from home to work, hounded by his car mode. Once 5 minutes needed to reach the nearest stop of an alternative means, the mode *car as driver* is the most widely used. Even the bicycle is used to route short and medium. The set of alternative means covers about 10% of the options chosen by the employees. Similarly, it appears that the income of the employee does not influence the decision on the means of transport to and from work. In fact, the private car is majority used (except mode *afoot* that does not have direct costs) by employees with average income as well as by employees with low income, thus showing a low correlation between their income and the means employed (Fig. 12).

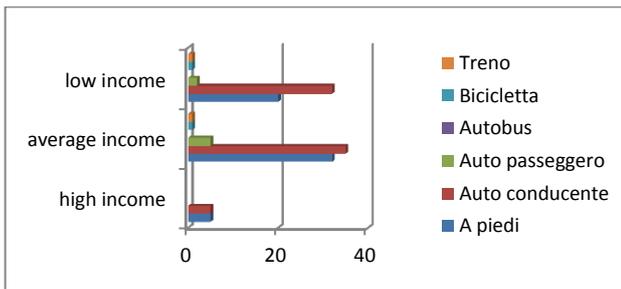


Fig. 12. Income of the employees of the City of Andria in function of your choices in the home-work

Finally, only 35 out of 192 state employees have to do shifts in the intermediate and from work, typically to accompany (or resume) children in sole or assistance to elderly or disabled parents or commissions. All 35 employees use your own car. Whereas the private car is used by 90 employees, this implies that 65 employees (plus 8 as passengers) use this medium to the only way to work, regardless of the distance and the time required to travel the distance. The fact that seven (out of 192) employees use the car as a passenger shows that less than 4% of employees use the car-pooling for commuting.

Another analysis in the economic aspect is directly related to displacement. Fig. 13 shows the distribution of employees according to the monthly cost incurred for the ride. Just over half of the employees bears a cost of less than € 50, more than a quarter spends between € 50 and € 100, about 20% at a cost of more than € 100/month, and some of these more than 150 €/month.

Exploding the graph of Fig. 13, Fig. 14 shows that the mode of transport *car as driver* is the only cost more than € 100/month for more than 20% of employees who have chosen it. In addition, the car-pooling allows more than 80% of employees who use it to keep costs below 50 €.

As the private car is the means of transport most widely used by the employees, we have analysed the reasons for this choice. 92% of the reasons lies in the aspects that affect the need to minimize the time spent traveling to and from work (excessive travel time, lack of direct connections, occasional connections, stops away); only 2% believed that the use of public transport is not an economic alternative.

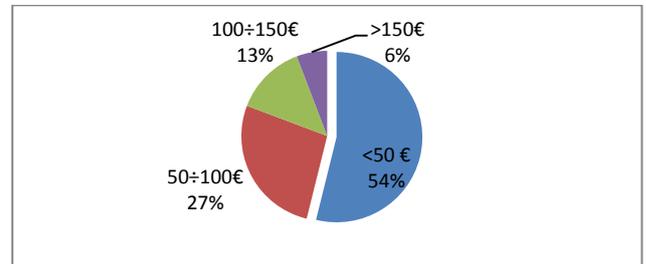


Fig. 13. Monthly cost incurred by the employees of the City of Andria for the home-work

Given the previous result, it is asked to employees under what conditions they would be willing to use public transport. The results (Fig. 15) highlight the critical issues related to the ability to reach the workplace in short times (15%) and at convenient times (19%). 19% of employees would not use anyway public transport; a full 41% did not give any response. Areas for improvement are clearly identifiable in changing times and in improving link services (about 34%).

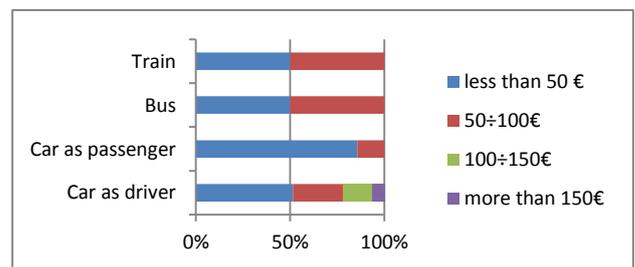


Fig. 14. Distribution of transport modes as a function of the costs incurred by the employees of the City of Andria

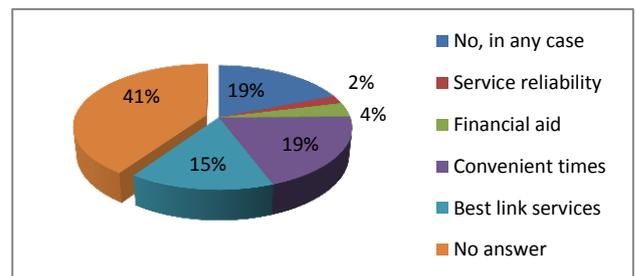


Fig. 15. Conditions of the employees of the City of Andria to use public transport

Other than public transport have been also evaluated (Fig. 16). Car-pooling (already used by some employees) is evaluated as a possible alternative by 37% of employees who use the car, provided that this does not result in a dilation of the travel time. The bike-sharing is considered as a possible alternative by 53% of employees self-equipped (Fig. 17), provided that there are stalls equipped bike paths and bike hire public. The remaining 47% does not evaluate this possibility in any case.

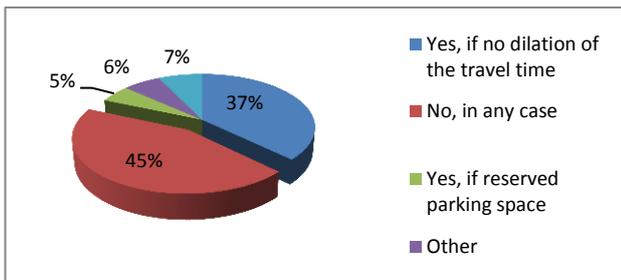


Fig. 16. Conditions of the employees of the City of Andria to use the car-pooling

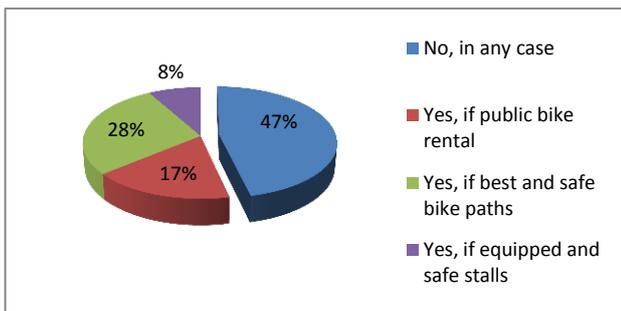


Fig. 17. Conditions of the employees of the City of Andria to use the bike-sharing

C. Municipality of Trani

The number of municipal employees is 135, of which 49 (36%) was not available to respond to the questionnaire. The completed questionnaires were 86 (64%), of which 73 belong to resident employees (84% of the dataset).

The first analysis concerns the mode of travel from home to work. Fig. 18 shows the number of employees for each type, which shows that the private car is the main means of transport, followed by mode *afoot*. Very low is the use of public transport, especially the train (typically used by staff outside-seat), being very low number of employees off-seat. The use of the private car (driver + passenger) represents about 60% of the mode of travel. This, probably, takes into account the fact that as many as 45 employees have a private parking space in their house, which, in addition to being a head start from home, avoiding the problem of parking to return from work; Furthermore, all employees say they benefit from free parking, when they reach the workplace. The sum of all the values do not reach the number of questionnaires (86) as some employees did not give any indication of the means of transport.

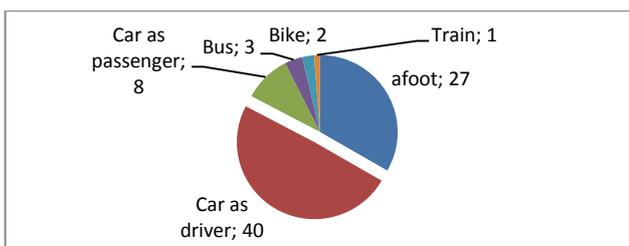


Fig. 18. Modes of travel to and from work for employees of the City of Trani

Another analysis concerned the time needed to reach the bus transportation mode closest to your home. Fig. 19

shows the time needed to reach the nearest bus stop, taking into account the mobility mode currently used.

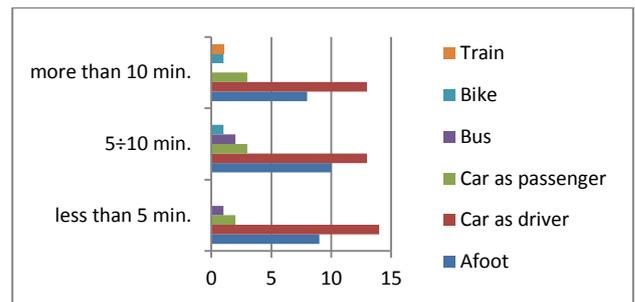


Fig. 19. Time to reach the stop nearest to your home for the employees of the City of Trani

It appears that the private car is the most widely used regardless of the time required to reach the stop in an alternate means. Even the bicycle is used to route the average.

Similarly, it appears that the income of the employee does not influence the decision on the means of transport to and from work. In fact, the private car has been majority used by employees with average income as well as by employees with low income, with distributions similar to those of the other two cities. Finally only 17 employees out of 86 say they have to do in the intermediate displacements from work, typically to accompany (or resume) children in sole or assistance to elderly or disabled parents or commissions. All 17 employees use your own car. Whereas the private car is used by 40 employees, this implies that 23 employees (plus 8 as passengers) use this medium to the only way to work, regardless of the distance and the time required to travel the distance. The fact that 7 (of 48) employees use the car as a passenger showed a 14% of employees who use the car-pooling for commuting, higher than the other two cities survey. Another analysis in the economic aspect directly related to displacement. Fig. 20 shows the distribution of employees according to the monthly cost incurred for the ride. Almost two-thirds of the employees support a cost of less than € 50, while about a third spend between € 50 and € 100; only 4% at a cost of more than € 100/month.

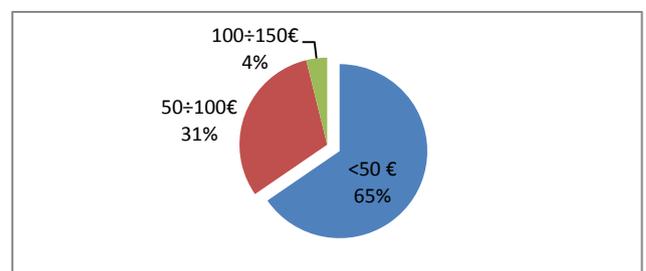


Fig. 20. Monthly cost incurred by the employees of the City of Trani for the home-work

Exploding the graph of Fig. 20, Fig. 21 shows that the mode of transport *car as driver* has the smallest percentage of employees (just over 60%) with a monthly cost of less than 50 €; then as much as 40% of employees who use their own car has a monthly cost above 50 € and a 4% cost in excess of € 100.

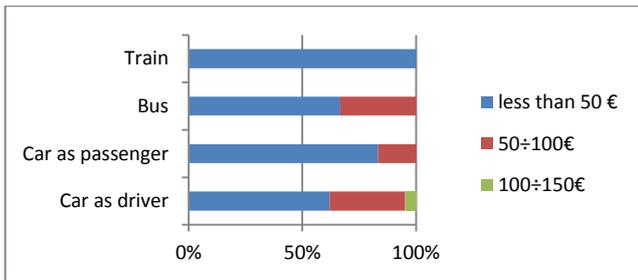


Fig. 21. Distribution of transport modes as a function of the costs incurred by the employees of the City of Trani

As the private car is the means of transport most widely used by the employees, we have analysed the reasons for this choice. 95% of employees identifies the causes specified, related to public transport. For example, 11% believed that the use of public transport is not a cheap alternative, while 75% of the reasons lies in the aspects that affect the need to minimize the time spent traveling to and from work (excessive travel time, lack of direct connections, occasional connections).

Given the previous result, it is asked to employees under what conditions they would be willing to use public transport (Fig. 22).

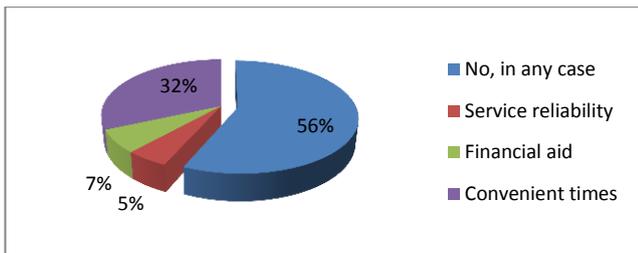


Fig. 22. Conditions of the employees of the City of Trani to use public transport

As many as 56% of them still would not use public transport, while 32% would consider if the times were adjusted to the needs of displacement; 7% would be willing to review the current choices in the presence of financial aid.

They have also evaluated other options. Car-pooling (Fig. 23) is evaluated as a possible alternative by 38% of employees who use the car, provided that this does not result in an expansion of the travel time. 13% would consider it if there were reserved parking space, 14% already use it. The remaining 35% do not take into account it in any case. The bike-sharing (Fig. 24) is evaluated as a possible alternative by 55% of employees self-equipped, provided that there are stalls equipped (15%), safe cycle tracks (25%) and rental options or free use of bike (15%), while the remaining 45% does not evaluate this possibility in any case.

3. Conclusion

This study has given several suggestions. First of all, the use of a private car cannot be easily changed, because of consolidated habits or intermediate stops. The medium used is not dependent from the income neither from the distance with respect to the nearest stop of a public medium. Moreover, it results that sometimes the reasons are related to the organization of the urban public transportation, whereas sometimes they depend from

personal reasons. Alternative modes of mobility (as car-pooling or bike-sharing) could be chosen by about half of the employees, if specific conditions were satisfied. Unfortunately, these conditions cannot be always satisfied. For these last cases, an effective solutions to mitigate the pollution could be the use of the electric vehicles, nevertheless these cities are not yet equipped with public electric charging stations which could reduce the CO₂ emissions.

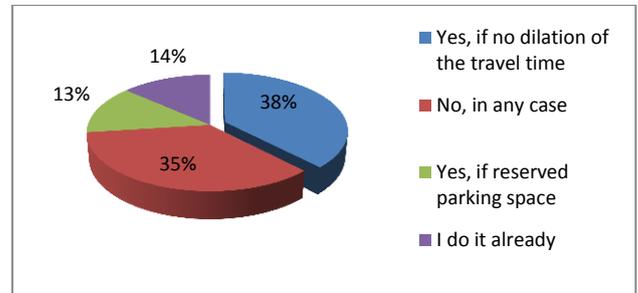


Fig. 23. Conditions of the employees of the City of Trani to use the car-pooling

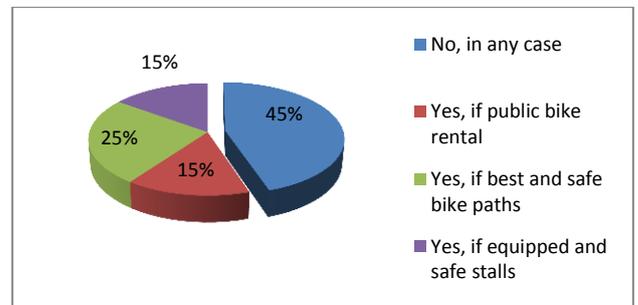


Fig. 24. Conditions of the employees of the City of Trani to use the bike-sharing

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