Transportation Research Part A 60 (2014) 53–68

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

A virtual environment for the formulation of policy packages

Araz Taeihagh [a], René Bañares-Alcántara [a,*], Moshe Givoni [b]

[a] Department of Engineering Science, University of Oxford, Parks Road, Oxford OX1 3PJ, UK
[b] Transport Studies Unit, School of Geography and the Environment, University of Oxford, South Parks Road, Oxford OX1 3QY, UK

ARTICLE INFO

Article history:
Available online 9 November 2013

Keywords:
Policy formulation
Decision support systems
Policy packaging
Virtual environments
Agent-based modelling
Transport policy

ABSTRACT

The interdependence and complexity of socio-technical systems and availability of a wide variety of policy measures to address policy problems make the process of policy formulation difficult. In order to formulate sustainable and efficient transport policies, development of new tools and techniques is necessary. One of the approaches gaining ground is policy packaging, which shifts focus from implementation of individual policy measures to implementation of combinations of measures with the aim of increasing efficiency and effectiveness of policy interventions by increasing synergies and reducing potential contradictions among policy measures. In this paper, we describe the development of a virtual environment for the exploration and analysis of different configurations of policy measures in order to build policy packages. By developing systematic approaches it is possible to examine more alternatives at a greater depth, decrease the time required for the overall analysis, provide real-time assessment and feedback on the effect of changes in the configurations, and ultimately form more effective policies. The results from this research demonstrate the usefulness of computational approaches in addressing the complexity inherent in the formulation of policy packages. This new approach has been applied to the formulation of policies to advance sustainable transportation.

1. Introduction

The complexity and interdependence of socio-economic systems require the development of new tools and techniques to support a better understanding of the intricacies in these systems and to formulate policies that address the problems associated with such systems. Unlike in the physical sciences and economics, the use of computational approaches in the public policy realm has been mainly focused on the simulation and optimisation of policy alternatives rather than on their synthesis and generation.

Until recently policy analysis has mainly focused on impact of individual policy measures. Policy formulation is increasingly becoming more difficult due to the complexity of the systems and increase in the number of policy measures available for addressing the problems. For instance, in Transport policy, for combatting climate change challenges in the VIBAT project, 123 policy measures were considered (Banister and Hickman, 2006). The VIBAT-London study identified over 120 individual measures (Hickman, 2010) or the Visions-2030 project (Tight et al., 2011 – used for illustration of the system developed in this paper) identified 142 measures to promote Walking and Cycling (W&C) in cities. An accepted trend is that formulation of integrated policy packages, rather than a loose combination of policy measures that are considered and deployed in isolation, increases the success of policies (May and Roberts, 1995; Banister et al., 2000; Feitelson, 2003; OECD, 2007; Givoni et al., 2013 and Givoni, 2014). Development of a systematic framework and methodologies for development of policy packages

* Corresponding author. Tel.: +44 1865 27 31 78; fax: +44 1865 28 32 73.
E-mail address: rene.banares@eng.ox.ac.uk (R. Bañares-Alcántara).

0965-8564/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.tra.2013.10.017

is very helpful. In this paper, we focus on the development of a virtual environment for the exploration and analysis of different configurations of policy measures in order to build policy packages. The virtual environment allows testing the effects of changing the policy measures and/or their properties on the performance of the policy packages using different criteria and provides means of exploring the effects of uncertainties in policy formulation. The approach utilises and integrates techniques such as conceptual design, network analysis, Agent-Based Modelling (ABM) and multiple criteria decision analysis. Information about the policy measures' internal properties and their interactions with other policy measures and the user[1] preferences are used in the analysis and formulation of policies. The final decision on which policy to implement will rest with the decision makers who may decide to include additional policy measures or remove some of the measures recommended by the system.

We believe that by developing systematic approaches for the formulation and analysis of policies it is possible to decompose the problem into subproblems with more manageable size, analyse different alternatives at a greater depth, examine more alternatives, and decrease the time required for the overall analysis. Moreover, it is possible to provide real-time assessment and feedback to the domain experts on the effect of changes in the configuration of policy measures included in the package. This ultimately will help in forming more effective policy packages with synergistic and reinforcing attributes while avoiding internal contradictions. The approach is based on a previously proposed six-step framework for policy formulation (Taeihagh et al., 2009a) and the OPTIC framework for policy packaging (Givoni et al., 2013; Justen et al., 2014a). We showcase the system by applying the methodology to the formulation of a policy to increase walking and cycling (W&C) by using policy measures from the Visions 2030 project (Tight et al., 2011 – see Section 2.3 for more detail).

The background information is discussed in Section 2. Section 3 describes the architecture, objectives and conceptual framework used in the modelling approach and Section 4 illustrates its implementation. The results achieved are presented in Section 5 and conclusions and future work are described in Section 6.

2. Background information

2.1. Policy design, formulation and packaging

A policy is a principle or guideline for action in a specific context (Pohl, 2008), and policy design is the task in which the components of a policy are selected and the overall policy is formulated. Currently, decisions on what to include in policies (their *synthesis*) are done manually, and considering the size of the space of alternative policies, a large portion of this space is left unexplored. Some aspects of a policy can be modelled mathematically, however, mathematical modelling is only part of the general policy-making process as decisions about desirable futures and the policies to attain them, are questions of social values and political choice (Robinson et al., 2006). In particular, simulation and optimisation routines can be utilised for the selection of an appropriate alternative, however these techniques have difficulty in dealing with 'wicked' problems[2] (Rittel and Webber, 1973; Bakshi, 2011; Justen et al., 2014b).

The major challenge faced by policy makers is no longer a lack of understanding about possible solutions nor a lack of options to implement. Given the complexity of the problems we are facing, the challenge is how to analyse and explore a large number of complex options, and arrive at the best solutions given time, geographical, budgetary and a myriad of other constraints. It is apparent that without having a systematic approach and access to decision aid tools, the number and complexity of different policy alternatives jeopardize the identification of the best options.

Research has already shown that capturing and processing large amounts of information is difficult for the human mind (McKee, 2003). Furthermore, Jones et al. (2009) point to evidence that excessive amounts of information can cause inertia and consideration of very few options. We believe that the traditional approach to policy-making can be enhanced to better address current shortcomings and help in addressing 21st century's challenges. The methodology for the generation of alternatives can be greatly enhanced, and a systematic approach will accelerate the task of policy-making and improve policy effectiveness.

We have proposed a six-step framework to facilitate policy formulation for achieving a set of user-defined goals and targets (for more information see Taeihagh et al. (2009a)). A software system has been implemented using this framework and the OPTIC framework for policy packaging (Givoni et al., 2013; Justen et al., 2014a), with consideration for reusability and flexibility of use with different targets, sectors and geographical scopes. A wide range of options should be explored and implemented to increase the probability of policy success.

2.2. Specification of relations among policy measures

Once a library of policy measures has been developed, the next step in the analysis is to identify and formalise relations that capture the policy measure interactions. Five types of mutually exclusive relations among policy measures are

[1] The term user in this paper always refers to the individual who is using the system, e.g. policy expert or planner.

[2] Rittel and Webber (1973) assigned 10 characteristics to wicked problems which have been further generalised by Conklin (2005) to the following six characteristics: 1. Wicked problem cannot be understood until a solution has been developed. 2. Wicked problems have no stopping rules. 3. Solutions to wicked problems are not right or wrong they are better or worse. 4. Every wicked problem is essentially unique and novel. 5. Every solution to a wicked problem is a one-shot operation. 6. Wicked problems have no given alternative solutions.