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A new look at planning and designing transportation systems: A decision-making model based on cognitive rationality, stakeholder engagement and quantitative methods

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ABSTRACT

Transportation systems are complex sociotechnical systems and this dual nature is reflected in the literature dealing with their planning, i.e. defining courses of action from both public and private points of view. On the one hand, the social sciences literature makes it clear that most decisions related to transportation are "wicked", i.e. they cannot be tackled with traditional engineering approaches since they are poorly defined. On the other, transportation systems have a strong technical component affecting most of such decisions, as they have to (or should) comply with compelling technical and economic requirements. The literature on transport engineering and economics deals with transportation planning mostly as a rational process based on the formulation and comparison of alternative options.

In this paper, we propose an approach to planning and designing transportation systems, at least in the more complex cases, meant to bridge the gap between social and technical points of view. The proposed approach is cross-disciplinary, as it integrates notions from cognitive sciences, organization and management sciences with transportation systems analysis. Transportation planning, both under public and private market-oriented viewpoints, is seen as a complex decision-making process where different actors (decision-makers, stakeholders, professionals) interact in different contexts and according to different "models" or approaches.

After a brief discussion of the main elements of most planning processes and of the different decision making models, the paper proposes a decision-making model based on three parallel and intertwined processes: a cognitive rational approach to organizing the decision-making process, a five-level stakeholder engagement process, and a revised role of quantitative analyses and methods drawing on tools from engineering and economics, amongst other disciplines.

We also present a real application of the proposed decision-making model to the case study of the Regional Metro System (RMS) project in Campania (southern Italy), where a complex decisional context with different stakeholders and multiple (often contrasting) interests was managed in the integrated framework for over a decade, resulting in the largest and most effective of such projects in Italy.

Finally, the paper proposes new roles and new challenges for quantitative analyses and mathematical tools to support participated decision-making processes, extending their well-established functions for designing and assessing transportation solutions.

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1. Introduction

Transportation systems are complex social and technical systems. Their twofold nature is reflected in the literature dealing with their planning, in which courses of action have to be defined from both public and private standpoints. In one respect there are technical problems requiring the approaches and tools of engineering and economics, amongst other disciplines, to produce projects that are both technically feasible and economically viable. Obviously, the complexity of decision-making processes in transportation has long been recognized in the relevant planning literature, together with the need to "open up" such processes and broaden the consensus around alternative courses of action (see for instance Manheim et al., 1972 and Suhrbier et al., 1987, as well

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as the far-sighted chapter dedicated to choices in transportation in Manheim, 1979). However, the above references had only a limited impact on the transportation literature as most of the contributions (e.g. Florian et al., 1988; Meyer and Miller, 2001; Cascetta, 2009; Willumsen and Ortuzar, 2011) are rooted in the engineering/economics culture. It is assumed that the decision-making process has, or should have, some form of "rationality" and that quantitative tools, i.e. statistical analyses and mathematical models, play a central role in it. Against this background, transportation system analysis and planning are seen mostly as activities based on the design and simulation of alternative projects and the assessment of priorities. However, such assumptions are often not satisfied in real-life complex cases. Transport-related decisions can be a-rational or "sub-optimal" with respect to stated, formal objectives, and still "rational" in the context of a wider, less defined set of contrasting objectives including maximizing consensus and/or minimizing opposition to proposed solutions.

From another angle, plans and projects often impact on multiple and contrasting interests in a complex institutional setting, and result from decision-making processes involving several actors, both public and private. From this perspective they belong to a wider class of problems known in the social sciences literature as "wicked problems" (see, for example, the seminal paper by Rittel and Webber (1973), Conklin (2005); for a recent state-of-the-art, see Landscape and Urban Planning Editorial, (2013)). They include many public policy issues, e.g. the problem of crime, the introduction of a tax rate, the reduction of GHG, etc., sharing a number of characteristics such as the lack of a definitive formulation, of stopping rules and single objective evaluation criteria, the essential uniqueness of each problem, referring to being symptoms of other problems.

There is a vast literature on "planning failures" in transportation (see, e.g. Hall, 1980; Winston, 2000; Button, 2005; Flyvbjerg et al., 2005; Bartholomew, 2007; Knoflacher, 2007; Lemp and Kockelman, 2009). The poor performance of transportation planning can be at least partially attributed to the distance between the two approaches, as recognized several years ago by Manheim et al. (1972). In this respect, we try to contribute to reduce this gap by analyzing the elements of most decision-making processes related to transportation systems, discussing some classes of decisions (plans/projects) and theoretical models of real-life processes, including rational (according to a set of proposed necessary conditions) and a-rational models.

The basic assumption of this paper is that the quality of the decision-making process is a key factor for "successful" planning, and that the quality of the decisions depends critically on how the process is structured. Planning and designing transportation systems should expressly be recognized as managing complex, multi-agent decision-making processes in which political, technical and communication abilities should all be involved in order to design solutions which are technically consistent and, at the same time, maximize stakeholder consensus.

In light of the above considerations, we propose an approach to planning and designing transportation systems, at least in the more complex cases, based on three parallel and intertwined processes:

- a cognitive rational approach to organizing the decision-making process;
- a five-level stakeholder engagement process;
- a technical analysis process based on an extended role of quantitative methods.

We also present an application of the proposed decision-making model to the case study of the Regional Metro System (RMS) project of Campania in southern Italy, where a complex decision context with different stakeholders and multiple (often contrasting) interests was managed in an integrated framework for over a decade.

Finally, the paper revisits the use of quantitative tools to support the proposed decision-making framework in addition to their unquestioned role in designing and assessing transport systems. These suggestions are intended to close the gap between the technical literature and the practice of transportation planning and design as (open) decision making processes.

The paper is organized as follows. Section 2 summarizes the main elements of transportation planning as a decision-making process, while Section 3 describes the key elements of stakeholder engagement. In Section 4, the proposed integrated framework based on cognitive rationality, public engagement and quantitative analysis is discussed. Section 5 presents the application to the case study of the Regional Metro System (RMS) project of Campania in Italy. The potential roles of quantitative methods in the wider vision of the planning process are described in Section 6. Finally, Section 7 reports the main conclusions and highlights some further research perspectives.

2. Decisions in transportation systems

2.1. Elements of the decision-making process

The range of real-life processes leading to decisions on transportation systems, or related to them, is virtually endless, as are the possible combinations of actors, institutional contexts, physical locations, and possible solutions. However, some of the main elements contributing to transportation planning processes can be singled out.

- *Opportunities and problems (needs)*–stimulate the decision-making process, giving rise to different planning perspectives (e.g. mobility, environmental, land-use, business planning), depending on the institutional role of the main decision-makers as well as on the opportunities or needs to which decisions respond.
- *Decision-makers*–are those who are formally in charge of the choice. Their nature i.e. their being public administrations or companies, characterizes the planning perspective. In addition, the same planning process may involve several decision-makers at different scales and types, with often multiple and contrasting interests/objectives.
- *Market regulations*–frame the context in which decisions are taken, it being either a natural monopoly, where only one subject is allowed for the construction and/or management of a transport system, or a competitive market, where several subjects compete for the same economic activity.
- *Process coordination*–is represented by those resources and procedures aimed at planning and managing each stage of the process. This role is essential for anticipating and responding to possible unexpected problems and for improving the quality of the whole process. However, this element is often not explicitly recognized and institutionalized, thus undermining the whole process.
- *Stakeholders*–i.e. people and organizations who hold a *stake* in a particular issue, even though they have no formal role in the decision-making process. They may have an institutional, professional, or economic interest in the project, or their environment or livelihood may be affected in some way by the implementation of the project (i.e. conflicting interests).
- *Objectives*–are multiple and conflicting, as the targets that both decision-makers and stakeholders would like to achieve through decisions on the transportation system, or related to it. They can be classified into stated objectives (e.g. improve

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