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Activity-travel adaptations in response to a tradable driving credits scheme

Nico Dogterom*, Dick Ettema, Martin Dijst

Utrecht University, Faculty of Geosciences, P.O. Box 80.115, 3508 TC, Utrecht, the Netherlands

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ABSTRACT

Although interest in the concept of tradable driving credits (TDC) has increased in recent years, empirical research into the potential effects of such a measure is scarce. The study reported in this paper employed an activity-based approach to investigate drivers' responses to two distance-based TDC scenarios. Three hundred and eight Dutch frequent car commuters participated in an online stated adaptation experiment in which they recorded their car use for 7 days and, in response to the TDC scenarios, had the opportunity to reorganise their car use pattern, if desired. This paper investigates adaptation behaviours at the trip level. The results show that approximately 30% of trips made for maintenance and leisure-oriented activities were subject to change. In cases of change, a travel mode change was the most preferred adaptation strategy. A mixed logit modelling framework is used to test the effect of a variety of activity/trip attributes, TDC scenario attributes, and individual characteristics on the preference for adaptation alternatives.

1. Introduction

In the ongoing search for instruments that aim to mitigate the steady growth of car use and associated problems of congestion and emissions in urban areas worldwide, tradable credit schemes have recently received increasing attention. Although the concept of tradable credits (TC) has been developed and applied in the environmental field for decades (Dales, 1968; Baumol and Oates, 1988), the exploration of the potential of 'cap-and-trade' measures in the context of personal transport is relatively new (Verhoef et al., 1997a; Viegas, 2001; Raux and Marlot, 2005; Buitelaar et al., 2007; Yang and Wang, 2011). This interest is part of a broader interest in new travel demand management (TDM) strategies that, as alternatives to the traditional approach of charging for all road use, which has proven highly controversial, propose to manage traffic flows through incentive-based and revenue-neutral approaches, such as the Dutch 'peak avoidance' experiment (Knockaert et al., 2012; Ben-Elia and Ettema, 2011) and the FAIR lanes in the US (Fan et al., 2016; DeCorla-Souza, 2005).

In a typical car use-tailored TC scheme, a regulatory body sets a cap on aggregate car use in a defined area and time period (e.g., defined as a total distance or emissions target). Credits representing an individual portion of the rationed quantity (e.g., kilometres, fuel consumption) are distributed to eligible car drivers, who can use these credits, purchase additional credits or sell excess credits in a market. Through this market mechanism, TC schemes can deliver certain goals at minimised social costs, in contrast with traditional 'command-and-control' measures (Verhoef et al., 1997a). Furthermore, the introduction of a freely allocated credit budget and the incorporation of a reward element are important favourable features for motivating behavioural change and public acceptability compared with conventional pricing mechanisms (Viegas, 2001; Kockelman and Kalmanje, 2004; Capstick and Lewis, 2010; Wadud, 2011).

Although several studies have conceptually explored the concept of tradable driving credits (TDC) with regard to design and function (for reviews, see Fan and Jiang, 2013; Grant-Muller and Xu, 2014), empirical research on driver responses is limited. Empirically grounded research is critical to come to understand the potential effects of TDC. As they are largely explorative in nature, current empirical studies only addressed the willingness to change car use under a TDC policy or approached behavioural adaptations under TDC in a generalised manner that did not consider car drivers' actual activity/trip patterns (for an overview, see Dogterom et al., 2017). As such, these studies have not addressed how daily activity/trip scheduling would be affected by such a measure. This is in contrast with the broad consensus among transport researchers that travel and its adaptations in response to TDM measures should be understood in the context of people's actual needs and desires to participate in different activities, the temporal and spatial characteristics of these activities and the complex interdependencies between them (Arentze et al., 2004; Ettema and Timmermans, 1997; Axhausen and Gärling, 1992). An exemption is the work of Harwatt et al. (2011), that used participants' reported one-week car travel as the starting point for analysis of the impact of a TDC

* Corresponding author.
E-mail addresses: nicodogterom@gmail.com (N. Dogterom), D.F.Ettema@uu.nl (D. Ettema), M.J.Dijst@uu.nl (M. Dijst).

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scheme. However, this study remained largely descriptive in nature due to the small sample size.

The space-time fixity/flexibility of activities and travel have traditionally been central to a transport geographic approach of travel behaviour; these characteristics and other activity attributes such as the activity type and importance have been used to investigate patterns of activity/travel scheduling and modification (Hägerstrand, 1970; Cullen and Godson, 1975; Jones, 1979; Miller, 2005; Doherty, 2006; Schwanen et al., 2008). The attributes of people's activities, car travel and available alternative travel options determine the framework within which people make their actual adaptation choices based on trade-offs between the costs of car driving under the TDC, the costs of not performing the activity and the costs of organising their travel differently in terms of money, time and effort (Loukopoulos et al., 2006; Gärling et al., 2002). Based on these notions, we designed a stated adaptation experiment to analyse the impact of distance-based TDC scenarios on car drivers' behaviour and identify the role of activity/trip attributes on decisions concerning the types of trips to change and alternatives to choose under the scenarios in cases of change. As such, this paper extends a preceding paper (Author et al., under review a), in which change in car use was analysed on a more aggregate level, focusing on the willingness to change and the size of change. In the current paper, activity/trip attributes such as activity type, geographical context, importance, frequency, spatial and temporal flexibility, and the perceived ability to travel with other modes were used to examine car use adaptation behaviour at the trip level.

In the next section, we discuss our research design and data collection in more detail. Section 3 presents a descriptive analysis of behavioural change under the TDC scenarios. Section 4 describes the modelling approach and presents the estimation results. A mixed logit choice model is applied to model adaptation choice as a function of participant, scenario and activity/trip characteristics. Section 5 presents a conclusion and discussion.

2. Experiment and data collection

Detailed information about the design of the experiment, data collection procedure and participant recruitment can be found in Dogterom et al. (2018). This section summarises the essential details for the analyses presented in this paper.

In the first part of the experiment, participants were asked to fill out a car travel diary for a full week. Each car trip a participant made as a driver to arrive at an activity-location was defined as an individual trip, so trip chains were recorded in the format of separate trips. For each trip, participants entered a start and destination location that could be selected in a Google Maps interface and provided information about the type of activity carried out at the destination, the importance of the activity and the flexibility of the activity and trip (see Table 1 for the variables).

Based on the collected travel diaries, fixed individual budgets of 280 and 230 free credits (one credit representing 1 km) were defined for two scenarios that were presented consecutively. The sum of the credits available in the budgets for all participants corresponded to a 17.5% and 32.2% reduction of the total distance driven by the sample. The budgets, which were set directly after collection of the travel diary, were originally defined to represent 15% and 30% reductions, respectively, in total kilometres; the discrepancy was caused by participants with inconsistent data in the original or adapted travel diaries that was removed during post-data collection scrutiny. Setting equal credit budget sizes for all participants meant that some participants received more credits than needed and thus would already earn money in a situation without behavioural change: 45.4% and 35.1% of the participants faced a gain in scenario 1 and 2, respectively. Each participant was randomly assigned a fixed price level of 0.10, 0.15 or 0.20 Euros per credit, which had to be paid when buying additional credits or could be earned by selling credits.

Table 1
Summary of trip characteristics for different activity categories.

Trip characteristics	Description	Work & Education	Daily shopping	Non-daily shopping & Personal services	Sports, hobby & recreation	Social & Cultural	Pick up/Drop off	Other
Number of activities		1306	262	234	222	362	220	132
Presence passenger	% of trips made with passenger(s)	6.8	29.5	39.7	49.1	59.7	63.3	49.2
Part of trip chain	% of trips that are part of larger trip chain (i.e. combination of trips)	21.3	39.3	37.2	28.8	34.3	65.9	44.7
Distance	Mean distance in kilometers[1] (s. d. in parentheses)	27.6 (24.0)	3.2 (3.5)	10.3 (13.8)	16.0 (28.9)	30.6 (39.2)	9.1 (14.4)	14.1 (21.6)
Importance	How important is this trip to you (i.e. the need to make this trip)?[2] (mean)	4.75	3.98	3.79	4.16	4.17	4.45	4.48
Temporal flexibility	How easily could you perform this activity at another time?[3] (mean)	1.88	3.71	3.24	2.49	2.84	1.72	2.25
Spatial flexibility	How easy is it for you to perform this activity at another location?[3] (mean)	1.37	3.23	2.25	1.89	1.48	1.14	1.38
Bike alternative	How easy is it for you to replace the car by slow mode (bike, etc.) for this trip?[3] (mean)	1.87	2.62	2.30	2.73	2.11	2.09	2.19
PT alternative	How easy is it for you to replace the car by public transport for this trip?[3] (mean)	2.09	1.54	1.83	1.63	1.96	1.60	1.64
Carpool alternative	How easy is it for you to travel with somebody else by car for this trip?[3] (mean)	1.59	1.50	1.55	1.74	1.55	1.31	1.53
Frequency reduction capacity	How easy is it for you to reduce the frequency of this activity?[3] (mean)	1.42	2.79	2.64	2.39	2.48	1.73	1.92