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Behavioural effects of a tradable driving credit scheme: Results of an online stated adaptation experiment in the Netherlands

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ABSTRACT

There is increasing interest in the application of tradable credit schemes in the context of personal travel. To anticipate the short-term effects of a distance-based tradable driving credit (TDC) scheme, an innovative stated adaptation experiment has been conducted. Using an activity-based approach, Dutch participants who frequently commute by car could reschedule their car-based activities and alter the travel pattern they reported in an online travel diary for a full week. This paper presents the results of model estimations that describe the likelihood of changing car use and the number of kilometres driven in response to two TDC scenarios. Reductions were larger for those who experienced a loss under the measure compared to those who could expect a gain. Participants who worked more hours and who lived in non-urban areas showed lower car use reduction levels, whereas participants with middle incomes and who were 18–25 years old showed higher reduction levels. A car dependency measure was added to the models to assess how these effects are related to the availability of car use alternatives.

1. Introduction

Car traffic poses a range of problems in terms of congestion and pollution in many urban areas of the world, leading to major losses in the economic performance of cities and the quality of life of their inhabitants. Without adequate responses, undesirable consequences of growing traffic, such as time losses, social stress and harmful emissions, are expected to worsen given the steady increase in car travel demand and the considerable increase in car ownership in many rapidly developing economies (Girod et al., 2013; Pucher et al., 2007). Various policy responses to curb traffic volume and to influence car travel demand have been proposed at different spatial scales and in different contexts. Many of these initiatives have incorporated pricing mechanisms, as road pricing is believed to be an efficient tool for allocating scarce road space and making drivers pay for the negative externalities they impose on others (Pigou, 1920; Vickrey, 1969; Rouwendal and Verhoef, 2006). However, fierce societal and political resistance against pricing measures makes implementing initiatives that could affect car traffic flows at a significant scale difficult (Schade and Schlag, 2003).

The use of tradable driving credits (TDC) has been identified as a promising alternative method of managing the growth of car use in an effective and efficient yet potentially socially feasible way (Viegas, 2001; Goddard, 1999; Verhoef et al., 1997). In general, TDC schemes refer to market-based instruments that set a limit on aggregate car use and distribute credits, representing individual shares of this capped car use, to participating agents. These credits could be traded, so that credits flow to agents with the highest value of using the resource, while those with the lowest abatement costs are able to sell their excess credits.

Various TDC forms have been discussed in terms of scheme design and potential functioning (Goddard, 1999; Verhoef et al., 1997; Viegas, 2001; Raux and Marlot, 2005; Buitelaar et al., 2007). Other studies have theoretically explored TDC schemes from a

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mathematical perspective by modelling traffic flows and times under different credit allocation and traveller assumptions (e.g., Yang and Wang, 2011; Nie, 2012; Xiao et al., 2013; Bao et al., 2014). However, until now, little effort has been made to investigate drivers' responses to TDC schemes at the individual level. Yet, in order to anticipate TDC effects, an empirical approach that relates credit consumption to individual car travel patterns and socio-demographic characteristics is critically needed.

A number of studies has started to empirically approach responses to credit-based pricing schemes. Raux et al. (2015) empirically investigated the effects of a personal carbon trading scheme on travel behaviour alone, whereas Zanni et al. (2013), Parag et al. (2011) and Capstick and Lewis (2010) studied the effects of such a scheme on all energy consuming actions of individual households. Kockelman and Kalmanje (2005) explored drivers' reactions to a credit-based congestion pricing policy, in which credits were not formally tradable in a market but could be exchanged for money. However, these studies have generally investigated responses either in fictitious decision contexts or at a highly aggregated level. That is, they either elicited responses to scenarios that were based on hypothetical, non-experienced trips (e.g., Kockelman and Kalmanje, 2005) or presented options to respondents in which they could change their annual mileage or number of trips without a clear and direct connection to concrete activities and trips (e.g., Raux et al., 2015; Zanni et al., 2013; Parag et al., 2011; Capstick and Lewis, 2010). We argue, however, that placing TDC responses in the context of people's daily activity patterns leads to a more reliable understanding of TDC decision-making as a trade-off between credit availability and real activity and travel needs.

Therefore, this paper discusses the results of an online stated adaptation experiment that has been developed to anticipate short-term responses to a TDC scheme using an activity-based approach (Axhausen and Gärling, 1992; Ettema and Timmermans, 1997). Participants reported their car-based activities for a full week and could reorganise this activity/trip pattern in response to two TDC scenarios. Using a sample of 308 Dutch car commuters, this study is the first to use a quantitative stated adaptation method that grounds TDC responses in actual trips and contextual characteristics on a large scale. In this paper, we specifically discuss the extent to which the investigated distance-based TDC scenarios leads to changes in vehicle kilometres travelled and how these changes relate to characteristics of the participants. In doing so, special attention is paid to the effect of facing a loss or a gain under these TDC scenarios, the influence of perceived car dependency and the role of participants' residential location, the latter being an aspect that studies on TDC have largely overlooked until now.

In the next section, we review theoretic and empirical work on TDC instruments. Section 3 describes the methodology and discusses the experiment, the scheme and the sample in more detail. Section 4 presents the results, and Section 5 provides a conclusion and discussion.

2. Literature

Tradable credit (TC) programmes offer regulators powerful tools to cope with the problem of the commons by rationing access to a resource and privatising access rights. In *The Problem of Social Costs* (1960), Coase argued that the lack of well-defined property rights causes the existence of externalities. These externalities could be eliminated if resource users could trade delineated private access rights in a market, which would lead to the efficient use of the resource regardless of the initial allocation of rights in situations with zero transaction costs and zero income effects. For a more thorough discussion of the theoretical foundations and practical details (e.g., its basic theorems, the issue of transaction costs, the issue of administration costs), we refer to Montgomery (1972), Baumol and Oates (1988), Hahn and Hester (1989), Hepburn (2006) and Tietenberg (2003). Compared to traditional pricing and taxing, the major advantages of TC schemes are that they provide regulators direct control over the quantity of total consumption and that price setting, which in the case of Pigouvian taxing is often problematic because of the need for a priori information about the precise valuation of the true costs of externalities and the demand and costs structures of the market, is left to the market (Verhoef et al., 1997). TC schemes have found several applications in upstream programmes in contexts such as air pollution control, fisheries, water resource management and land use control (Sovacool, 2011; Costello et al., 2008), but examples of implementation at the downstream, individual level are still absent.

Various authors, however, have started to conceptually explore the potential of TC in the personal transport domain. Verhoef et al. (1997) discussed several TC applications on the vehicle user side, as well as on the side of vehicle and fuel industries. Goddard (1999) proposed replacing the Mexico City non-driving-day vehicle restriction scheme with a more flexible tradable driving-day scheme. Examples of other proposals include mobility rights to drive in specific tolled areas and to ride public transport (Viegas, 2001), tradable fuel credits (Raux and Marlot, 2005; Crals et al., 2003) and, inspired by airport slot-allocation approaches, tradable road access rights (Buitelaar et al., 2007). For an elaborate review on various TC proposals in the transport domain, we refer to Grant-Muller and Xu (2014) and Fan and Jiang (2013). At the same time, a parallel series of studies on the potential of so-called personal carbon trading schemes, targeting not only personal transport but all carbon emitting sources used by households, has emerged in the environmental literature (e.g., Starkey, 2012; Fawcett, 2010; Capstick and Lewis, 2010). The overall conclusions of these proposals are that TC schemes are theoretically efficient and could feasibly replace current road pricing and rationing initiatives, that widely encounter low acceptability rates (Jaensirisak et al., 2005; Schade and Schlag, 2003) and often lead to substantial undesirable side effects (Hao et al., 2011; Davis, 2008).

As a combination of control and pricing measures, TC schemes introduce flexibility and freedom of choice for drivers with respect to credit use within the limits of the cap on aggregate car travel. It is argued that the allocation of free credits to participants and the circulation of money among participants make TC schemes less likely to be perceived as a tax (Wadud, 2011). The opportunity to realise gains under the measure, as a positive incentive, could further enhance its acceptability and could function as an additional motivation for drivers to reduce their resource consumption. Moreover, the progressive nature of TC schemes – they will benefit groups with lower energy consumption/car use levels, which are usually lower-income groups – and the possibility for regulators to