Eur. Transp. Res. Rev. (2017) 9:54
DOI 10.1007/s12544-017-0268-2

ORIGINAL PAPER

# Towards a decision-support procedure to foster stakeholder involvement and acceptability of urban freight transport policies

Michela Le Pira[1] · Edoardo Marcucci[2,3] · Valerio Gatta[2] · Matteo Ignaccolo[1] · Giuseppe Inturri[1] · Alessandro Pluchino[4]

Received: 5 January 2017 / Accepted: 19 September 2017


**Abstract**
*Purpose* This paper addresses the complex problem of multi-stakeholder decisions in urban freight transport policy-making from a public authority perspective, by proposing a procedure based on a modelling approach to support stakeholder involvement in the decision-making process. The paper analyses the existing methods that can be used for participatory decision-support, with the intent of contextualizing and introducing the innovative modelling approach.
*Methods* The modelling approach consists of a well-thought integration of discrete choice models (DCM) with agent-based models (ABM) as an effective way to account for stakeholders' opinions in the policy-making process, while mimicking their interaction to find a shared policy package. The integrated modelling approach is able to combine the advantages of the two methods while overcoming their respective weaknesses. Since it is well grounded on sound microeconomic theory, it provides a detailed (static) stakeholders' behavioural knowledge, but it is also capable of reproducing agents' (dynamic) interaction during the decision-making process. The integration allows performing an *ex-ante* behavioural analysis, with the aim of testing the potential acceptability of the solutions proposed. The methodology is applied in a real case study to prove its feasibility and usefulness for participatory decision-making.
*Results* The integrated modelling approach can be used for participatory decision-support and it can be casted in the overall UFT policy-making process. The results of the behavioural analysis, in terms of ranking of potentially accepted policies, linked with the technical evaluations from transport network modelling tools, provide a sound basis for active participation and deliberation with stakeholders and policy-makers. The aim is to guide an effective participation process aimed at consensus building among stakeholders, by proposing them a subset of policies that, as a result of a preliminary analysis, are likely to be accepted while performing well in terms of technical results.
*Conclusions* This approach, integrating DCM and ABM, represents a promising way to tackle the complexity of multi-stakeholder involvement in UFT policy-making and to support an efficient and effective decision-making process. It produces an added value for UFT policy-making and it can be framed in the overall context of transport planning. In fact, together with technical and economic analyses, the stakeholder behavioural analysis proposed contributes to the *ex-ante* policy assessment needed to support decision-makers in taking well-thought decisions.

**Keywords** Stakeholder behavioural analysis · Discrete choice models · Agent-based models · City logistics · Participatory policy-making

This article is part of Topical Collection on Accommodating urban freight in city planning

✉ Michela Le Pira
michela.lepira@uniroma3.it

[1] Department of Civil Engineering and Architecture, Università degli Studi di Catania, Via Santa Sofia 64, 95125 Catania, Italy

[2] Department of Political Sciences, Università degli Studi Roma Tre, Via Gabriello Chiabrera 199, 00145 Rome, Italy

[3] Department of Logistics, Molde University College, PO. Box 2110, 6402 Molde, Norway

[4] Department of Physics and Astronomy, Università degli Studi di Catania and INFN Catania, Via Santa Sofia 64, 95125 Catania, Italy

Published online: 09 November 2017

## 1 Introduction

Urban freight transport (UFT) is an important and under researched/undervalued topic policy-makers have to deal with. UFT is a complex world characterized by scarce knowledge and heterogeneous stakeholders with conflicting objectives [1–4]. Local policy-makers try to strike a balance between public and private interests, aiming at city sustainability while fostering freight distribution efficiency [5, 6]. *Stakeholder engagement* and *ex-ante policy evaluations* are two fundamental issues to be addressed to guarantee an effective and efficient decision-making process [7]. *Stakeholder engagement* implies that all the parties interested in the decisions are directly involved in the policy-making process. It is convincingly argued that better decisions are implemented with less conflict and more success when they are stakeholder-driven [8]. Taylor [1] identifies four fundamental stakeholders to be consulted when evaluating UFT policies: (1) shippers; (2) freight carriers; (3) residents; (4) planners/regulators. Shippers generate freight demand with the intent of either making final goods available to end consumers or alternatively to import/export semi-finished goods from/to other industrial partners. Planners/regulators define the overall framework under which transport providers perform delivery tasks. Public successfully implemented regulations are only possible when they are practically feasible for private stakeholders and help them pursuing their distinctive objectives. A dilemma often arises among the conflicting objectives of urban freight operators and their customers, on one side, and the community, on the other [9]. Private actors directly involved in urban freight distribution are mainly concerned with constraints, such as congestion or street/area-wide access restrictions, since these restrictions impose additional costs and delays on operations. Public actors involved in the oversight of urban freight distribution, as well as urban residents are, in general, concerned with congestion, air pollution, as well as overall city liveability [10]. There is usually a *status quo* bias in urban freight [11]: on the one side, city governments expect business to set up new logistic services fit to the emerging customers' and retailers' needs while also beneficial to the environment; on the other side, logisticians are expecting municipalities to initiate (and subsidize) new services before starting businesses which, otherwise, could prove poorly profitable and highly risky. Besides, Dablanc et al. [12] underline the importance of the territorial scale for stakeholder involvement to obtain an effective behaviour change: consultations are of little use at the local and municipal levels, if not combined with metropolitan or region-wide consultations.

*Ex-ante policy evaluations* are also fundamental to understand, before implementing, the potential impacts of the solutions proposed. In general, technicians and planners make use of quantitative methods and simulation models for economic and technical analysis. Simulation models can be used to forecast *ex-ante* and also validate *ex-post* the impacts of the solutions implemented, mostly from a technical point of view [13]. While quantitative methods to evaluate *ex-ante* the effects of transport policies from a technical/economic point of view are well-established [14], in general there is a lack of methods aimed at assessing policy acceptability from a stakeholder's point of view. From a modelling standpoint, individual interests and the ensuing behavioural changes that a modification of the *status quo* would most likely induce, must be included in the framework used when dealing with policies influencing the overall city logistics framework. Freight behaviour research aims at understanding agents' behaviour and exploring their preferences with respect to alternative system configurations [15–17]. Empirical survey data are necessary to estimate behavioural models capable of forecasting stakeholders' reactions to alternative policies based on agents' stated preferences [18–21]. Nevertheless, for a successful participatory decision-making process, it is important not only to forecast stakeholders' reaction to policy change, but also to predict the outcome of an interaction process aimed at consensus building. In other words, in order to test the potential policy acceptability, it is important to model the stakeholders' interacting behaviour. Therefore, new additional phases and tools are needed to support an effective and efficient participatory decision-making process. This is even more relevant for UFT policy-making, considered its peculiarities compared to passenger transport [22], i.e. the: (1) strong influence of the private sector, characterized by heterogeneous stakeholders with conflicting interests [11], (2) lack of knowledge and understanding of UFT problems [4], (3) relatively new inclusion of freight transport in the sustainable mobility planning agenda [23]. To this purpose, the authors propose an integrated extension of the decision-making model described in [24], which consists of three parallel and intertwined processes, combining a (i) cognitive rational approach to organising the decision-making process, (ii) a five-level stakeholder engagement process, and (iii) quantitative analyses and methods. The "fourth leg" introduced consists of behavioural analyses based on sound data and models aimed at supporting the stakeholder engagement process and, thus, the overall decision-making process. These new analyses complement the technical ones aimed at identifying and evaluating effective and shared policies, by considering both their feasibility and acceptability (Fig. 1).

Under this respect, the paper addresses the problem of complex multi-stakeholder UFT policy-making from a public authority perspective, by proposing a procedure aimed at a stakeholder behavioural analysis based on integrated models.

The remainder of the paper is organized as follows: section 2 provides a literature review of some useful methods for participatory decision-support, with the intent of contextualizing and introducing the innovative modelling approach;

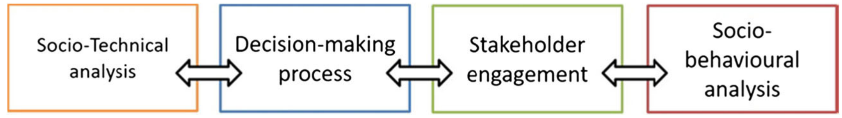


**Fig. 1** The four blocks of decision-making in transport planning

section 3 presents the participatory decision-support procedure based on integrated modelling approaches; section 4 describes an application of the methodology in a case study; section 5 shows the implications for UFT planning; section 6 draws some conclusions and discusses future research.

## 2 Methods and tools to support stakeholder engagement

Even if public participation is considered important for the success of a decision-making process, in general it is not well-structured and there is a lack of group decision-support methods (GDSMs) that can guide stakeholders' involvement towards well-thought-out decisions. In this respect, the gap of knowledge between methods used for technical/economic evaluation and those exploited to support stakeholder engagement is high. The rationale of this section is to provide a broad, yet not exhaustive, review of some interesting methods used for participatory decision-support, both in passenger and freight transport planning and in generic decision-making process oriented to stakeholder involvement. The choice of including non-specific freight transport tools is the result of a lack of knowledge and research in the field of transport, in general, and freight transport, in particular. Some of them are based on well-known decision-support methods and tools (i.e. focus groups, multi-criteria decision-making methods, geographic information system (GIS) and discrete choice models) while others are more recent and involve social analysis (i.e. social network analysis and agent-based modelling). Some of them help stakeholders understanding the problem and making decisions (i.e. multi-criteria decision-making methods, Participatory GIS, focus groups), while others support practitioners and policy-makers by providing insight into stakeholders' preferences and complex social aspects (social network analysis, discrete choice models, agent-based modelling). In this respect, the former can be considered as decision-support tools for stakeholder consultation and participation, while the latter can provide support for stakeholder analysis and forecast of their choices and preferences.

*Focus groups* (or *Mega Focus groups*) are among the typical methods that can be used to support a participatory process [25]. They are meetings made up of a selected group of people (bigger in Mega Focus Groups) that can provide qualitative data and information thanks to the participation in a discussion focused on a given subject [26]. In general, a moderator leads the group and guides the conversation with the aim of collecting "rich, detailed data" [27]. They are particularly useful in an initial phase of a decision-making process to perform a preliminary analysis and pave the way to further in-depth stakeholders' preferences investigations. In this respect, they can provide the input necessary to design a stated preference survey [3, 28–30]. In UFT, they are useful to gain insight on freight distribution problems. For example, one can organize separate stakeholders' focus groups first to get single participants' informations and then a joint meeting where participants can discuss together and find a common definition of the problem nature [3]. A learning process based on sequential focus groups can help adjusting initial opinion differences thanks to a dynamic dialogue among participants [31].

*Multi-criteria decision-making (MCDM) methods* are widely used to evaluate transport solutions from a multi objective multi stakeholder point of view. With MCDM methods alternative comparison is based on the assessment of their contributions to different evaluation criteria, that can be expressed by heterogeneous measures (monetary, physical and linguistic). In transport planning, multi-criteria analysis has been widely used to overcome the limits of traditional Cost-Benefit Analysis (CBA). CBA postulates the choice of the project generating the highest increase in the net utility of the reference community, among a set of competing alternatives. Annema [32] argues if CBA or MCDM is the appropriate tool and proposes an integrated approach based on a trade-off sheet which embraces them by adding a post-analysis phase of political debate and voting. In [33] a review of more than two hundred publications concerning the use of MCDM for transport projects evaluation is provided, defined as "a set of possible human activities that organize, optimize or facilitate the movement of persons or freight from location a to location b". The authors acknowledge from their analysis that in most of the current MCDM analysis of transport projects, stakeholder participation is not appropriately arranged, while only in a few cases it is considered crucial and included in the whole analysis via a well-structured procedure. In this respect, Macharis [34] proposes a method, called Multi Actor Multi-Criteria Analysis (MAMCA) that, starting from single-stakeholder analyses, evaluates the different alternatives through an overall MCA to derive stakeholder-driven priority rankings among different alternative projects. The MAMCA method was used in different contexts of transport decisions to assess sustainability judgments about alternatives in transport projects (e.g. [35–37]) and to derive a framework for city freight distribution (CD-MAMCA) [38]. UFT solutions have been largely explored with the support of different MCDM methods and hybrid approaches [39–42]. Among the variety of MCDM methods, the Analytic Hierarchy Process (AHP) by Thomas Saaty [43] has proved to be suitable for complex multi-stakeholder multi-criteria decision-making [44–47]. It is a process based on the decomposition of a decision-making problem into a tree structured decisions' hierarchy and pairwise comparisons through the building of matrixes to derive priority scales and weights. The priority of each stakeholder can be aggregated according to different methods resulting in a group priority ranking [48]. Le Pira et al. [47] demonstrate that a combination of AHP with consensus building procedures (i.e. Delphi method) is useful to support complex multi-actor decision-making processes.

MCDM in transport can largely benefit from the support of Geographic Information System (GIS), due to the intrinsic spatial nature of transport systems and the capability of GIS maps to easily visualize the impacts of transport choices on land use, environment and communities [49]. In this context, *Public Participation GIS (PPGIS)* or *Participatory GIS* [50–53] have been developed as a powerful tool for supporting non-experts' involvement in transport decision-making processes, thanks to the power of visualization which increases the awareness about the decision to be made. According to Piantanakulchai and Saengkhao [44], GIS-based transport models combine Engineering Model (i.e. mathematical model that relates physical quantity regarding the impact being considered in space) and Weight Decision Model (i.e. model that relates physical quantity in engineering model with social preference). The spatial information in GIS and the result of objective weights can help stakeholders' participation in the decision-making process.

Having a clear insight on the actors involved in the decision-making process and the interactions among them is helpful to sort out the tools that can be used to support practitioners and policy-makers in understanding the dynamics of participatory processes and in representing stakeholders in the relevant social networks. In this respect, *Social Network Analysis (SNA)* allows to quantify the social importance of a given individual in a network via centrality indexes and to understand the potential problems deriving from topology [54]. Social networks are graphs consisting of nodes (i.e. the social agents) and links (i.e. the relationships among them). They fall within the category of complex networks, whose structure is irregular, complex and dynamically evolving in time [55] and adequate methods are needed to study their structure and dynamics. The use of SNA in the field of stakeholder engagement can simply consists of stakeholder mapping or it can include centrality measures [56, 57]. Social networks re-creation can be performed using different methods, e.g. the "name generator" technique, which identifies social networks through in-depth interviews [58, 59], or the "snowballing" technique, where a small number of people are asked to nominate others, the nominees are asked for further nominations and the network builds up like a snowball [54]. There are also automatic tools which can create a network and extract information from it, such as UCINET [60] or StakeSource, a web-based tool that uses social networks, a "crowdsourcing" approach to identify and prioritise stakeholders and their requirements [61].

If SNA is useful to understand the social relations and importance of stakeholders, *ex-ante* behavioural analyses are important to provide insights into stakeholders' behaviour and preferences. *Discrete choice models (DCM)* aim at analysing the behaviour of a decision-maker when choosing among different (discrete) alternatives, assuming that she maximizes her utility (rational decision-maker). They can be used to investigate stakeholders' preference heterogeneity in order to forecast their individual choice behaviour related to policy-making, i.e. as a tool for stakeholder's behaviour analysis and forecast. Economic analysis of individual discrete choices makes use of random utility theory [62, 63]. Stated preference (SP) experiments are useful as a basis for DCM to study policy acceptance in terms of stakeholders' reaction to policy change. A choice experiment aims at acquiring high quality data to generate reliable and useful estimates of the parameters of interest, with different response format (i.e. choice, ranking or rating) [64]. There are many studies across different sectors that relate community and stakeholder acceptance of public policies with discrete choice theory, as a way to facilitate improved community (or stakeholder) analysis [65–70]. DCM have been used to determine behaviourally consistent policy evaluation in the field of UFT policy-making (e.g. [20, 21, 71, 72]). In this respect, the authors acknowledge that stakeholder-specific data acquisition is needed not only when local authorities want to adopt distinct policy instruments for different stakeholders or stakeholders types, but also when homogeneous policies impacting the various stakeholders are considered. Other relevant application of SP data and DCM for analysing stakeholders' behaviour with respect to UFT policies can be found in [15, 73–78]. DCM are useful in helping decision-makers defining the possible policies stakeholders most prefer, given their stated choices for alternative policy configurations. The main advantage is the possibility to estimate *ex-ante* the willingness to pay [79] or the substitution rate between different policy characteristics (e.g. access fee and number of loading and unloading bays inside a Limited Traffic Zone). Although their significant contribution to increasing the knowledge of stakeholders' preferences based on a sound microeconomic analysis, DCM are not well suited to investigate dynamic interactions among actors that should, on the contrary, need to be addressed to provide effective policies [22].

*Agent-based models (ABM)* are typically used to model complex systems and reproduce communities of autonomous and intelligent agents, acting and interacting with the environment and the other agents according to their interests [80].

One of the main ABM characteristics is the emergence of collective phenomena, not easily predictable from agents' simple behavioural rules. In the field of freight transport, they have been traditionally used to simulate stakeholders' interaction and trigger their reaction to some policies or regulations [81–86]. In the field of consensus building and collective policy-making, ABM are well suited to reproduce the dynamic interactions occurring within communities of stakeholders, linked in social networks and cooperating to find a convergence of opinions towards a shared solution [87]. Le Pira et al. [25, 88–90] reproduce participatory processes in passenger and freight transport planning via opinion dynamics models [91], characterising the agents with opinions and with an interactive behavioural rule aimed at consensus building. The models proposed allow to reproduce different contexts of decision-making processes involving stakeholders, understanding the role of network topology and other sensitive variables in reaching a convergence of opinions and avoiding the risk of decision deadlock due to inconsistency. The output of the simulations can be used to understand which conditions favour the convergence of opinions among stakeholders and which policy packages should be considered as good candidates that will likely be accepted by stakeholders.

In this context, DCM play a fundamental role in characterizing agents with their own utility functions based on data derived from stated preference exercises. In fact, one of the main ABM limitations is the lack of reliable data to feed the model that is trying to mimic agents' behaviour. The DCM-derived utility functions represent a valuable input for ABM since they describe agent-specific preferences for alternative policy packages [22].

Table 1 provides an overview of the methods and tools that can support stakeholder engagement in UFT policy-making. Next section will show the methodology proposed to support participatory decision-making in UFT planning, based on a DCM and ABM integration approach aimed at providing a sound and realistic stakeholder behavioural analysis.

## 3 Towards a participatory decision-support procedure

### 3.1 The integrated modelling approach

The procedure is based on a well-thought-out integration of DCM with ABM as an effective way to take into account stakeholders' opinions in the policy-making process, while reproducing their interaction to find a policy package which is likely to be accepted by them.

An application of this integrated approach has already been performed in [92] by implementing an ABM fed with DCM utility functions. Based on this work, the main features of the combined ABM + DCM model are described below, following the approach proposed in [93]:

- Types of agents

  The agents are heterogeneous entities, endowed with own preferences. They are autonomous in the sense that they act without external intervention; they are interactive and adaptive with respect to the other agents and the environment. In the case of UFT, the agents are the stakeholders involved in the policy-making process, belonging to the private and the public sector (e.g., retailers, transport providers from the private side; citizens, consumers and the local authorities from the public side).
- Agents' properties

  Agents show heterogeneous interests and preferences, that have repercussions on their behaviour. In this regard, investigating their preferences through SP experiments and deriving agent-specific utility functions from DCM allow simulating stakeholders' behavioural response to single measures included in a given policy package. Assuming that stakeholders decide to cooperate in finding a shared decision with respect to alternative policies, they can be endowed with a certain willingness to change opinion, where the probability of opinion change substantially depends on the utility associated to alternative

**Table 1** Overview of methods and tools to support stakeholder engagement

| Method | Description | Phase of the participation process |
|---|---|---|
| Focus Groups/Mega Focus Groups | Meetings made up of a selected group of people (bigger in Mega Focus Groups) involved in a discussion focused on a determined subject | Consultation |
| Multi Actor MCDM methods | Comparative assessment of alternatives evaluating their contributions to different evaluation criteria and stakeholders | Consultation/Participation |
| PPGIS | Use of Geographic Information Systems to promote knowledge production by stakeholders | Consultation/Participation |
| SNA | Analysis of the relationships and the social importance of nodes (e.g. stakeholders) linked in social networks | Stakeholder analysis |
| DCM | Econometric models aimed at analysing the behaviour of a decision-maker when choosing among different (discrete) alternatives | Stakeholder analysis/forecast |
| ABM | Models that reproduce communities of autonomous and intelligent agents, acting and interacting with the environment and the other agents according to their interests | Stakeholder analysis/forecast |

policies considered. Influence factors can also be considered so to reflect their level of power in the decision-making process [94]. Information about the potential "influenceability" by other agents can be acquired via appropriate tailored questions, in the SP survey, investigating the "social component" importance on agents' behaviour [59].

- Environment and topological structure

  The environment where the agents act is an "opinion space": it reflects interaction opportunities during formal meetings or other forms of communication. The environment perception of the agents is local, since they know and react only to the opinions of other agents connected by a direct link (i.e. their neighbours). Agents react to the environment by updating their opinions at each simulation step according to the local state of the system, i.e. the opinion of the neighbours. The connections among agents depend on the topological structure that, in the case of social systems, assumes the aspect of complex social networks [55].
- Agents' behavioural rules

  In a consensus building process, agents' behavioural rules follow opinion dynamics mechanisms. Opinion dynamics models aim at defining the opinion states of a population and the elementary processes governing the transitions between such states [91]. The type of opinion dynamics depends on the interaction process under investigation. A majority rule can be applied, following the Galam model [95] where, at each step a random group of agents is selected and, as a consequence of the interaction, all of them take the majority opinion inside the group. Another well-known model is the Hegselmann and Krause (HK) compromise model [96], where agents form their actual opinion by taking an average opinion based on their neighbours' ones. This leads to a dynamical process which should flow into a consensus among all agents.
- Key performance indicators (KPIs)

  The definition of key performance indicators (KPIs) is necessary to evaluate the impact of the proposed policies on the state of the system and analyse emergent patterns. Two are the main variables to monitor in a participatory process aimed at consensus building: 1) the degree of consensus and 2) the utility perceived by the agents. A combination of these parameters can represent a measure of the potential acceptability of the alternative polices under consideration. In general, the opinion dynamics process leads to an increase in the degree of consensus, as interaction takes place, and a decrease in the average utility perceived by the agents, as they are willing to negotiate with the others, which inevitably leads to a utility loss. A good policy consists of a package of measures which stakeholders can easily accept thus being supported by a good number of them, while leaving marginally unsatisfied all the others.

The block diagram of Fig. 2 summarizes the main features of the integrated model with the combination of individual behaviour components, based on agent-specific utility functions, and social interaction mechanisms, as described by an opinion dynamics model. The use of utility functions derived from SP data and the estimation of DCM provide higher robustness and realism to the ABM, which is able to simulate the dynamic behaviour of interacting heterogeneous stakeholders according to the rules of the opinion dynamics model and the topology of the social network.

### 3.2 The participatory decision-support procedure

The integrated modelling approach can be used to support a participatory decision-making process which is presented next. It consists of two main parts: a modelling process and a real participation process. The whole procedure can be divided into 7 steps:

1. Problem definition

   The definition of the problem is the first and most important preliminary step. The problem under consideration could be of different nature, e.g. a decision-making process about the introduction of (a) market-based measures, (b) regulatory measures, (c) land use planning rules, (d) infrastructural measures, (e) new technologies, and (f) management measures [18]. Context analysis is important in this phase to better outline the problem.
2. Preliminary analysis

   The preliminary analysis aims at identifying relevant UFT stakeholders to be involved and define the policy package components. In this respect, it is important to identify the most appropriate attributes and levels to be used in the experimental design. A multi-stage multi-agent efficient design is desirable, consisting of a repeated evaluation of a priori values for the attribute coefficients, updated an appropriate number of times so to improve attribute statistical significance and/or potentially reduce the sample size needed for obtaining statistically significant parameters [72].
3. Survey

   The survey aims at collecting data needed to characterize agents' preferences and choices. In particular, stated preference (SP) exercises are useful to investigate stakeholders' preferences for hypothetical policy scenarios and provide the data needed for DCM estimation and agent-specific utility functions. Qualitative questions about the agents' "social circle" can be used to gain additional insights into social interaction (SI) issues, such as the social network, agents' social properties and behavioural rules (e.g. according to the influence, influenceability). Social networks re-creation and social influence investigation can be performed using different techniques, such as those described in section 2 (e.g. "name generator", "snowballing", web-based tools).

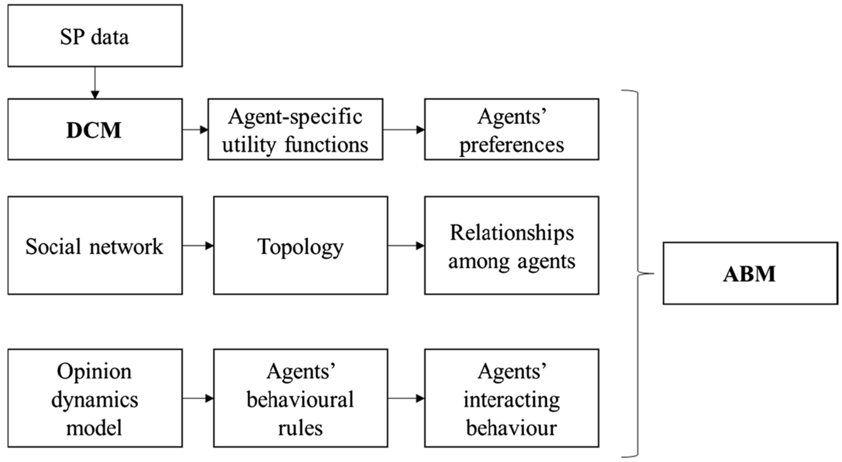


**Fig. 2** Framework of the UFT policy-making ABM

4. Modelling phase

   In the modelling phase, DCM are estimated and the ABM implemented accordingly by feeding it with all the data and the agent-specific utility functions. The interaction process is reproduced via opinion dynamics mechanisms, assuming that stakeholders decide to cooperate to find a shared decision with respect to alternative policies available. Since agents are characterised with individual utility functions, they can be endowed with a certain willingness to change opinion, where the probability of changing opinion is linked to the utility alternative policies produce for the specific agent considered. In parallel, mathematical models could be used to simulate *ex-ante* the effects of the policies on the transport network.
5. Scenario simulations

   Scenario simulations allow to analyse stakeholder interaction dynamics with respect to different policy packages and monitor the consensus building process within the stakeholders' network. In general, the opinion dynamics process leads to an increase in the degree of consensus as interactions take place, while the overall utility decreases, since agents, being willing to negotiate, can change opinion toward the non-preferred option. The *ex-ante* policy acceptability evaluation can be combined with the technical evaluation of policies derived from sound models/methods [14].
6. Presentations of results to stakeholders and policy-maker

   The results of the evaluations are presented to stakeholders and policy-makers with the intent of validating them and using them as a starting point of a participation process aimed at consensus building. The aim is to identify *ex-ante* which policies are most likely to be accepted and perform also well from a technical analysis perspective.
7. Participation process aimed at consensus building

   The output of the consensus building process should be a subset of shared (from the participatory process) and effective (from the technical evaluations) policies, derived from the first set of policies which emerged from the modelling process.

Figure 3 summarizes the proposed framework which can be used as a decision-support tool for promoting stakeholder engagement in UFT policy-making, while providing *ex-ante* evaluation of UFT policy packages and accounting for stakeholders' heterogeneous preferences, as well as for the interaction dynamics among them within a participatory decision-making process.

## 4 How to apply the participatory decision-support procedure for UFT policy-making: the case of Rome

This section aims at illustrating, through a case study, how to apply the participatory decision-support procedure for UFT policy-making. The case study refers to urban freight distribution in Rome, where the extensive work performed in [17, 21, 64, 72, 97] provides an in-depth knowledge of the decision-making context and of the preferences of heterogeneous stakeholders. In this respect, the authors demonstrate, using the case of Rome as reference, how an agent-specific approach, both when acquiring and modelling SP data, is needed to: 1) deal with heterogeneity in preferences, 2) increase decision-makers' awareness and 3) help taking better decisions [17, 21, 72]. In [17] transport providers' preferences for alternative loading bays and pricing policies are investigated and results underline the relevance of both preference heterogeneity and non-linear attribute effects. Gatta and Marcucci [21] test the implications deriving from the presence of inter-agent heterogeneity (between transport providers, retailers and own-account operators) obtaining an "optimal" policy composition

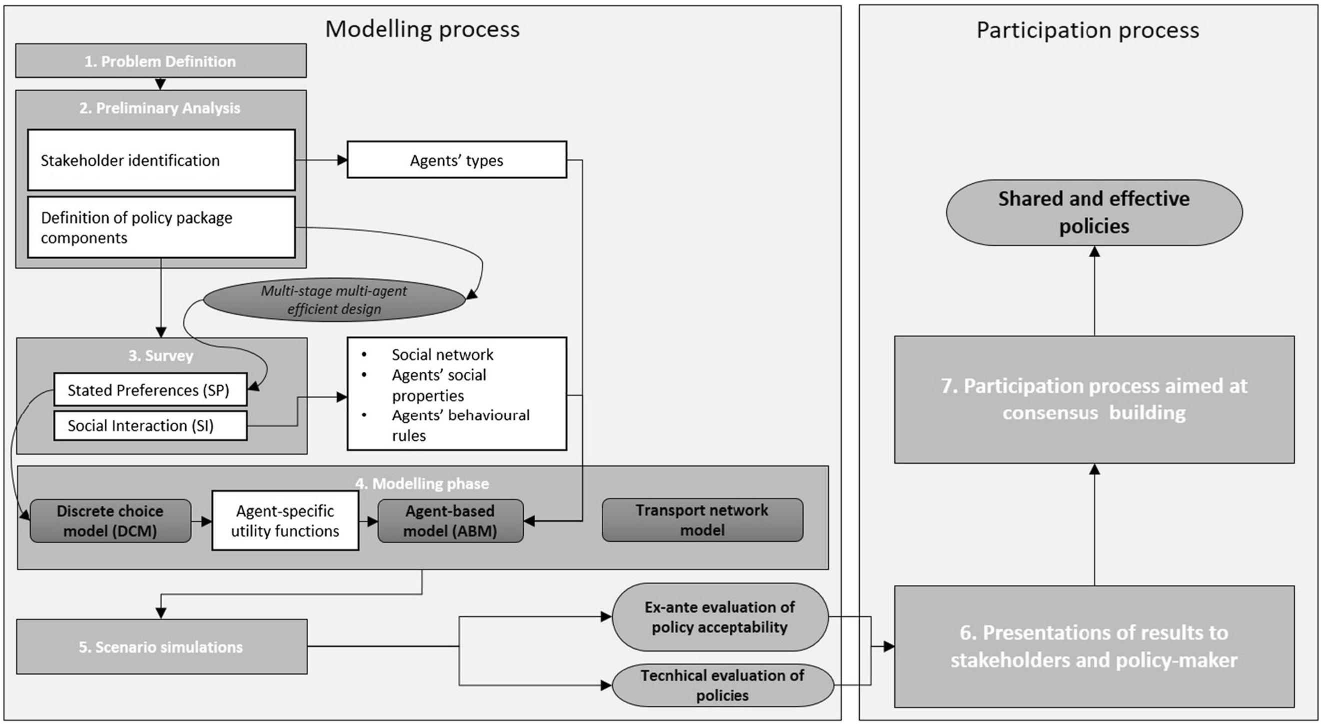


**Fig. 3** Participatory decision-support procedure for UFT policy-making (based on [22])

of an improving and equally impacting intervention on all agent-types' utility based on heterogeneous willingness to pay considerations. Gatta and Marcucci [72] shows the potential policy distortions and bias if a stakeholder-generic approach is used instead of adopting a well-defined stakeholder-specific perspective in both data acquisition and modelling.

Besides, an application of the integrated ABM + DCM approach related to Rome's case study has been performed in [92], by implementing an ABM fed with DCM agent-specific utility functions, proving its usefulness in obtaining a ranking of plausible policies that maximize consensus building while minimizing utility losses thanks to the negotiation process.

The steps of the participatory decision-support procedure described in Fig. 3 are reported below for the case of Rome. While the modelling process (steps 1–5) refers to a real world application of the framework (even if data acquisition is temporally disjoint from the modelling phase), the participation process (steps 6–7) is here presented with the intent of extending the case study for further research and prove the feasibility of the proposed approach.

- **Problem definition**. The problem under discussion consists of how to modify the regulation related to the Limited Traffic Zone (LTZ) in Rome to improve UFT services. Data refer to LTZ legislation in 2009, when access and parking of freight vehicles in the LTZ were subject to time windows restrictions between 10.00–14.00 and 16.00–20.00 enforced by optical character recognition camera technology and the yearly entrance fee was around 600€ per number-plate [3].
- **Preliminary analysis**. Stakeholders were identified and divided in three categories: (a) demand (i.e. representatives of associations for traders and producers); (b) supply (i.e. freight transport companies, industrial freight associations); (c) local policy-makers (i.e. local public transport company, local planning authorities). They were interviewed in a sequence of focus group meetings to identify freight delivery issues in Rome's LTZ. Stakeholder consultation was carried out in two phases: (1) separately, so to obtain an uninhibited description of the groups' own ideas with respect to relevant problems/issues; (2) in a joint meeting, with the aim of stimulating a wider discussion partly based on the results obtained from phase 1. Phase 1 allowed to select the most preferred policy solutions, in view of the subjective problem perception and current regulation; phase 2 allowed to gain confirmation of the information gathered in phase 1, make stakeholders interact with each other and obtain relevant inputs to define the crucial elements for constructing the SP survey.
- **Survey**. The SP survey aimed at collecting data needed to characterize agents' preferences (both from demand and supply side) towards policy mix adjustments with the intent of increasing UFT efficiency. Demand actors were further split into retailers and own-account operators

(who themselves organise transport services). The following criteria were chosen for attribute selection: (1) attributes need to be credible and salient for the majority of respondents; (2) support for a policy attribute needs to be shared among respondents; (3) attributes need to reflect plausible future changes to the current policy scenario. The final attributes identified were: number of loading/unloading (L/U) bays (three levels: 400, 800, 1200); probability to find L/U bays free (three levels: 10%, 20%, 30%); entrance fees (five levels: 200€, 400€, 600€, 800 €, 1000€); time windows (three levels: open 18:00–08:00 and 14:00–16:00; open 20:00–10:00 and 14:00–16:00; open 04:00–20:00). A total of 229 stakeholders were interviewed among retailers (39%), own-account (32%) and transport providers (29%). The questionnaire was divided in five parts with the first part aimed at collecting socioeconomic data. No information about "social network" and relationships among and within categories were acquired. In this respect, an additional section of the questionnaire could have elicited characteristics related to their social behaviour via qualitative questions, e.g. by asking how many people belong to the same social circle, to what extent the members of the social circle can influence stakeholders' opinions and how much stakeholders are able to convince others in their social circle [98]. The social network could also have been recreated by using the techniques described in section 2 (e.g. "name generator", "snowballing", web-based tools).

- **Modelling phase.** In the modelling phase, agent-specific DCM have been estimated and an ABM has been implemented and fed with all the data and the agent-specific utility functions. In particular, latent class models have been estimated for each agent category [92]. Transport providers can be split into three classes having different preference structures, while retailers and own-account operators are both characterized by two classes. Starting from the three models presented, individual-specific posterior estimates of the coefficients have been obtained by averaging class parameter estimates weighted by person-specific conditional class probabilities [92]. The participation process for UFT policy-making is described in the ABM by means of a multilayer network, where each layer represents a different level of description and details of the process. The ABM links stakeholders in a social network, where the nodes represent the agents and the links are the relationships among them. The interaction process is simulated by means of an opinion dynamics model, reproducing the opinion flows through the network of relationships. Each simulation reproduces the decision between the *status quo* and a given policy change. The modelling approach assumes that stakeholders initially choose the policy they prefer according to the associated utility function. Once the dynamic process starts, they can modify their opinion depending on the interactions with other actors. Their willingness to change is increased by repeated cycles of interactions. It expresses a cooperative attitude where a decrease in utility is accepted in front of the higher goal of a collective interest toward a shared solution. A complete description of the model can be found in [92]. In parallel, mathematical models should be used to simulate *ex-ante* the effects of the policies simulated on the transport network.
- **Scenario simulations**. Scenario simulations have been performed by reproducing different policy changes to be compared with the *status quo*. The rationale behind the choices made is the following: different scenarios for improving LTZ accessibility and usability conditions were considered by varying the attribute levels used in the experimental design, within the range defined by two extreme scenarios, i.e. "the worst case scenario", where the entrance fee is maximized *vis-à-vis*. The provision of no other improvements, and "the best case scenario", with maximum attribute improvements for the three categories *vis-à-vis* no increase in the entrance fee [92]. Different scenarios more in line with one of the three categories were also tested on the base of some *a-priori* knowledge about their preferences [21]. Results are expressed in terms of a policy ranking based on a dynamic parameter called "global satisfaction", defined as the product between the degree of consensus and a (normalized) overall utility. In general, due to the interaction and the opinion change, the degree of consensus usually shows an increasing trend, while the overall utility generally decreases. As a consequence, the global satisfaction, being the product of these two quantities, initially increases in time, rapidly reaching a maximum, then slowly decreases. Policy ranking is based on 5 potentially accepted policy changes. The best policy in terms of global satisfaction is the one that maximizes at the same time the improvements for the three categories while slightly increasing the entrance fee, i.e. a policy composed of 1200 loading/unloading bays (vs. 400 of the *status quo*), 30% of probability to find bays free (vs. 10% of the *status quo*), time window opens from 4 to 20 (vs. 20–10/14–16 of the *status quo*), annual entrance fee of 800 € (vs. 600 € of the *status quo*) [92]. This *ex-ante* evaluation of policy acceptability should be combined with other evaluations (e.g. cost-benefit analysis, traffic forecast simulations) aimed at assessing policies from an economic/technical point of view.
- **Presentations of results to stakeholders and policy-maker**. The results of the evaluations should be presented to stakeholders and policy-makers with the intent of validating them and using them as a starting point of a participation process aimed at consensus building. In the case of Rome's LTZ regulation, transport providers, retailers and own-account operators should be involved in a public

meeting where the procedure is presented together with the main results. It is important to explain all the steps that led to those results, so to make stakeholders (and policy-makers) aware of the transparency and reproducibility features characterising the entire procedure.

- **Participation process aimed at consensus building**. A consensus building process should be set up with the aim of obtaining a convergence of opinions towards a subset of shared (from the participatory process) and effective (from the technical evaluations) policies, based on the first set of policies which resulted from the modelling process. In the case of Rome's LTZ regulation, a series of consensus meetings could be organized to make stakeholders discuss, exchange opinions and, possibly, converge towards the same policies. Another way to foster a convergence of opinions could be to use a Delphi-like iterative procedure, where stakeholders participate by answering a questionnaire iteratively. At each round they are asked to align their opinions according to a range where the 50% of the opinions stands and this "anonymous interaction" aims at mitigating strong positions and building consensus [90].

## 5 Implications for UFT planning

The proposed modelling approach produces an added value for UFT policy-making and it can be appreciated in an UFT planning context. In fact, along with technical and economic analyses, the stakeholder behavioural analysis contributes to the *ex-ante* policy assessment needed to support policy-makers in taking well-thought-out decisions.

Cascetta et al. [24] underline the importance of including stakeholders' engagement activities (green blocks in Fig. 4) running in parallel to the traditional decision-making process (blue blocks), supported by quantitative analysis and modelling (yellow blocks). This "three legs" planning framework aims at building an effective

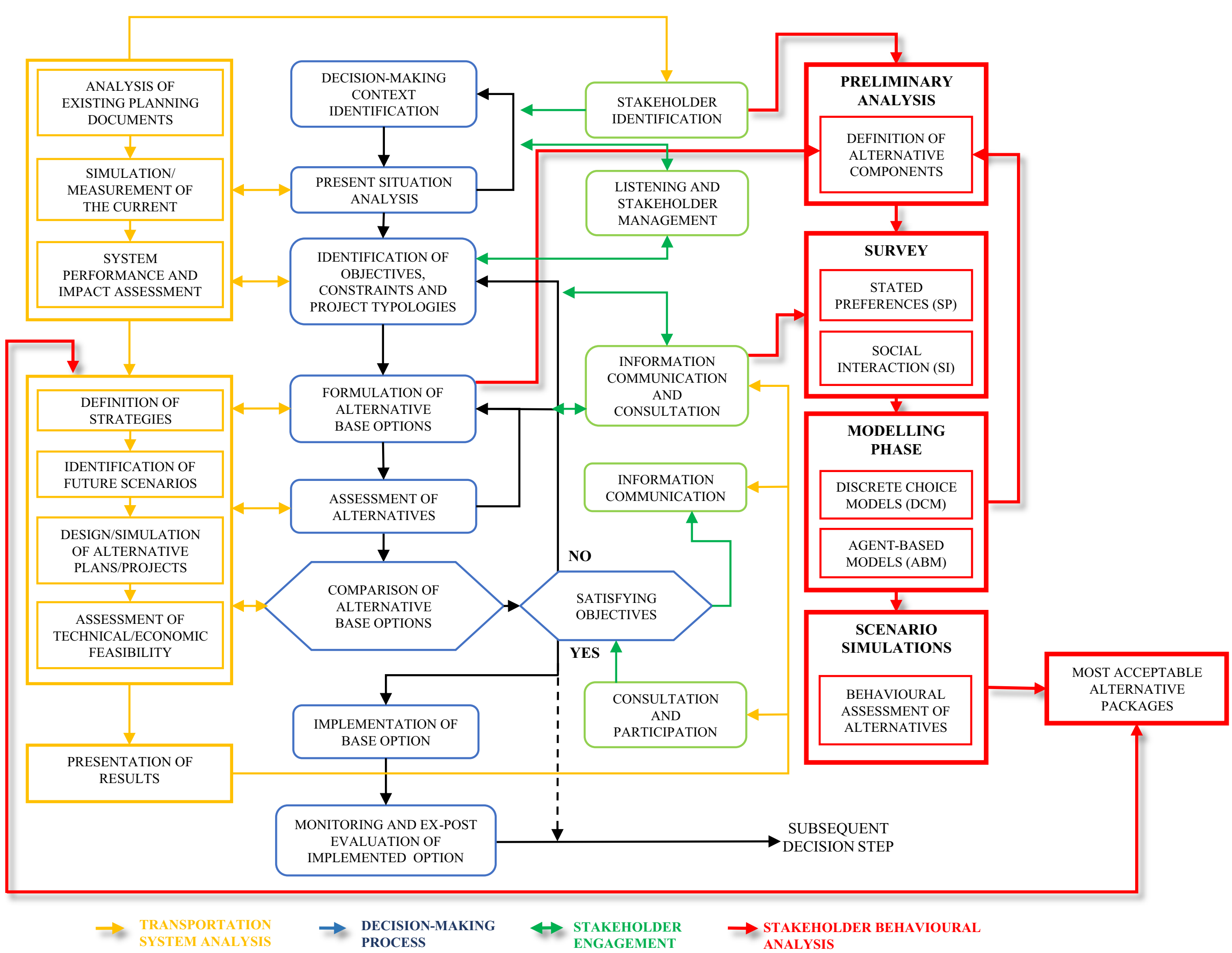


**Fig. 4** The modified (3 + 1) decision-making model described in [24] for UFT planning (The process is iterative and consists of subsequent steps. For the sake of simplicity, only the first step is reported in this flow diagram. For more information, the reader can refer to [24])

communication strategy fostering the emergence of a stakeholders' coalition supporting the plan rather than an actual collective decision-making. As reported in section 1, a decision-making process for UFT planning requires a deeper knowledge of the heterogeneous nature and preferences of the stakeholders involved, whose aims and behaviours can be hardly predicted by conventional transport models. Actually, stakeholder behavioural analysis can and should be considered as an additional set of activities (red blocks) representing the "fourth leg" of the UFT planning process (Fig. 4).

The "fourth leg" introduced consists of a: (i) preliminary analysis aimed at defining the components of the alternatives to be submitted to stakeholder evaluation, which could benefit from the feedbacks of phase (iii); (ii) survey aimed at eliciting stakeholder preferences – via SP exercises – and understanding the nature of their existing social interaction; (iii) simulation tool integrating DCM and ABM to provide (iv) scenario simulations of interaction processes among stakeholders with the aim of unveiling acceptable alternative packages.

The stakeholder behavioural analysis proposed is strictly linked with the overall decision-making process, since the technical/economic feasibility of the "most acceptable policy package" derived from the simulations has to be evaluated by quantitative methods and tools, capable of simulating the effects of alternative transport system's configurations[1] (i.e. transportation system analysis of Fig. 4). Finally, assessment results are presented to decision-makers and stakeholders, so to support the final decision that should be consistent with the previously identified objectives (see Fig. 4).

The modelling framework proposed within a UFT context can realistically be applied to any decision-making process dealing with transport planning, especially when the complexity of the decision, the heterogeneity of the actors involved and the interaction of mixed competitive and cooperative behaviour are relevant for the implementation and the success of the plan, as in the case of UFT.

## 6 Conclusions

This paper presented a procedure based on an integrated modelling approach to support stakeholder involvement in the decision-making processes regarding urban freight transport solutions. The integrated modelling approach is based on a well-thought-out integration of discrete choice models and agent-based models to take into account stakeholders' heterogeneous preferences and simulate their interactive behaviour in a consensus building process, providing useful suggestions for policy-makers on the potential acceptability of a set of policies to be eventually discussed with stakeholders. The integrated modelling approach is able to combine the advantages of the two methods while overcoming their weaknesses, since it is well grounded on sound microeconomic theory providing a detailed (static) stakeholders' behavioural knowledge, but also capable of reproducing agents' (dynamic) interaction during the decision-making process. It produces an added value for UFT policy-making and it can be framed in the overall context of transport planning. In fact, together with technical and economic analyses, the stakeholder behavioural analysis proposed contributes to the *ex-ante* policy assessment needed to support decision-makers in taking well-thought-out decisions. In future development of this research, the authors will test the procedure in different decision-making contexts regarding urban freight transport solutions, trying to adapt it to the specific problem type. In this sense, the behavioural analysis proposed can be considered as the general framework for a participatory decision-support tool.

[1] According to Cascetta et al. [24] a new and more innovative role of quantitative methods consists of the contribution to stakeholder engagement "by providing information for interaction among decision-makers, process coordinators and stakeholders. This function can be useful from the very beginning of the process, as it helps to develop a common understanding of the current performance and deficiencies of the system, based on data and analysis and not only on impressions and points of view".

**Acknowledgements** This work was par1ally supported by Volvo Research Founda1on, Grant #SP-2007-50 ("Innova1ve solu1ons to freight distribu1on in the complex large urban area of Rome"), the Italian Ministry of Educa1on, University and Research, N. 2008YEPPM3_005 ("Methods and models for es1ma1ng the effec1veness of strategies for urban distribu1on of goods"), and the FIR Research Project 2014 N. ABDD94 of Catania University.



## References

1. Taylor MAP (2005) The City logistics paradigm for urban freight transport. In: Proceedings of the 2nd state of Australian cities conference pp 1–19
2. Gatta V, Marcucci E, Le Pira M (2017) Smart urban freight planning process: integrating desk, living lab and modelling approaches in decision-making. Eur Transp Res Rev 9:32

3. Marcucci E, Gatta V, Valeri E, Stathopoulos A (2013) Urban Freight transport modelling: an agent-specific approach. FrancoAngeli, Milano
4. Marsden G, Ballantyne E E F, Whiteing A E (2011) An analysis of local authority views and treatment of urban freight in the UK. In: Universities' Transport Study Group, Archives. 43rd Universities' Transport Study Group Conference, 5–7 Jan 2011, Milton Keynes. Universities' Transport Study Group. http://eprints.whiterose.ac.uk/79065/. Accessed 23 June 2017
5. DG MOVE (2012) European commission: study on urban freight transport – final report http://ec.europa.eu/transport/sites/transport/files/themes/urban/studies/doc/2012-04-urban-freight-transport.pdf. Accessed 23 June 2017
6. Comi A, Delle Site P, Filippi F, Marcucci E, Nuzzolo A (2008) Differentiated regulation of urban freight traffic: Conceptual framework and examples from Italy. Proceedings of the 13th International Conference of Hong Kong Society for Transportation Studies: Transportation and Management Science, pp. 815–824
7. Lindholm M (2013) Urban freight transport from a local authority perspective – a literature review. European Transport / Trasporti Europei (2013) Issue 54, Paper n° 3, ISSN 1825-3997
8. Voinov A, Bousquet F (2010) Modelling with stakeholders. Environ Model Softw 25(11):1268–1281
9. Browne W, Allen J (1999) The impact of sustainability policies on urban freight transport and logistics systems. In: Meesman H, Van De Voorde E, Winkelmans W (eds) World transport research, Transport modes and systems, vol 1. Oxford, Elsevier, pp 505–518
10. Rodrigue JP, Comtois C, Slack B (2013) The geography of transport systems. Routledge, Abingdon
11. Dablanc L (2007) Goods transport in large European cities: difficult to organize, difficult to modernize. Transp Res A 41:280–285
12. Dablanc L, Diziain D, Levifve H (2011) Urban freight consultation in the Paris region. Eur Transp Res Rev 3(1):47–57
13. Ortúzar JD, Willumsen L (2011) Modelling transport, 4th edn. Wiley, New York
14. Cascetta E (2009) Transportation system analysis. Models and applications (2nd edition ed.). New York: Springer
15. Holguín-Veras J, Sánchez-Díaz I, Reim B (2016) ETC adoption, time-of-travel choice, and comprehensive policies to enhance time-of-day pricing: a stated preference investigation. Transportation 43: 273–299
16. Holguín-Veras J, Sánchez-Díaz I (2016) Freight demand management and the potential of receiver-led consolidation programs. Transp Res A 84:109–130
17. Marcucci E, Gatta V, Scaccia L (2015) Urban freight, parking and pricing policies: an evaluation from a transport providers' perspective. Transp Res A 74:239–249
18. Stathopoulos A, Valeri E, Marcucci E (2012) Stakeholder reactions to urban freight policy innovation. J Transp Geogr 22:34–45
19. Marcucci E, Gatta V (2012) Dissecting preference heterogeneity in consumer stated choices. Transp Res Part E 48:331–339
20. Marcucci E, Gatta V (2013) Intra-agent heterogeneity in urban freight distribution: the case of own-account operators. Int J Transp Econ 40(2):267–286
21. Gatta V, Marcucci E (2014) Urban freight transport and policy changes: improving decision makers' awareness via an agent-specific approach. Transp Policy 36:248–252
22. Le Pira M, Marcucci E, Gatta V, Inturri G, Ignaccolo M, Pluchino A (2017) Integrating discrete choice models and agent-based models for ex-ante evaluation of stakeholder policy acceptability in urban freight transport. Res Trans Econ. https://doi.org/10.1016/j.retrec.2017.08.002
23. EC – European Commission (2013). A concept for sustainable urban mobility plans. Annex to the communication from the commission to the european parliament, the council, the european economic and social committee and the committee of the regions together towards competitive and resource-efficient urban mobility COM(2013) 913 final. https://ec.europa.eu/transport/sites/transport/files/themes/urban/doc/ump/com(2013)913-annex_en.pdf. Accessed 23 June 2017
24. Cascetta E, Cartenì A, Pagliara F, Montanino M (2015) A new look at planning and designing transportation systems: a decision-making model based on cognitive rationality, stakeholder engagement and quantitative methods. Transp Policy 38:27–39
25. Le Pira M (2015) Towards participatory decision-making processes in transport planning: an agent-based approach. PhD dissertation, University of Catania, Italy
26. Bordagaray M, dell'Olio L, Ibeas Á, Barreda R, Alonso B (2015) Modeling the service quality of public bicycle schemes considering user heterogeneity. Int J Sustain Transp 9(8):580–591
27. Carey MA, Asbury JE (2016) Focus group research. Routledge, Abingdon
28. dell'Olio L, Ibeas A, Barreda R, Sañudo R (2013) Passenger behavior in trains during emergency situations. J Saf Res 46: 157–166
29. Marcucci E, Le Pira M, Carrocci CS, Gatta V, Pieralice E (2017) Connected shared mobility for passengers and freight: Investigating the potential of crowdshipping in urban areas. In Models and Technologies for Intelligent Transportation Systems (MT-ITS), 2017 5th IEEE International Conference on (pp. 839–843). IEEE
30. Marcucci E, Gatta V (2017) Investigating the potential for off-hour deliveries in the city of Rome: Retailers' perceptions and stated reactions. Transp Res A Policy Pract 102:142–156
31. Soria-Lara JA, Banister D (2017) Dynamic participation processes for policy packaging in transport backcasting studies. Transp Policy 58:19–30
32. Annema JA, Mouter N, Razaei J (2015) Cost-benefit analysis (CBA), or multi-criteria decision-making (MCDM) or both: politicians' perspective in transport policy appraisal. Transp Res Procedia 10:788–797
33. Macharis C, Bernardini A (2015) Reviewing the use of multi-criteria decision analysis for the evaluation of transport projects: time for a multi-actor approach. Transp Policy 37:177–186
34. Macharis C (2004) The importance of stakeholder analysis in freight transport: the MAMCA methodology. Eur Transp (Trasporti Europei) 25(26):114–126
35. Macharis C, De Witte A, Turcksin L (2010) The multi-actor multi-criteria analysis (MAMCA) application in the Flemish long-term decision-making process on mobility and logistics. Transp Policy 17:303–311
36. De Brucker K, Macharis C, Verbeke A (2013) Multi-criteria analysis and the resolution of sustainable development dilemmas: a stakeholder management approach. Eur J Oper Res 224:122–131
37. Vermote L, Macharis C, Hollevoet J, Putman K (2014) Participatory evaluation of regional light rail scenarios: a Flemish case on sustainable mobility and land-use. Environ Sci Pol 37:101–120
38. Macharis C, Milan L, Verlinde S (2014) A stakeholder-based multicriteria evaluation framework for city distribution. Res Transp Bus Manag 11:75–84
39. Awasthi A, Chauhan SS, Goyal SK (2011) A multi-criteria decision making approach for location planning for urban distribution centers under uncertainty. Math Comput Model 53(1):98–109
40. Tadić S, Zečević S, Krstić M (2014) A novel hybrid MCDM model based on fuzzy DEMATEL, fuzzy ANP and fuzzy VIKOR for city logistics concept selection. Expert Syst Appl 41(18):8112–8128
41. Rao C, Goh M, Zhao Y, Zheng J (2015) Location selection of city logistics centers under sustainability. Transp Res Part D: Transp Environ 36:29–44

42. Awasthi A, Chauhan SS (2012) A hybrid approach integrating affinity diagram, AHP and fuzzy TOPSIS for sustainable city logistics planning. Appl Math Model 36(2):573–584
43. Saaty TL (1980) The analytic hierarchy process. McGraw Hill, New York
44. Piantanakulchai M, Saengkhao N (2003) Evaluation of alternatives in transportation planning using multi-stakeholders multi-objectives AHP modelling. Proceedings of the Eastern Asia Society for Transportation Studies, vol. 4
45. De Luca S (2014) Public engagement in strategic transportation planning: an analytic hierarchy process based approach. Transp Policy 33:110–124
46. Le Pira, M., Inturri, G., Ignaccolo, M., Pluchino, A., (2018). Dealing with the Complexity of Stakeholder Interaction in Participatory Transport Planning. In Zak, J., Hadas, Y., Rossi, R. (eds.) "Advanced Concepts, Methodologies and Technologies for Transportation and Logistics". Advances in Intelligent Systems and Computing 572. Springer International Publishing. https://doi.org/10.1007/978-3-319-57105-8_3
47. Le Pira M, Inturri G, Ignaccolo M (2016) Combined expert, stakeholder and citizen involvement for priority setting of cycling mobility strategies using analytic hierarchy process. International Conference on Traffic and Transport Engineering (ICTTE) – Belgrade, November 24–25, 2016. ISBN 978-86-916153-3-8
48. Ishizaka A, Nemery P (2013) Multi-criteria decision analysis. Methods and Software, Wiley, Hoboken
49. Malczewski J (2006) GIS-based multicriteria decision analysis: a survey of the literature. Int J Geogr Inf Sci 20(7):703–726
50. Sarjakoski T (1998) Networked GIS for public participation – emphasis on utilizing image data. Comput Environ Urban Syst 22(4): 381–392
51. Tang KX, Waters NM (2005) The internet, GIS and public participation in transportation planning. Prog Plan 64:7–62
52. Zhong T, Young RK, Lowry M, Rutherford GS (2008) A model for public involvement in transportation improvement programming using participatory Geographic Information Systems. Comput Environ Urban Syst 32:123–133
53. Jankowski P (2009) Towards participatory geographic information systems for community-based environmental decision making. J Environ Manag 90:1966–1971
54. Scott J (2013) Social network analysis. SAGE Publications Ltd, Thousand Oaks
55. Boccaletti S, Latora V, Moreno Y, Chavez M, Hwang D-U (2006) Complex networks: Structure and dynamics. Phys Rep 424:175–308
56. Prell C, Hubacek K, Reed M (2009) Stakeholder analysis and social network analysis in natural resource management. Soc Nat Res Int J 22:501–518
57. García Melón M, Estruch Guitart V, Aragonés-Beltrán P, Monterde-Roca B (2013) Social network analysis in participatory environmental decision making. The case of Spanish wetland La Albufera. 12th international symposium on the analytic hierarchy process (ISAHP 2013). Multi-criteria Decision Making. Kuala Lumpur, Malaysia
58. Carrasco JA, Miller EJ (2009) The social dimension in action: a multilevel, personal networks model of social activity frequency between individual. Transp Res A 43:90–104
59. Ryley TJ, Zanni AM (2013) An examination of the relationship between social interactions and travel uncertainty. J Transp Geogr 31:249–257
60. Borgatti S, Everett M, Freeman L (2002) Ucinet for windows: software for social network analysis. Analytic Technologies, Harvard
61. Lim SL, Quercia D, Finkelstein A (2010) StakeSource: harnessing the power of crowdsourcing and social networks in stakeholder analysis. In: Proceedings of the 32nd ACM/IEEE international conference on software engineering-volume 2, pp. 239–242
62. Block H, Marschak J (1960) Random orderings and stochastic theories of responses. In: Olkin I, Ghurye S et al (eds) Contributions to probability and statistics. Stanford University Press, Stanford, pp 97–132
63. Marschak J (1959) Binary choice constraints and random utility indicators. In: Arrow K, Karlin S, Suppes P (eds) Mathematical methods in the social sciences, 1959. Stanford University Press, Stanford, California, pp 312–329
64. Marcucci E, Stathopoulos A, Gatta V, Valeri E (2012) A stated ranking experiment to study policy acceptance: the case of freight operators in Rome's LTZ. Ital J Reg Sci 11(3):11–30
65. Kelly J, Haider W, Williams PW, Englund K (2007) Stated preferences of tourists for eco-efficient destination planning options. Tour Manag 28:377–390
66. Hackbarth A, Madlener R (2013) Consumer preferences for alternative fuel vehicles: a discrete choice analysis. Transp Res D 25:5–17
67. Huh S, Kwak D, Lee J, Shin J (2014) Quantifying drivers' acceptance of renewable fuel standard: results from a choice experiment in South Korea. Transp Res D 32:320–333
68. Que S, Awuah-Offei K, Samaranayake VA (2015) Classifying critical factors that influence community acceptance of mining projects for discrete choice experiments in the United States. J Clean Prod 87:489–500
69. Rijnsoever FJ, van Mossel A, Broecks KPF (2015) Public acceptance of energy technologies: the effects of labeling, time, and heterogeneity in a discrete choice experiment. Renew Sust Energ Rev 45:817–829
70. Valeri E, Gatta V, Teobaldelli D, Polidori P, Barratt B, Fuzzi S, Kazepov Y, Sergi V, Williams M, Maione M (2016) Modelling individual preferences for environmental policy drivers: empirical evidence of Italian lifestyle changes using a latent class approach. Environ Sci Policy 65:65–74
71. Marcucci E, Gatta V (2016) How good are retailers in predicting transport providers' preferences for urban freight policies?... and vice versa? Transp Res Procedia 12:193–202
72. Gatta V, Marcucci E (2016) Stakeholder-specific data acquisition and urban freight policy evaluation: evidence, implications and new suggestions. Transp Rev 36(5):585–609
73. Holguín-Veras J, Wang Q, Xu N, Ozbay K, Cetin M, Polimeni J (2006) The impacts of time of day pricing on the behavior of freight carriers in a congested urban area: Implications to road pricing. Transp Res A Policy Pract 40(9):744–766
74. Holguín-Veras J, Silas M, Polimeni J, Cruz B (2007) An investigation on the effectiveness of joint receiver–carrier policies to increase truck traffic in the off-peak hours. Part I: the behavior of receivers. Netw Spat Econ 7(3):277–295
75. Holguín-Veras J, Silas M, Polimeni J, Cruz B (2008) An investigation on the effectiveness of joint receiver–carrier policies to increase truck traffic in the off-peak hours. Part II: The Behavior of Carriers Netw Spat Econ 8(4):327–354
76. Puckett SM, Hensher DA, Rose JM, Collins A (2007) Design and development of a stated choice experiment for interdependent agents: accounting for interactions between buyers and sellers of urban freight services. Transportation 34:429. https://doi.org/10.1007/s11116-007-9114-z
77. Hensher DA, Puckett SM (2005) Refocusing the modelling of freight distribution: Development of an economic-based framework to evaluate supply chain behaviour in response to congestion charging. Transportation 32:573–602
78. Rotaris L, Danielis R, Sarman I, Marcucci E (2012) Testing for nonlinearity in the choice of a freight transport service. European Transport - Trasporti Europei 50:1–22
79. Gatta V, Marcucci E, Scaccia L (2015) On finite sample performance of confidence intervals methods for willingness to pay measures. Transp Res A Policy Pract 82:169–192

80. Macal CM, North MJ (2010) Tutorial on agent-based modelling and simulation. J Simul 4:151–162
81. Taniguchi E, Tamagawa D (2005) Evaluating city logistics measures considering the behavior of several stakeholders. J East Asia Soc Transp Stud 6:3062–3076
82. van Duin JHR, van Kolcka A, Anand N, Tavasszy LA (2012) Towards an agent-based modelling approach for the evaluation of dynamic usage of urban distribution centres. Procedia Soc Behav Sci 39:333–348
83. Roorda MJ, Cavalcante R, McCabe S, Kwan H (2010) A conceptual framework for agent-based modelling of logistics services. Transp Res E 46:18–31
84. Liedtke G (2009) Principles of micro-behavior commodity transport modeling. Transp Res E 45:795–809
85. Tamagawa D, Taniguchi E, Yamada T (2010) Evaluating city logistics measures using a multi-agent model. Procedia Soc Behav Sci 2(3):6002–6012
86. Holmgren J, Davidsson P, Persson JA, Ramstedt L (2012) TAPAS: a multi-agent-based model for simulation of transport chains. Simul Model Pract Theory 23:1–18
87. Le Pira M, Ignaccolo M, Inturri G, Pluchino A, Rapisarda A (2017) Finding shared decisions in stakeholder networks: an agent-based approach. Physica A: Stat Mech Appl 466:277–287
88. Le Pira M, Inturri G, Ignaccolo M, Pluchino A, Rapisarda A (2015) Simulating opinion dynamics on stakeholders' networks through agent-based modeling for collective transport decisions. Procedia Comput Sci 52:884–889
89. Le Pira M, Ignaccolo M, Inturri G, Pluchino A, Rapisarda A (2016) Modelling stakeholder participation in transport planning. Case Stud Transp Policy 4(3):230–238
90. Le Pira M, Inturri G, Ignaccolo M, Pluchino A (2017) Modelling consensus building in Delphi practices for participated transport planning. Transp Res Procedia 25C:3729–3739
91. Castellano C, Fortunato S, Loreto V (2009) Statistical physics of social dynamics. Rev Mod Phys 81:591–646
92. Marcucci E, Le Pira M, Gatta V, Ignaccolo M, Inturri G, Pluchino A (2017) Simulating participatory urban freight transport policy-making: accounting for heterogeneous stakeholders' preferences and interaction effects. Transp Res E 103:69–86
93. Le Pira M (2018) Transport planning with stakeholders: an agent-based modelling approach. Winning paper of the 3rd Edition of the IJTE Prize. To be published in International Journal of Transport Economics (IJTE)
94. Holguín-Veras J, Aros-Vera F, Browne M (2015) Agent interactions and the response of supply chains to pricing and incentives. Econ Transp 4(3):147–155
95. Galam S (2002) Minority opinion spreading in random geometry. Eur Phys J B 25(4):403–406
96. Hegselmann R, Krause U (2002) Opinion dynamics and bounded confidence: models, analysis and simulation. J Artif Societies Soc Simulation 5(3):1–23
97. Gatta V, Marcucci E (2016) Behavioural implications of non-linear effects on urban freight transport policies: the case of retailers and transport providers in Rome. Case Stud Transp Policy 4(1):22–28
98. Zanni AM, Ryley T (2013). Discrete choice and social networks: an analysis of extreme weather uncertainty in travel behaviour. In: ENVECON Conference, London, The Royal Society, 15 March 2013. https://www.researchgate.net/publication/265507941_Discrete_choice_and_social_networks_an_analysis_of_extreme_weather_uncertainty_in_travel_behaviour. Accessed 23 June 2017