Agent-based modelling of stakeholder involvement for urban freight transport policy-making

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Abstract

Policy-making about urban freight transport (UFT) is a complex task, mainly due to the presence of multiple stakeholders with often diverging interests. Knowing in advance objectives and behavioural aspects related to stakeholders can increase policy-makers’ awareness and help them taking better decisions (Taniguchi and Tamagawa, 2005). Besides, direct involvement of all the interested parties in the decision-making process becomes fundamental to find the most shared policy derived from a deliberative and transparent process.

In this respect, it has been demonstrated that interaction and deliberation can change stakeholders’ mind about public policy problems (Quick et al., 2014) and lead to a convergence of opinions, moderating strong diverging objectives and pursuing a collective decision (Le Pira et al., 2015). A good design and management of the participation process is crucial for the success of the decision-making process. The aim of this paper is to investigate the inclusive decision-making process about UFT policies involving different stakeholders through an agent-based model. Agent-based modelling is typically used to simulate complex systems, such as social systems, but its use in the field of urban freight transport is quite recent, even though the modelling approach is widely used to reproduce city logistics problems (Anand et el., 2015). Simulations represent a powerful tool in predicting the results of a participation process and giving insights and suggestions on the interaction process, being able to capture emergent phenomena which are difficult to be analytically treated.

Extended abstract

Objectives and motivation

Policy-making about urban freight transport (UFT) is a complex task, mainly due to the presence of multiple stakeholders with often diverging interests. Knowing in advance objectives and behavioural aspects related to stakeholders can increase policy-makers’ awareness and help them taking better decisions (Taniguchi and Tamagawa, 2005). Besides, direct involvement of all the interested parties in the decision-making process becomes fundamental to find the most shared policy derived from a deliberative and transparent process.

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General description

The participatory decision-making process in UFT transport is described by means of a multi-layer network, where each layer represents a different level of description and details of the process, and they are interconnected with each other. The new approach of multi-layer networks allow a more realistic and effective representation of complex phenomena (Boccaletti et al., 2014). In the case of socio-economic systems, such as decision-making processes, a particular type of multi-layer network should be used, the so called “multiplex network”, where each node belongs to all the layers but the relationships among them can change within the layers.

The problem of UFT policy-making involving stakeholders is represented as a multiplex network with three layers and the following structure:

- the bottom layer is the “interaction” level, represented by all the stakeholders linked in networks with the other members of the same category and they can interact with each other;
- the middle layer is the “negotiation” level, where an agent acts as the spokesperson of its category and it is directly linked with all the other members of the same category;
- the top layer is the “decision” level, where the spokesperson of the three categories are linked with each other and can interact to find a shared decision.

The simulations are performed within the software environment NetLogo (https://ccl.northwestern.edu/netlogo), particularly suitable for agent-based modelling.

Three stakeholder categories are considered in the model, i.e. retailers, transport providers and own-account operators. In order to realistically consider the stakeholders’ behaviour, agents are endowed with utility functions derived from an econometric model, based on a stated preference survey (Stathopoulos et al., 2012). Utility functions are evaluated for each respondent (individual utility function) and for each category (group utility function), being an agent-specific approach (Marcucci and Gatta, 2014).

At the beginning of the simulation, a set of alternative policies is considered and each node chooses the one which maximizes its utility. Then, with an iterative bottom-up/top-down mechanisms based on opinion dynamics models, they can interact in the three layers to find a convergence of opinions towards a shared policy.

Results and conclusions

The implemented agent-based model allows predictions to be made about the possible decision derived from an interaction process. Results show that the repeated interaction leads to an increase in the the average degree of consensus, supporting the idea that communication and deliberation among stakeholders can attenuate strong diverging points of views.
Agent-based modelling proved to be a suitable tool in reproducing UFT decision-making processes, helping policy-makers to deal with the variety of stakeholders involved and the complexity of decision-making.

References


Keywords: stakeholder interaction modelling; agent-specific approach; stated preferences; urban freight transport policy-making; agent-based simulation.