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Public Engagement for Designing New Transport Services: Investigating Citizen Preferences from a Multiple Criteria Perspective

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Abstract

This paper presents a multi-criteria-based methodology to involve the general public in transport decision-making, aiming at collecting information useful to design a technically sound and well-accepted transport service. The case study presented is part of a wider participation procedure, involving experts and key stakeholders in the definition of the problem and of the possible solutions. It regards the connection between a metro station and a park-and-ride facility through a short-range transit system in the city of Catania (Italy). Around six hundred citizens have been involved via a wide consultation survey adopting a multi-criteria perspective, asking them to perform pairwise comparisons of different elements (i.e. criteria) that can characterize a transport service. Results of the analysis are useful to understand their heterogeneous preferences and pave the way for a well-thought-out design of a new transport service.

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1. Introduction

Public engagement in transport planning has become fundamental to find solutions that are both well accepted and technically sound (Cascetta et al., 2015; Le Pira et al., 2018). The word "public" is usually referred to all those potentially affected by or interested in a decision, i.e. the potential "stakeholders". All those that can be affected by

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the consequences of decisions regarding the transport system should have a role in the decision-making process. In general, institutions, economic operators, transport operators and users are stakeholders with a direct interest, while local communities and unions or business associations are indirectly involved (Cascetta and Pagliara, 2013). The European Union (EU) encourages Member States to adopt Sustainable Urban Mobility Plans (SUMP), foreseeing a direct and continuous involvement of all the relevant stakeholders from the beginning of the planning process (Wefering et al., 2014). Italy recently enacted a law that binds municipalities and metropolitan cities with more than 100,000 inhabitants to adopt SUMP, with the idea that public funding will be given only for those intervention strategies and measures that are part of the plan (Italian National Decree 4 August 2017). For the first time, public participation has been included as an integral part of the planning process, with rules and procedures that should be decided *ex-ante*. Besides, inspired by French "Débat Public", since 2016 it has been introduced the "public debate" for great infrastructure projects that can have an impact on city sustainability and livability (New Italian Public Procurement Code, D.L. 50/2016). Appropriate procedures and methods should be employed for successful and effective participation processes. Among the variety of tools that can be used for participatory decision-support, one can recall focus groups, workshops, public conferences, in-depth interviews, citizen juries (Rowe and Frewe, 2000; Quick and Zhao, 2011; Carey and Asbury, 2016). As well, "fix-or-fit" approach dealing with each stakeholder specific expectation have been proposed as a tool to collect stakeholder feedback in public sector organizations (Luoma-aho et al., 2013). Whatever the method used, having a clear insight on stakeholder heterogeneous preferences is fundamental to understand, *ex-ante* and before implementation, the potential impacts of the solutions proposed (Gatta and Marcucci, 2014).

Quantitative methods to evaluate *ex-ante* technical/economic performance and effects of transport policies are well-established (Cascetta, 2009). Conversely, in general there is a lack of methods aimed at assessing policy acceptability from a stakeholder's point of view. Under this respect, Le Pira et al. (2017b) propose a procedure based on stated preference surveys and agent-based models for a stakeholder behavioral analysis aimed at investigating their preferences and acceptability of proposed solutions using sound theoretical methods and models.

Besides, complex transport decisions requiring the evaluation of multiple and heterogeneous aspects (e.g. environmental, social, economic) need to be tackled with a multicriteria approach. Therefore, an effective participation process should be based on multicriteria decision-making/aiding (MCDM/A) methods, and should foresee the involvement of different stakeholders in several phases (Le Pira et al., 2018).

Based on this premise, this paper presents the results of a citizen consultation, as a step of a wider participation procedure (Ignaccolo et al., 2017a), to support a stakeholder-driven transport decision from a multi-stakeholder multi-criteria perspective.

Public engagement can be performed at different levels, depending on the specific plan/project/policy under consideration. The design and implementation of a new transport system/service is a case in point, since it can highly influence citizens' life. Under this respect, while it is important to involve all the potentially affected people, it is often unfeasible to perform wide consultation processes. In general, the participation process is limited to groups of stakeholders or to a small sample of citizens (Le Pira et al., 2017a). This paper contributes to the current literature and approaches used by proposing a procedure to involve the general public in decision-making, by performing a survey aimed at investigating their heterogeneous preferences from a multiple criteria point of view, and deriving useful information for the design of new transport services.

The remainder of the paper is organized as follows: section 2 will present the methodology, framing it into the context of a multi-step participatory decision-support procedure; section 3 will present the results of the survey and discuss them deriving some useful implications for decision-making highlighting main future research directions; section 4 will resume and conclude the paper.

2. Methodology

2.1. Background

Public administrations and decision-makers have to deal with several actors with different levels of competences and interests (Cascetta and Pagliara, 2013). They can be simply classified into three main categories: experts, with high competence and low interests; stakeholders, with a certain degree level of competences and specific interests;

citizens, with low competences and very high public interest (Le Pira et al., 2016). In order to include all of them in the decision-making process, appropriate methods should be used according to the aims that one wants to pursue. In the following, different steps of a participatory procedure will be described, with reference to a specific case study. The analysed case study regards the connection between a metro station and a park-and-ride facility through a short-range transit system in the city of Catania (Italy). Catania is a city of about 300,000 inhabitants in the southern part of Italy (Sicily), characterized by heavy traffic congestion due to a high private transport share and poor public transport ridership (Torrisi et al., 2017). The municipality of Catania approved the Urban Traffic Plan in 2013, i.e. a short-term traffic plan aimed at managing the existing infrastructures without the provision of long-term investments, which, instead, should be addressed by a strategic plan. Nevertheless, in the last 20 years, the metro company "Ferrovia Circumetnea" (FCE), directly managed by the Italian Ministry of Transport and Infrastructures, has built a metro line connecting the historic city center with residential and service areas of the city. In 2017, a new metro station has opened near a high-demand district, including University spaces, health-care services and a park-and-ride facility serving the University dwellers and residents. Despite the fact that this high-demand area is located at a walkable distance from the metro station, it is hardly accessible due to a high slope and poor pedestrian infrastructures.

In this respect, it is under discussion the building of a new transport system to connect the metro station with the park-and-ride facility, serving the high-demand area.

Four alternatives have been proposed by University experts (i.e. a bus, a people mover, a monorail and a ropeway) for evaluation, and a multi-stakeholder multicriteria approach has been developed, by involving (1) key stakeholders and (2) citizens to elicit their preferences according to several evaluation criteria, described as follows.

2.2. The multicriteria approach

In the first step of the procedure, we performed in-depth interviews with five key stakeholders, representing the main interest groups affected by the intervention, i.e. the Municipality of Catania, the University of Catania (students and professors), and the two public transport operators, FCE and Azienda Metropolitana Trasporti (AMT). Interviews aimed at understanding their interest and points of view with respect to the different transport alternatives proposed, via SWOT analyses. Results allowed understanding the problem and identifying the key elements to be considered in a multicriteria evaluation (Ignaccolo et al., 2017b). Subsequently, a hierarchy of the problem was structured into four different levels: the goal of the decision-making process, a set of criteria, sub-criteria and four alternatives. A role-playing game with University students acting as key stakeholders allowed to test the multi-criteria decision-making model from a multi-stakeholder perspective, and to have a first draft evaluation of the alternatives (Ignaccolo et al., 2017a).

Analytic Hierarchy Process (AHP) (Saaty, 1980) has been chosen as MCDM/A method, being a particularly useful method when the decision maker is unable to construct a utility function. The AHP method involves four steps to obtain the ranking of alternatives (Ishizaka and Nemery, 2013):

- First, the problem is structured into a hierarchy, composed of at least three levels: the top element is the goal of the decision-making process, the second level represents the criteria (with an eventual further level representing sub-criteria), while in the last level the alternatives are considered.
- Priority rankings are derived based on pairwise comparisons between elements of the same level, provided by the decision-maker(s) via a relative verbal appreciation on a scale from 1 (i.e. equal importance attributed to the two elements) to 9 (i.e. extreme importance attributed to the first element). Priority vectors are evaluated on (at least) three levels, representing: (1) the importance of each criterion with respect to the top goal (criteria priorities); (2) the importance of each alternative with respect to each criterion (local alternative priorities); the importance of alternatives with respect to all criteria and, consequently, to the overall goal (global alternative priorities).
- A consistency check can be performed to check the consistency of the decision maker evaluations, so to reduce bias in the evaluation process.
- Finally, a sensitivity analysis is carried out to confirm the robustness of the results.

When multiple actors are involved, individual priority rankings from AHP can be combined into a unique group ranking; this can be achieved through different aggregation techniques (Ishizaka and Nemery, 2013):

- at pairwise comparisons' level, whenever an agreement is reached, or a mathematical aggregation is performed on the value of each pairwise comparison (aggregation of individual judgments), or

- at the priorities' level, when mathematical aggregation is performed (aggregation of individual priorities), or consensus vote is achieved after priorities calculation for each single actor of the decision-making process.

AHP is widely used to support complex decision-making in transport planning and management (e.g. Piantanakulchai and Saengkhao, 2003; Sivilevičius and Maskeliūnaite, 2010; Mahmoud and Hine, 2013; Le Pira et al., 2017a). Through pairwise comparisons, it helps to capture both subjective and objective aspects of complex decisions; moreover, the easiness of the judgement scale makes it a suitable method to foster the involvement of a broad public. In this respect, in the last step of the participation procedure, citizens were involved in the multi-criteria evaluation via a survey that will be described in the next section.

2.3. The survey

Citizens were consulted through a structured questionnaire, composed of the following sections:

i. the first section included some questions about socio-economic characteristics of the interviewees: age, sex, residence location, education, job/occupation;
ii. questions about travel behavior and habits were asked in the second section, regarding: transport mode to reach the study area and frequency of the trips, including a question regarding the use of public transport (i.e. "do you regularly use public transport for your urban trips?");
iii. in the third section, citizens were asked to evaluate criteria and sub-criteria according to the importance they attributed to them, adopting a simplified/modified version of the hierarchy described in Ignaccolo et al., (2017a), and used for stakeholder evaluation (with less sub-criteria and without alternatives). In this respect, four criteria (transport, economic, environmental and social) and six sub-criteria (fare, perceived security, frequency, visual intrusion, pollution and travel time) were considered. The simplified hierarchy is reported in Fig.1a, compared to the complete hierarchy reported in Ignaccolo et al. (2017a) (Fig. 1b).

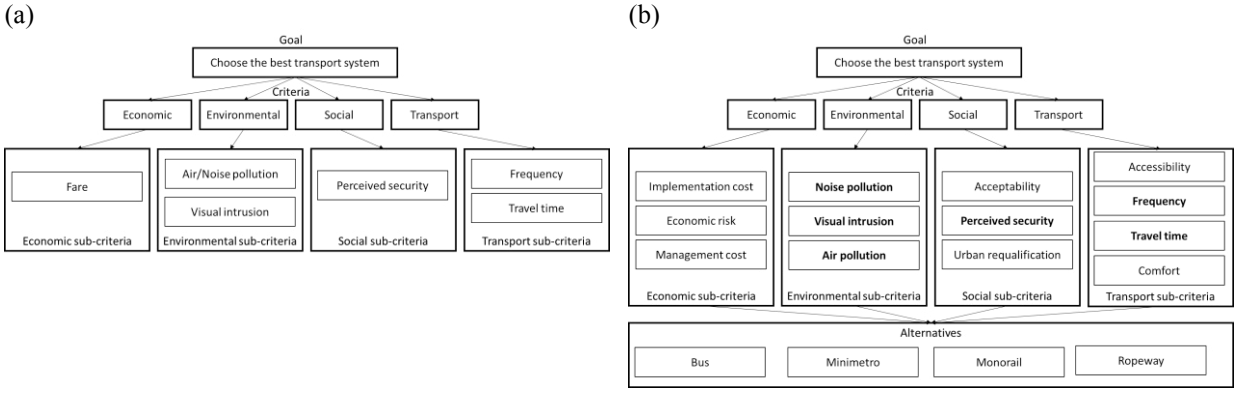

Fig. 1. Simplified hierarchy (a) and complete hierarchy (b) (the same criteria used in the two hierarchies are reported in bold).

Five different versions of the questionnaire were prepared by changing the order of the pairwise comparisons so to mitigate the "order effect", i.e. the potential distortions of judgments due to the sequence of the different questions, as suggested in Kallas et al. (2011).

First, data collected during the interviews underwent a *cleaning* phase in which their validity and integrity was verified; afterward, data were processed for global and disaggregated analysis. In this respect, data from the third section of the questionnaire allowed the derivation of aggregated priority scales and weights of different sample segments via AHP (Saaty and Hu, 1998). Finally, starting from the results obtained from the analysis of the questionnaires, some implications for decision-making related to the strengths and weaknesses of each alternative transport system have been derived.

3. Results and discussion

3.1. Results of the survey

A total of 674 interviews have been performed in 11 different locations placed throughout the study area, 9 corresponding to the entrances/exits of the main facilities (health and educational services) and 2 to the most crowded bus stops (Fig.2a). The location analysis of the sample shows that all the respondents were resident in Sicily, with the highest rate in Catania and its surroundings (see Fig.2b).

(a) (b)

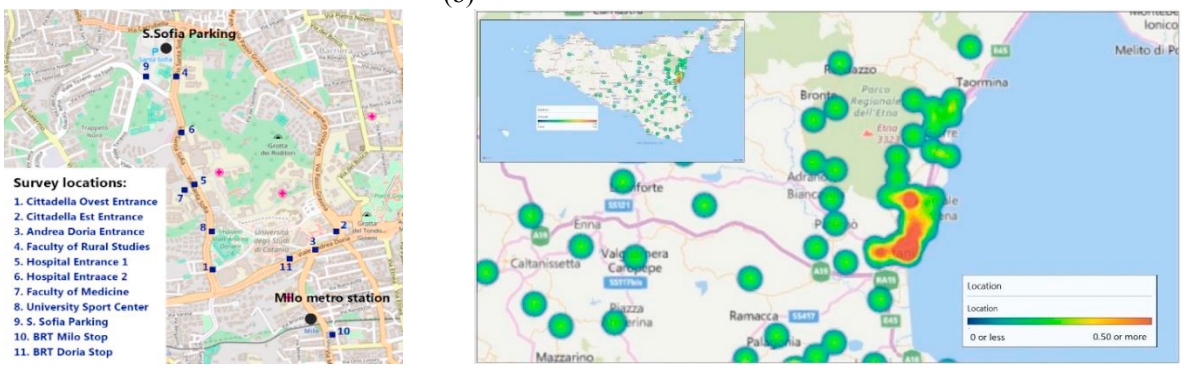

Fig. 2. Survey location (a) and heat map of respondents' residence (b).

Aggregation of individual judgments was performed using the geometric mean method (Ishizaka and Nemery, 2013). Consistency check was satisfied with less than 1% of inconsistency for both criteria and subcriteria. Aggregated results show that perceived security, belonging to the social dimension, is the first-ranked sub-criterion, followed by frequency and travel time (i.e. transport sub-criteria), fare (economic sub-criterion), and finally pollution and visual intrusion (environmental sub-criteria) (Fig. 3). This result is quite consistent with the ones obtained for criteria, in particular regarding the first two ranked criteria, i.e. social and transport, respectively weighing 0,29 and 0,27, while the resulting weights are 0,24 for the environmental criterion and 0,20 for the economic one.

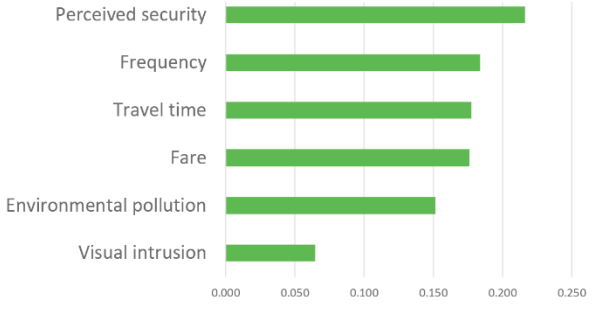

Fig. 3. Aggregated results of subcriteria weights derived from AHP.

A detailed analysis has been performed, by segmenting the sample, so to investigate preference heterogeneity. The sample has been divided into eight categories, according to the following criteria:

- the majority of people attending each day the study area, i.e. University students, with a percentage of 72% of the sample, followed by employees (13%), residents (8%), and others (7%);

- the frequency of trips from/to the study area, considering interviewees with a daily (68%) or weekly frequency (32%);
- the transport modes usually used to reach the study area, categorizing the sample into three different categories: public transport (i.e. Bus/BRT (Bus Rapid Transit)/metro) (38%), private transport (i.e. private car as a driver/ private car as a passenger/car-pooling/motorcycle) (47%), soft mobility (i.e. walkers/bikers) (15%);
- public transport ridership, by selecting two other categories, i.e. habitual (53%) and non-habitual users of public transport (47%).

The obtained weights for each sub-criterion for the different categories are summarized in Table 1.

Results from disaggregated data, in terms of sub-criteria rankings, are similar to the ones obtained with the aggregated data, showing a certain homogeneity[†]. The less important sub-criteria are environmental pollution and visual intrusion, while perceived security and frequency, followed by fare and travel time, are perceived as important characteristics for the choice of the transport system. For instance, considering the point of view of University students, perceived security and frequency are important, but also travel time is considered crucial, since they need to arrive on time at University classes, as well as those who daily attend (e.g. for work reasons) the study area. Thus, for daily visitors, the same results are confirmed. However, with specific reference to visitors with weekly frequency, the sub-criterion that assumes greater importance is frequency, maybe to meet the requirement of flexibility of these travelers that sporadically attend the study area, and in different times of the day. No substantial difference is found for users of private/public transport. While, for walkers or bikers, fare is fundamental, probably because they do not actually spend money (e.g. in terms of public transport ticket) to reach the area. Finally, considering the habitual and non-habitual users of public transport, the first two sub-criteria (i.e. perceived security and frequency) are still considered as the most important. Particularly, non-habitual users weigh less fare and travel time, while the habitual ones are more concerned about these aspects, especially fare.

Table 1. Weights of sub-criteria for the different categories derived by sample segmentation

Categories	Sub-criteria					
	Perceived Security	Frequency	Travel time	Fare	Environmental Pollution	Visual Intrusion
University Students	**0.209**	0.190	0.177	0.175	0.153	0.063
Daily Visitors	**0.221**	0.183	0.178	0.176	0.149	0.062
Weekly Visitors	0.192	**0.195**	0.175	0.182	0.158	0.070
Public transport	**0.225**	0.184	0.174	0.176	0.144	0.064
Private transport	**0.216**	0.182	0.178	0.169	0.158	0.066
Walkers and Bikers	0.193	0.188	0.189	**0.203**	0.149	0.061
Habitual users of Public Transport	**0.221**	0.183	0.173	0.169	0.160	0.066
Non-habitual users of Public Transport	**0.211**	0.184	0.181	0.181	0.143	0.063

The quite homogeneity of results, if from one side can be seen as an indication of consistency of preferences (across categories), needs further analyses to test data validity. In this respect, we performed a simple test by segmenting the sample according to the different versions of the questionnaire. In fact, as explained in section 2.3, five versions were prepared by changing the ordering of the pairwise comparisons so to mitigate the "order effect". By applying AHP to the five sub-samples, consisting of people potentially belonging to all the different categories, some differences emerge but the main results are confirmed, i.e. perceived security as the first preferred sub-criterion in 4 out of 5 cases, and visual intrusion as the last ranked in all cases, followed by environmental pollution in the majority of cases (3/5).

[†] It is worthy of notice that the survey was conducted in 11 locations and in different days of the week, for a period of approximately 4 months, covering all the attractive places in the study area and interviewing people usually attending them.

It is worthy of notice that further statistical tests, both to check the validity and consistency of results, e.g. according to the procedure proposed by Saaty and Vargas (2007), would allow to derive more reliable conclusions. Nevertheless, for the scope of this work, i.e. to make a wide consultation that could potentially help decision-making, they are considered suitable as a starting point for discussion, as described in the next section.

3.2. Discussion of results and future research

The analysis performed allows deriving some useful elements for discussion regarding the decision-making process under consideration. As already said, four alternatives were proposed by the experts, i.e. a Bus, a People Mover (i.e. Minimetro), a Monorail and a Ropeway. In particular, the Bus is the most popular mean of collective public transport and its technology is well established. Moreover, taking into account the route conditions (i.e. a fairly linear path) of the study area, it is reasonable to design a system with high performances, similar to a BHLS (Bus with High Level of Service). The Minimetro is an automatic rail transport system, characterized by a segregated right of way and high frequency. The Monorail is a modular system that can be manual or with a fully automatic system. Finally, the Ropeway is a cable transport, which consists of ascending and descending units, able to connect areas divided by a very high slope.

By analyzing both global and category-specific results, it is reasonable to state that the choice of the best transport mode for the connection may not be the ropeway, since the sub-criterion considered most important is the perceived security. Besides, taking into consideration the priorities results obtained from the previous step of the participation process, involving University students acting as the five key stakeholders described in section 2.2 in a role-playing game, this finding is confirmed. In that case, after evaluating the different alternatives via AHP, the group of stakeholders/students discussed the results obtained and unanimously decided that the Bus could have been the best alternative in the short period, while in the long period the Minimetro should have been preferred, and Ropeway was not considered as a feasible solution (Ignaccolo et al., 2017a).

In principle, Minimetro and Monorail are better than Bus in terms of travel times and frequencies. However, it would be possible to consider BHLS, even if, despite the dedicated lane, it could suffer from interaction with private traffic. In fact, perceived security could be higher for Bus than for Monorail or Minimetro. This aspect needs to be further investigated.

These preliminary results can give an idea of what citizens perceive as most important for designing a new transport service in their city and they can be useful to have a global vision of their preferences. Of course, they need further validation and analyses to be potentially valuable for decision-making, in the overall idea that a transport system is used if it is well accepted and meets their preferences and objectives. Further analyses will be performed in future steps of the research, so to have a deep insight on citizen preference structures. In this respect, stated choice tasks will be used to investigate citizen preferences for hypothetical scenarios of transport services, and results will be compared and combined with those derived from AHP, as done e.g. in Kallas et al. (2011).

4. Conclusions

This paper presented the result of a wide consultation survey aimed at involving the general public in transport decision-making. The survey was designed to investigate citizens' preferences via a multicriteria approach, so to collect information useful to design a technically sound and well-accepted transport service. The case study regards the connection between a metro station and a park-and-ride facility through a short-range transit system in the city of Catania (Italy) and it is part of a wider participation procedure (Ignaccolo et al., 2017a). Around six hundreds citizens have been involved and results analysed by segmenting the sample according to the main characteristics of the interviewees. Results of the analysis are useful to understand their heterogeneous preferences and pave the way for further analyses aimed at a well-thought-out design of a new transport service. All the results obtained will be useful to derive a comprehensive alternative evaluation. In this respect, the outcomes of public consultation and, in general, of participation processes, should be included in the technical/economic analyses, with the overall aim of making transport decision-making processes sound, transparent and inclusive.

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