Transport Policy 30 (2013) 229–237

Contents lists available at ScienceDirect

Transport Policy

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

Coping with congestion: Understanding the role of simultaneous transportation demand management policies on commuters

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ARTICLE INFO

Available online 18 October 2013

Keywords:
Transportation demand management policy
Logit model
Stated preferences
Marginal effect
Main effect
Interaction effect

ABSTRACT

This paper examines the role of transportation demand management (TDM) policies on commuters' mode choice in the city of Tehran. The analysis is based on the results of a stated preferences survey developed through the design of experiments approach. Five policies covering increasing parking cost, increasing fuel cost, cordon pricing, transit time reduction, and transit access improvement are assessed in order to study their impact on commuters' consideration of six modes of transportation to travel to work. A multinomial logit model was developed for the 366 commuters who regularly commute to their workplace in the center of the city. In addition to a number of commuting and contextual variables, the model shows that the single policies main effect and multiple policies interactions are significant in affecting commuters' mode choice. The marginal effects of policies are presented, and simultaneous effects of the policies on car usage variations are provided.

1. Introduction

Congestion due to driving a car is a common problem for megalopolis citizens because it imposes environmental and social costs such as air and noise pollution, depletion of energy, road casualties and daily delays. Among these outcomes, delay on the roads is reported as the most pervasive and costly problem (de Palma and Lindsey, 2001). Because of limitations on expanding transportation networks, policymakers and transportation planners have attempted to reduce car usage by proposing transportation demand management (TDM) policies over the past several decades. TDM is a general term for strategies that result in more efficient use of transportation resources and a rather comprehensive set of about 80 policies have been emerged so far (Litman, 2013).

To choose more appropriate TDM policies, a coerciveness-based classification approach has been recommended by some researchers (e.g., Marshall and Banister, 2000; Chen and Lai, 2011; Van Malderen et al., 2012). In this approach, coerciveness towards mode change divides the policies into two categories, namely pull and push policies (Steg and Vlek, 1997). Pull policies encourage the use of non-car modes by making them attractive to car users. Inversely, push policies are those that discourage car usage by making it less attractive (see also Santos et al., 2010a, 2010b), for a more general review of both push and pull policies).

Although there are many studies that look at the impact of a single TDM policy on a society, such as studies on congestion charging (Borjesson et al., 2012), park and ride (Hounsell et al., 2011), and parking pricing (Caicedo, 2012), few studies focus on the impact of multiple policies. As the importance of implementing more than one TDM policy has been addressed (Marshall and Banister, 2000; Meyer, 1999), the possibility of simultaneous TDM policies occurrences as a result of public and private organizations' uncoordinated decisions has also been reported (Litman, 2013). In fact, implementing more TDM policies may cover more individual trips and may be more effective, although some studies have pointed out the difficulties (May and Tight, 2006). Vieira et al. found that adopting more than one TDM policy, which they called multi-instrumentality, could possibly overcome some of the identified weaknesses of and eventually enhance the strengths of single implementations of policies (Vieira et al., 2007).

In the context of multiple policies in recent years, studies have mainly focused on the effectiveness and ranking of TDM measures (Stradling et al., 2000; Mackett, 2001; Kingham et al., 2001; Eriksson et al., 2008). Washbrook et al. examined the role of main effects of seven policies on mode choice (Washbrook et al., 2006). O'Fallon et al. explored the potential effect of 11 policies on the respondent's decision to choose to drive a car to work or school through a stated preferences survey and recommended a study with fewer policies to explore the possible impacts of interaction of specific policies (O'Fallon et al., 2004).

Pendyala et al. studied the effects of simultaneous implementation of five TDM policies by adopting an activity-based micro-simulation model system (AMOS) to simulate changes in individual

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http://dx.doi.org/10.1016/j.tranpol.2013.09.009

travel patterns (Pendyala et al., 1997). They assessed combinations of specific policies in four transportation control management scenarios and determined the possible impacts in those scenarios. Thorpe et al. presented the individuals' attitudinal responses to three push and one pull TDM policies (Thorpe et al., 2000). They concluded that there was evidence of interaction effects between levels of public acceptance of TDM policies when considered separately and in combination with other policies. They suggest performing a stated preferences experimental design of alternative TDM packages, which allow the investigation of both main and interaction effects.[1]

Eriksson et al. examined the acceptability of one push policy (raised 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 (Eriksson et al., 2008). They concluded that while the pull policies are perceived to be effective, fair, and acceptable, the push policy and the packages are perceived to be ineffective, unfair, and unacceptable. By focusing on improved public transport, raised tax on fuel, and their combination as a package, these authors showed that the combination led to larger expected car usage reduction than the individual policies (Eriksson et al., 2010). 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 sought when planning and designing one (or several) core policy(s) aiming to fulfill one particular policy more effectively (Vieira et al., 2007). By defining synergy concept as a benefit of integration, May et al. reviewed a number of examples to assess the concept and found little evidence of synergy in outcome indicators (May et al., 2006). Similar findings also resulted from a study on the European cities of Oslo, Leeds and York (Grant-Muller, 2005). Adopting the synergy concept, Kelly et al. developed an option generation tool to identify potential transport policy packages in the form of pairs of policy instruments (Kelly et al., 2008). Based on the levels of policies, Habibian and Kermanshah extend the synergy function and demonstrate the synergy area between the studied pairs of policies (Habibian and Kermanshah, 2011). May et al. enhanced the aforementioned option generation tool to identify the best complementarity policy to support an implicit policy or to identify the best combinations of several policies from a shortlist (May et al., 2012).

The above discussion shows that introducing more than one policy to manage transport demand of a megalopolis is a common issue faced by their policymakers. Therefore, assessing individual behavioral response to more than one TDM policy is an interesting issue within the TDM context. This paper is focused on modeling the role of five different TDM policies on commuters' mode choice (mode change), especially in regards to the interactions of these policies. Furthermore, the following two issues are also addressed in this paper: identifying other effective parameters in addition to the TDM policies on commuters' mode choice decision, and presenting a method to determine the results of simultaneous implementation of two TDM policies in the city of Tehran, Iran. After describing the research context, this paper describes the stated choice design and the stated preferences survey. Then, the developed mode choice model is explored, followed by presentation of policies' marginal effects and planning application graphically. The conclusion part summarizes the findings and discusses the implications of the results.

2. Stated preferences

The five policies selected for the city of Tehran consisted of three push and two pull policies. The policies were increasing parking cost, increasing fuel cost, cordon pricing into the extended central business district (CBD) area, transit (bus or subway) time reduction and transit access improvement. Since each policy has been implemented separately for some period at a time with some levels of success in the city of Tehran, people were familiar with them. This is the main reason that this study selects this set of policies to consider their simultaneous effect. Pull policies were described by setting measures in favor of the public transit vehicles in streets and intersections, decreasing the time of boarding and alighting at the stations, and increasing the number of bus lines and stops in the city.

Parking costs, fuel costs, and public transit time policies are designated with three levels, and cordon price and public access time are designed with two levels. Table 1 shows the policies and their levels. All push policies had fixed values for their levels; for pull policies, because there were variations in the transit time and transit access time for individuals, proportional values of the current state were used, which is different for each individual. The term *no change* in Table 1 refers to the current value of a policy that each individual already experiences. The mean values declared in the survey are also presented in Table 1 for a better description of the current state. As the cost of car usage is accumulated by the costs of push policies, the effectiveness of the levels are assessed by a pilot survey to avoid very high values of charge resulted from the combinations of policies.

In preparing a questionnaire for the stated preferences part, the design of experiments approach was adopted. Efficient design, a type of fractional factorial design, was used in the study, and a design with 89.5% efficiency was adopted, which allows assessing all two-way interactions of policies as well as the main effects with only 36 choice situations[2] (see (Rose and Bliemer, 2009) or (Kuhfeld, 2009), for more details on efficient design). To avoid a time-consuming questionnaire, 36 choice situations (scenarios) were randomly ordered and divided into six separate questionnaire types coded as 1–6. Each of the questionnaires had six scenarios, and each scenario consisted of five policies.

3. Survey

Two push policies are currently being implemented in the city of Tehran. The first is car-free planning in the CBD area of the city (about 30 km^2), and the second one is an odd-even scheme based on the last digit of car plates that attempt to enter extended CBD area, which is about three times larger than, and includes, the CBD area. Fig. 1 shows the CBD area and extended-CBD area of the city of Tehran. Based on their occupation, a few people can drive to the CBD area with a license called *permission*. A stated preferences survey was assigned for the morning car commuters to the extended CBD area, but they were asked to ignore these two policies to find the accurate sensitivity of individuals to the study policies. The extended CBD area is selected as study area for the two following reasons: (1) because of odd-even control, respondents are familiar with the fringes, and they can better imagine the entrance pricing area; and (2) respondents are familiar with the limits that they face half of the week and are thus aware of the alternative existing modes. Compared to the CBD area, the extended CBD area covers more car commuters, and the entrance restriction is more imaginable for this area than the former one. Respondents were interviewed face-to-face in their workplaces midway through the year 2009. The interviews were enhanced with a special card to better define the scenarios.

[1] In a few studies in choice modeling, researchers also examined the second order interactions of attributes in the models (e.g., Mogas et al., 2006).

[2] Efficient design is also adopted in other studies such as managed lanes (Burris and Patil, 2009).