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Pay as You Speed, ISA with incentives for not speeding: Results and interpretation of speed data

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ABSTRACT

To simulate a market introduction of Intelligent Speed Adaptation (ISA) and to study the effect of a Pay as You Speed (PAYS) concept, a field trial with 153 drivers was conducted during 2007–2009. The participants drove under PAYS conditions for a shorter or a longer period. The PAYS concept consisted of informative ISA linked with economic incentive for not speeding, measured through automatic count of penalty points whenever the speed limit was exceeded. The full incentive was set to 30% of a participant's insurance premium. The participants were exposed to different treatments, with and without incentive crossed with informative ISA present or absent. The results showed that ISA is an efficient tool for reducing speeding particularly on rural roads. The analysis of speed data demonstrated that the proportion of distance driven above the speed where the ISA equipment responded (PDA) was a sensitive measure for reflecting the effect of ISA, whereas mean free flow speed and the 85th percentile speed, were less sensitive to ISA effects. The PDA increased a little over time but still remained at a low level; however, when ISA was turned off, the participants' speeding relapsed to the baseline level. Both informative ISA and incentive ISA reduced the PDA, but there was no statistically significant interaction. Informative reduced it more than the incentive.

1. Introduction

1.1. Incentive ISA

Over the past two decades, several studies have reported positive effects on drivers' speed by installing Intelligent Speed Adaptation (ISA) equipment (see Carsten et al., 2008; Vlassenroot et al., 2007; Regan et al., 2006; Warner, 2006; Várhelyi et al., 2004; Biding and Lind, 2002 for ISA studies). The previous studies have provided proof of concept and contributed to development and refinement of the technologies that have pushed ISA forward from being a bright, though brittle, idea to being a mature safety technology close to market introduction. A few studies have tested various forms of recording ISA. Peltola et al. (2004) tested recording ISA on taxi drivers, using log data to give personal feedback to drivers about their speeding. In Belonitor (2009) participants could earn points by complying with speed limits and subsequently exchange the reward points for rewards. The rewards were indoor or outdoor experiences: active, cultural, sporting or simply relaxing. Participants also competed with each other every month to win the First Prize: a reward of 500 Euros. Hultkrantz and Lindberg (2009) gave participants a fixed monthly bonus which was subsequently reduced in proportion to the participants' speeding.

1.2. Pay as You Speed (PAYS), the General Idea

The study reported in this article, the Danish "Pay as You Speed" (PAYS) project, was based on the positive experience of previous ISA studies including the Danish INFATI project, which was a predecessor of PAYS (Lahrmann et al., 2001). However, the PAYS project was different from previous studies in its scope in that it was planned as a large-scale simulation of a market introduction of ISA equipment for private cars. With this perspective it was an obvious idea to combine the more attractive but less efficient (Päätalo et al., 2001; Dahlstedt, 2002) informative or advisory ISA equipment (Carsten and Tate, 2005) with a conditional discount on car insurance premiums. The cooperating partner, the insurance company "Topdanmark", set a 30%discount rate for participants in the PAYS project. The project name: "Pay as You Speed" refers to the close linkage of three factors: ISA equipment, driver behaviour and incentive for not speeding. From a market introduction perspective, young drivers were an obvious target group. Due to their high accident rate, young drivers pay high car insurance premiums and would therefore gain more than other drivers from having

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ISA installed in their private cars on PAYS conditions – provided of course that they would actually refrain from speeding. We hypothesized that if young drivers achieved good speed behaviour by driving with ISA then they would retain good speed behaviour even with no ISA in their car.

2. Method

2.1. Concepts and measures of driving speed in ISA studies

Despite the fact that the very purpose of ISA equipment is to prevent car drivers from exceeding the speed limit, most ISA studies have reported another measure: reduction in mean speed and standard deviation as effects of driving with ISA (see Warner, 2006 for a review). More relevant measures have been introduced, including the number of speed violations (De Ward and Brookhuis, 1997; Berg et al., 2008) or the time or distance driven at a speed above the speed limit (Regan et al., 2006; Warner and Åberg, 2007; Vlassenroot et al., 2007; Carsten et al., 2008), however, there is yet no common standard measure for describing the effect of ISA equipment on driving speed. Obviously, conventional speed measures, known from traffic engineering and traffic safety research (Nilsson, 2004; Elvik, 2005), are not convenient for assessing the effect of ISA equipment on speed. In the next few paragraphs we discuss the insufficiency of conventional speed measures in assessing effects of ISA and we propose more convenient standard measures for describing the effect of ISA on speed and speeding, in detail and with accuracy.

2.1.1. Different terms to describe speed observations

In previous studies, the effect of ISA has been described by observing changes in the participants' speed at different locations of the road such as locations with different speed limits (Várhelyi et al., 2004). The method copies the normal cross-sectional speed measurement method traditionally used in traffic engineering to describe traffic safety and congestion on roads; this kind of measurement is often referred to as point speed. Most frequently, point speed is simply described by its mean value and standard deviation. The 85th percentile of the point speed observations and the percentage of speeds above the speed limit or of the speed limit +10 km/h are also conventional descriptions of levels of speed in a cross section of a road (Lahrmann and Leleur, 1995). This tradition is due to the lack of methods other than cross-section measurement to measure speed. With log data from GPS receivers, however, this situation has changed. GPS receivers now enable us to log the position, the speed and the course every second and to get a detailed track of the movement of the individual car and thereby obtain an excellent dataset to describe the effect of ISA. But how can these observations be used to describe the effect? Some studies have based their calculations of the effect on the changes in these time-based observations (Hultkrantz and Lindberg, 2009; Regan et al., 2006; Biding and Lind, 2002). The effect is thus calculated in proportion to the time the car stayed on the road network. In describing traffic safety, time is not normally used as a unit—the normal unit is a length unit (Lahrmann and Leleur, 1995), but because our observations are time based we must use a method where we let the time-based observations count in proportion to the distance travelled between two observations. Mean speed of traffic across a road section with n speed observations should be calculated as follows:

$$\bar{v} = \frac{\sum_{i=1}^{n} v_i * l_i}{\sum_{i=1}^{n} l_i} \quad (1)$$

where v_i is speed and l_i is the distance travelled with the speed v_i.

Our "mean" is a weighted mean where each speed measurement v_i is weighted by the corresponding distance l_i.

This method was also used in other ISA projects (Hattem and Mazureck, 2006; Carsten et al., 2008; Berg et al., 2008).

The next question is whether all speed observations are relevant to the assessment of possible ISA effects. It may be argued that only speed observations where the driver's speed choice is not limited by a car ahead, a curve or a signalized intersection should be included in the assessment and thus in the calculation of the above-mentioned average speed and 85th percentile. But as the log files do not contain that kind of observation, we propose the next best solution which is to exclude speed data from the analysis in cases where speed choice can reasonably be assumed not to be a free choice. In the PAYS project we chose to exclude all speed observations considerably below the speed limit with regard to the dependence between speed and speed limit (see Table 1). The values in Table 1 are estimates based on our educated estimate about the lowest level of speed that a driver would select unless speed was influenced by external factors. These speeds were used in the PAYS project for calculating free flow speed (FFS). In the following sections we use the term mean free flow speed (MFFS). The MFFS is calculated using (1) and as such the MFFS is not the usual arithmetic mean but a weighted mean. The 85th percentile speed is calculated in the same way and is termed 85 free flow speed (85FFS).

2.1.2. Proportion of distance driven above the speed limit (PDA)

The purpose of ISA equipment is to prevent drivers from speeding rather than to reduce speed in general. An accurate and precise measure of the effect of ISA equipment is therefore the proportion of distance driven at a speed above the ISA activating level as compared to the same measure when driving without ISA. With logged data from a GPS receiver the proportion of distance driven above a specific speed level is easy to calculate. The ISA system used in the PAYS project was programmed to play a voice message warning whenever the speed limit has been exceeded by more than 5 km/h (see Section 2.4). The *proportion of distance above the speed limit + 5 km/h* (PDA) is therefore used to describe the change in speed behaviour caused by ISA; for comparative purposes, though, we reported the effect also as change of mean free flow speed, standard deviation and 85th percentile of free flow speed.

2.2. Journey time

Another important measure of the effect of ISA equipment is the increase in journey time linked to driving with ISA. A possible increase in journey time caused by ISA is only due to a reduction in the distance driven above the speed limit, whereas a number of external factors other than ISA may still prevent a free speed choice, e.g. the time where the speed is limited by a car ahead may increase when ISA is off compared to the situation where ISA is on. The calculation of travel time should therefore include all observations regardless of the speed level observed. In the PAYS project the assessment of a possible increase in journey time was calculated per 100 km across all speed observations.

2.3. Impact on individual level

The impact of PAYS was calculated on an individual level meaning that the effect is calculated individually for each participant. Subsequently, the total effect was calculated by averaging the individual impacts, each individual driver thus counting equally, regardless of differences in their mileages in the study.

2.4. Field trial set-up

The ISA technology used in the PAYS project enabled surveillance of driving speed on the entire road network in Northern Jutland – 22,000 km. The on-board equipment was a dashboard