Tradable Credits Scheme on Urban Travel Demand: A Linear Expenditure System Approach and Simulation in Beijing

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Abstract

Using a linear expenditure system (LES) approach, we investigate the influences of a new mobility management measure, a tradable credits scheme (TCS), on the pattern of daily trips measured in kilometres. Generally, we assume that an individuals’ travel consists of a car mode and a non-car mode. The effects of the TCS are discussed from a microeconomic perspective and using a scenario simulation study for the municipality of Beijing. Whilst other research has shown that travellers trade their credits and are generally inclined to non-car mode, the implementation of the tradable credits scheme demonstrated here is that travellers are likely to restrain their use of both car and non-car travel modes. Furthermore, both car and non-car mode trips are shown to be price inelastic, whilst the cross-price elasticity for different districts demonstrates a complementary relationship between car and bus modes.

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1. Introduction

Urban transport is a fast growing sector in the modern world, playing a major role in the quality of life for individuals and in regional development. However, the presence of negative externalities in the road transport sector such as congestion and vehicle emissions (Santos, et al. (2010)), have generated a series of social, economic and environmental challenges. A steady increase in urbanisation and motorisation can also be observed as a trend in many developing countries. As a result, policies and actions to solve or mitigate negative externalities that arise
from fast urbanisation are urgently needed. In this paper, we consider how a tradable credits scheme could help a city or urban area to achieve a target for a reduction in travel using the private car mode.

In order to avoid a progression towards an increasingly car-oriented society, there is a need to address the perception in some cultures of the car as a status symbol which people should aspire towards. A further issue is how to influence the mode choice of travellers and how to restrain the growing demand for car related travel. There are some direct ‘push’ mechanisms, such as ‘command and control’ policies including controls on car ownership (e.g., a quota system for new vehicle plates in Singapore, Chin and Smith (1997)), the driving ban scheme in Mexico City (Davis, 2008), road pricing (Yang and Bell, 1997; Yang and Huang, 2005), hybrid rationing and pricing policies (Daganzo, 1994) and taxation (Ribbink, Riel and Semeijn, 2006). There are also ‘pull’ mechanisms, such as prioritising the development of public transport and encouraging people to choose mass transit systems (Xu et al., 2010), reward measures (Ben-Elia and Ettema, 2011) and tradable credits schemes (Akamatsu, 2007; Yang and Wang, 2011; Grant-Muller and Xu, 2014).

The tradable credits scheme (TCS) is a ‘pull’ mechanism that has evolved over a relatively long period, particularly in relation to pollution control where it has been well studied and used in practice. In the transport sector, there are no wide-scale implementations of such a scheme in the world to date though, apart from the following four specific case studies (Fan and Jiang, 2013): credit-based congestion pricing (CBCP) in Austin (USA), a tradable driving day rights scheme (TDDR) in Mexico City (Mexico), the Genoa mobility rights trial (GMR) in Genoa (Italy), and a tradable driving rights trial (TDR) in Lyon (France). A recent, related hypothetical case study by Mamum et al. (2013) built on empirical data from Florida. It considered the regulation of vehicle miles travelled and compared socioeconomic impacts of three market-based measures including gasoline tax, mileage fee and tradable mobility credits.

There are many factors influencing travellers’ mode choice, e.g., travel cost, travel purpose, level of service of public transport, age, education, employment, etc., and there have been a number of studies in this field taking a disaggregate approach, e.g., Ben-Akiva and Lerman (1985), Dijst et al. (2002), Hensher and Rose (2007), Ho and Mulley (2013), Chidambaram et al. (2014), Habib and Weiss (2014)). From the perspective of transport authorities and decision makers, transport policy plays a crucial role in influencing travellers’ mode choice.

In this study, we investigate a fundamental transport policy question with a modelling approach, that is, how a tradable credits scheme is likely to affect travelers’ mode choice if it were implemented in practice. Different existing studies with TCS, e.g., the bottleneck model approach to travel choices in rush hour with TCS (Nie and Yin, 2013), and the bottleneck model approach to congestion management and modal split with heterogeneous users with TCS (Tian, Yang and Huang, 2013), we develop a modelling framework with LES to study the impacts of TCS on travelers’ mode choices. Specifically, we investigate how the number of vehicle kilometers travelled (VKT) may be influenced by implementing a tradable credits scheme. The study supposes that a regional authority is responsible for implementing the tradable credits scheme, the initial credit allocation is free and individuals receive a number of credits (representing vehicle-kilometers) based on a target to reduce the total VKT for the urban area. In maximizing their utility, individuals must consider their choice of travel mode in the light of their credit allocation. Each individual must consider the permitted number of kilometres and the credit price ($p_c$), then determine how many further credits they should purchase if they wish to travel additional kilometres using a car.

To investigate the influence of a TCS on car trips we present a simulated policy scenario based on a linear expenditure system (LES) approach to individuals’ mobility. Individuals’ travel choices are assumed to consist of car mode and non-car modes, which are assumed to be complementary relationship. The theoretical concept behind the proposed TCS and the state of art related to this measure are discussed in this paper. The number of VKT is compared before and after the introduction of the TCS. A fundamental difference with previous studies of tradable credits schemes, which are considered to be a comparative measure to road pricing, is that this study is based on influencing the number of VKT by individuals for the purpose of urban mobility management.

The paper is structured as follows. In Section 2, a literature review concerning TCS studies and the appropriateness of a LES approach for transport analysis are presented. In Section 3, a LES approach to individual trips both with and without a tradable credits scheme is proposed and a theoretical analysis based on price elasticities and cross-price elasticities is also presented. In Section 4, two simulated scenarios of individual daily trips (based on the LES model) with and without a tradable credits scheme are demonstrated. In Section 5, the approach is illustrated using 2010 census data for Beijing municipality, whilst the paper concludes in Section 6.
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