Scientia Iranica A (2011) 18 (5), 1037–1044

Sharif University of Technology

Scientia Iranica

Transactions A: Civil Engineering

www.sciencedirect.com

Exploring the role of transportation demand management policies' interactions

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Received 30 April 2011; revised 7 August 2011; accepted 27 August 2011

KEYWORDS

Integration;
Transportation demand management policy;
Synergy;
Interactions;
Car usage.

Abstract The integration of Transportation Demand Management (TDM) policies is a challenging issue in urban policy studies. Interactions between policies that are not addressed broadly in the integration context play a main role in the outcome of TDM policy packages. However, different individual daily trip purposes, city development, variations in land use and different levels of decision making about transportation often lead to the implementation of more than one TDM policy at a time. This study examined the role of TDM policy interactions on the macro and micro levels. On the macro level, this study showed that the introduction of two-way interactions in the model could improve the goodness of fit by 15%. On the micro level, we developed the concept of synergy for all levels of two policies. The results show that generally synergy is a function of policies' levels, and the integration of increasing parking cost with either cordon pricing or increasing fuel cost has greater synergy at higher levels of the two policies. In contrast, the integration of other two policies (i.e. cordon pricing and increasing fuel cost) had no synergy in the examined ranges.

1. Introduction

Currently, Transportation Demand Management (TDM) is a centerpiece of public policy around the world, especially in megalopolises. The environmental and social costs of congestion, such as air and noise pollution, depletion of energy, road casualties, and daily delays, lead urban policy makers to implement TDM policies. TDM is a general term for strategies that result in the more efficient use of transportation resources [1]. The generality of the TDM concept and its reliance on technology for implementation leads to the development of several policies, and some past studies have focused on the policies' definitions and characteristics [2,3]. In addition, some studies have attempted to classify the policies based on their features (e.g. [4–6]). For example, Steg and Vlek classified the policies based on their coerciveness toward mode change, and categorized policies as pull or push policies [7]. Pull policies encourage the use of non-car modes by making them attractive to car users; these policies include transit-oriented development, street reclaiming and the development of bus rapid transit. Inversely, push policies are those that discourage car usage by making it less attractive; these policies include road tolls, parking fees and cordon pricing.

Because each city consists of different types of individuals who are affected differently by TDM policies, and because the policies' features affects each individual travel pattern in a unique way, some studies recommend that a variety of TDM policies should be simultaneously implemented [6,8]. Implementing several TDM policies may cover more individual trips and may be more effective than implementing a single policy. Vieira et al. found that simultaneous adoption of TDM policies, which they called multi-instrumentality, might overcome some of the identified weaknesses and eventually enhance the strengths of single policies [9]. Additionally, a variety of decisions made by public and private organizations, which are often made without consideration of the indirect and long-term outcomes, affect transportation systems [3]. This issue shows that individuals often face many pull and push motives for or against car usage. To analyze the effects of such decisions on individuals' travel patterns, one should be aware of the effect of interactions among policies, in addition to the main effects of the policies.

Although the development of transportation demand management approaches has led to a wide and diverse range of policies in the past two decades, the recent challenge is to explore

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doi:10.1016/j.scient.2011.09.005

Production and hosting by Elsevier

how to integrate and implement TDM policies in a more effective way [9]. To solve urban transportation problems, the integration of transport policies is promoted as a more realistic and effective approach than the use of single policies, but the role of the interactions among different policies is said to be the difficulty of this approach from a research perspective [10].

This paper focuses on the role of the interactions of TDM policies and the mechanisms of their effects on car usage. After describing the research context in Section 2, the studied policies and general contribution of their interactions in prohibiting car usage (macro level) are described in Section 3. Section 4 focuses on the details of interactions of the integrated policies (micro level) by developing the concept of synergy of two policies. Section 5 summarizes the findings and describes the proposals for further developments.

2. Research context

The interaction between TDM policies is an issue that few studies have addressed. By investigating individuals' attitudinal responses to three push TDM policies and one pull TDM policy in two case-study cities in the UK, Cambridge and Newcastle, Thorpe et al. found that there is evidence of interaction effects between the levels of public acceptance of TDM policies, when considered separately and in combination with other policies [11]. They found that due to the interactions, the effect of integration of the studied policies is different from the summation of their effects, when each of the policies is implemented separately.

To assess the integrated policies, some studies have focused on a small number of TDM policies, and have introduced these policies to individuals as a limited number of packages. Pendyala et al. assessed five TDM policies by adopting an activity-based micro-simulation model system (AMOS) to simulate changes in individual travel patterns [12]. In their survey, they assessed the integration of specific policies in four transportation control management scenarios in addition to two single policy scenarios, and determined the possible impacts of the scenarios. Similarly, Eriksson et al. examined the acceptability of one push policy (increased tax on fuel) and two pull policies (improved public transport and subsidized renewable energy) individually and as packages combining one push and one pull policy [13]. By proposing a model of the factors predicting the acceptability of TDM policies, they concluded that while the pull policies were perceived to be effective, fair and acceptable, the push policy and the packages were perceived to be ineffective, unfair and unacceptable. By focusing on the improved public transport, increased tax on fuel and the combination of these two policies as a package, these authors further assessed the expected car usage reduction [14]. The results of their study showed that the integration of the two policies was more effective than the individual policies.

Increase in the number of studied policies and the levels of them, results in numerous combinations of policies as integrated scenarios. In such cases, researchers often adopt an experimental design approach that generates fewer choice sets by ignoring the effects of higher-order interactions. The details of some methods of the design of experiments in choice modeling are presented in [15]. O'Fallon et al. investigated the potential effect of 11 TDM policies on the respondent's decision to choose to drive a car to work or school during the morning peak period in three cities in New Zealand through a stated-preferences survey [16]. Because they ignored all interactions in the design of their study, they did not focus on policy integration, and recommended a study with fewer policies to explore the possible impacts of combinations of specific policies. Habibian investigated the effect of five TDM policies on morning car commuters' decisions of travel mode in [17]. He introduced TDM policies' two-way interactions in addition to their main effects, and found that the interaction variables were significant in the modeling process. He also found that these variables were significant with respect to individuals' mode changes.

From a different perspective, Vieira et al. explored the concept of multi-instrumentality as a procedure of policy integration and implementation, whereby a systematic search for complementary policies was completed when planning and designing one (or several) core policy(s) aiming to fulfill one particular policy more effectively [9]. They defined criteria to assess the TDM policies and analyzed four improvement mechanisms for each pair of policies. Based on meta-studies, they defined the potential improvement between different types of policies. Mayeres et al. identified four terms to describe the combinations of policy packages [18]. They defined the policies in a package in terms of complementarity, additivity, synergy and perfect substitutability state. Complementarity occurs when the simultaneous use of the two policies provides greater benefit than the use of either alone. Additivity exists when the benefit from the simultaneous use of the two policies is equal to the sum of the benefit gain of using each in isolation. Synergy occurs when the simultaneous use of the two policies gives a greater benefit than the sum of the benefits of using either one of them alone. Perfect substitutability exists when the use of one policy eliminates entirely the benefit gain from using another policy. Based on these definitions, additivity, synergy and perfect substitutability are all forms of complementarity. May et al. defined integration in terms of the way that they expected the implementation of the two policies to improve the attainment of the goals set relative to one policy implemented on its own [19]. They also used the Mayeres et al. [18] synergy concept as a benefit of integration, and reviewed a number of examples to assess the amount of synergy. By comparing the sum of benefit gains by using each policy's optimum level in isolation with the benefit gains from their simultaneous use on these levels, they found little evidence of synergy in outcome indicators.

Based on the above discussion, assessing the interaction of TDM policies is an interesting issue within the context of the integration of TDM policies. Two issues are addressed in this paper. First, the general contribution of the interactions of policies to the improvement of the mode choice model is investigated (macro level). Second, the amounts of synergy of the two policies based on the variation of their levels are determined (micro level). In other words, the method to determine the amount of synergy based on the optimum level of each single policy is generalized to all of its levels, and therefore, the amount of synergy is derived as a function of both policies' levels. It is notable that to find the answer to the above questions, this study adopted the mode choice model of the city of Tehran, which is presented in Appendix. Design of this model is based on the consideration of two-way interactions of policies (details of this model are presented in [17]).

3. Interaction effects (macro level)

3.1. The studied policies

The model used in this study was developed to assess the effects of five TDM policies in the city of Tehran. These policies consisted of three push policies and two pull policies. The