Charging versus rewarding: A comparison of road-pricing and rewarding peak avoidance in the Netherlands

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Abstract

The aim of this paper is to compare two congestion management schemes – road-pricing and peak avoidance rewarding – and their impact on commuter behaviour, based on two studies that were conducted in the Netherlands. The road-pricing study is based on stated preference data, whereas the study involving rewards was conducted in the context of a longitudinal field experiment. Given the substantial differences in data sources and analytical techniques applied beforehand, the comparison is made at an indicative level. It can be cautiously concluded that, as psychological theory predicts, rewarding is more effective in diverting commuters from peak periods. In both cases, the most popular alternative to peak-driving is off-peak driving. Most of the change in behaviour is attributed to introducing the new measure, whereas the impact of different price/reward levels is marginally decreasing in sensitivity and effectiveness. The short-term and long-term policy implications of these findings on the implementation of both measures are further discussed.

Key words:

Road-pricing, rewards, peak avoidance, commuting, behaviour-change, congestion.

1. Introduction

Traffic intensity is increasing every year and existing roads can often not handle the increase in demand, resulting in traffic congestion (Bovy, 2001; Bovy and Salomon, 1999). This is a trend that can be seen in urbanised areas all over the world (European Commission, 2006a, 2006b). Time losses due to congestion have a negative economic effect. Moreover, congestion has an impact on road safety, emissions and noise (ECMT, 1999; Mayeres et al., 1996). The main problem is that too many drivers are under way at more or less the same time periods (e.g. the morning rush hour). In the past, peak demand was accommodated primarily by building new infrastructure and thus by increasing supply. However, it has also been recognized that building more roads alone causes an increase in demand, resulting in a cyclical process of additional capacity increases (Goodwin, 1996). An alternative approach is to try and modify the behaviour of travellers to a certain extent (i.e. the demand side). Spreading peak demand over a larger time interval could result in considerable time savings and may reduce the uncertainty and external costs of congestion. However, convincing travellers to change their daily schedules is far from easy. Experimental studies suggest, for instance, that providing more accurate pre-trip information results in changes in departure time (e.g. Mahmassani and Liu, 1999; Srinivasan and Mahamassani, 2003). However, incomplete information can also result in an increase in overall travel time and user costs, when too many people change their behaviour at the same time (Arnott et al., 1999; Ettema and Timmermans, 2006; Ben-Akiva et al., 1991).

Demand-based solutions, such as road-pricing, have also been suggested (Shiftan and Golani, 2005). Pricing policies have been considered and even implemented in different urban areas around the world, one of the main objectives being to reduce congestion (costs/effects) (see e.g. Ministry of Transport, Public Works and Water Management, 2006; European Commission, 2001; Tfl, 2003; Phang and Toh, 1997). Examples of attempts to implement road pricing include: the electronic road-pricing scheme in

Singapore, the congestion charge in London, the introduction of the German *Maut* system for lorries and the congestion charge in Stockholm (see also Ubbels and De Jong, 2009). Today, the introduction of some kind of road-pricing scheme is considered in many European countries, either on an urban scale or at a national level. In 2007, the Dutch government decided to implement a nationwide kilometre charge, starting with a charge for lorries in 2012, followed by a differentiated (i.e. by time, place or environmental costs) kilometre charging system for cars and trucks in 2018. Because the system was meant to be budget neutral, indicating that the road pricing system was not meant to generate additional revenues, the plan was to gradually phase out fixed car taxes. Moreover, by means of a differentiation of the road pricing measure, for instance with respect to time (i.e. higher peak charge), the government hoped to spread peak demand more evenly and thus reduce traffic congestion problems. Model computations indicated that such system would have an influence on traffic congestion. The reduction in the number of kilometres driven would amount to 15% and vehicle loss hours would decrease by approximately 40% (Van Mourik et al., 2005). However, in 2010, a new government was installed, which mothballed the initiative for a nationwide kilometre-charge because of a combination of high implementation costs, relatively low public acceptance and an apparent naive belief in their ability to solve the problems just by building new roads.

In the context of commuters' behaviour which has been to the most part analyzed using microeconomic theories (McFadden, 2007), it is not surprising that the behavioural rationale of many demand based strategies to manage traffic congestion is based on negative incentives that associate driving with punishments such as fines, tolls or increased parking costs (Rothengatter, 1992; Schuitema, 2003). Conversely, people may respond differently when they are rewarded rather than punished (Kahneman and Tversky, 1984; Geller, 1989)[1]. Both rewards and punishments constitute types of incentives that influence human motivation. Maximizing pleasure and minimizing pain is a very basic rule in human and animal behaviour. Although there is no agreement in the behavioural literature which measure is more effective in motivating change of behaviour, psychologists tend to prefer positive rewarding measures over negative punishment ones. A considerable volume of empirical psychological evidence (e.g. Kreps, 1997; Berridge, 2001) supports the effectiveness of rewards to reinforce desirable behaviour. Thus, the potential of rewards as a base for congestion management policy is well worth considering, provided it is based on robust behavioural foundations. In the Netherlands, the notion of using rewards to change people's driving behaviour has been recently implemented in the context of the "Spitsmijden" (translated freely as peak avoidance) programme (Ettema and Verhoef, 2006; Ettema et al., 2010; Ben-Elia and Ettema, 2011a), thus far the largest systematic effort to analyse the potential of rewards as a policy instrument in this regard.

In this paper, we compare road-pricing and reward systems with respect to their impact on commuter behaviour, on the basis of two different and independent empirical data sets. As far as road-pricing is concerned, we use a stated preference study (SP) among car commuters that was carried out in 2004 (Tillema, 2007). With respect to rewards, we use the data collected in 2006 from a revealed preference pilot experiment called Spitsmijden, which investigated the potential impact of rewards on people's behaviour during the morning rush hour (Ben-Elia and Ettema, 2011b). More specifically, we focus on the effectiveness of these two measures during peak periods, look at the influence of the pricing measures on the alternatives that are chosen, and examine to what extent changes are influenced by the price/reward level, with the aim of providing an initial insight into the impact of 'punishing' and 'rewarding' systems on commuter behaviour and to help improve the applicability of congestion management schemes, both in the Netherlands and abroad.

2. Literature review

Pricing policy is a popular research topic, especially in the field of economics. This is mainly due to the typical economic aspects, found in pricing theory, such as the pricing of a scarcity (in this case infrastructure). Since nearly all forms of transport are associated with externalities like congestion and emissions, there has been a great deal of interest in various ways of pricing and internalising these externalities. Among economists, a widely accepted benchmark solution in the regulation of road transport externalities is first-best pricing (i.e. Pigouvian marginal external cost pricing; Pigou, 1920). As outlined in the 1920's (Knight, 1924; Pigou, 1920), a toll that reflects the true marginal cost of travel is implemented on the congested facilities, resulting in a reduction in the number of travellers at peak periods, which improves traffic flows (Nijkamp and Shefer, 1998; Rouwendal and Verhoef, 2006; Small and Verhoef, 2007). From an economic point of view, first-best pricing can be seen as the most efficient/optimal type of pricing policy, whereby all road users at all times pay exactly what they 'cost' society as a whole. Examples of such external costs are emission costs and congestion costs. With first-best pricing, it is assumed that: (1) optimal charging mechanisms are available, allowing regulators to set perfectly differentiated taxes for all road users and on all links of the network; (2) that first-best conditions prevail throughout the economic environment to which the transport system under consideration belongs; and (3) that all road users as well as the regulator have perfect information on traffic conditions and tolls at their disposal (see also Verhoef, 1996; Ubbels, 2002). Apart from the fact that these assumptions create almost unsolvable difficulties in terms of technical implementation[2], they also generate considerable resistance on the part of the actors involved. It is commonly acknowledged that the above-mentioned assumptions will hardly, if ever, be met in a real-life situation given the cognitive limitations, judgmental biases and bounded rationality that pertain to the common traveller (Simon, 1982; Tversky and Kahneman, 1974). That is why second-best pricing issues, based on less utopian assumptions, have received ample attention in literature (Verhoef, 2000; Ubbels, 2006).

Second-best schemes have been suggested to circumvent the difficulties in implementing first-best solutions (Small and Verhoef, 2007). Policy-makers have different policy levers when it comes to constructing second-best transport pricing measures. Pricing measures can vary on the basis of the price level, the level of differentiation, the coverage of the measure, the revenue use and other supplementary policies (Verhoef et al., 2008). Differentiation of the measure can, for example, be based on time, place and/or type of vehicle. With respect to coverage, Verhoef et al. (2004) distinguish the following levels (with regard to implementation): single lanes, single roads and different geographical levels (local, regional, national or international). Furthermore, different categories for revenue use can be distinguished. Revenues can, for example, be used to lower certain taxes, to fund new (or maintain old) infrastructure, to manage/control road infrastructure or to finance particular (traffic) policies (ibid). Due to the different design options, numerous pricing alternatives can be designed in theory.

There is a considerable amount of empirical evidence regarding the effectiveness of implemented road pricing and toll schemes around the world (see, e.g., Verhoef et al., 2008; Tillema, 2007; Ubbels, 2002; TfL, 2003; May et al., 2010). Ubbels and De Jong (2009) examine the effectiveness of road pricing by reviewing studies involving fourteen road pricing cases worldwide. They define road pricing as "…policy regimes where drivers have to pay for their actual use of the roads" (Ubbels and De Jong, 2009, p.1). Moreover, they focus on congestion pricing, excluding the well-known toll roads that exist, for instance, in France and Italy. They conclude that road pricing projects, where there are alternative routes and where the charges are likely to vary considerably throughout the day, will probably cause substantial changes in people's choice of route and departure time. Other effects (for instance, mode of transportation, car occupancy, trip frequency, car ownership) may also occur, but they are likely to be of minor importance in the short run. Although the different schemes worldwide seem to be rather effective in changing car driver's behaviour, their specific effects vary substantially, due to the concrete specification/characteristics of the measure. Moreover, there are no cases in the world where a complex nationwide kilometre charge for all car drivers, comparable to the one that was planned in the Netherlands, has been implemented.

Despite its appeal to policy-makers, road pricing is controversial and its exact behavioural implications are still not well understood. As suggested initially by Vickrey (1969), optimal pricing requires the design of variable tolls, making them quite difficult for drivers to understand (Bonsall et al., 2007; Verhoef, 2008). In addition, road pricing raises questions regarding social equity (Giuliano, 1994) as well as economic efficiency (Banister, 1994; Viegas, 2001). Harms and Van der Werff (2009) provide several possible explanations for the negative perception of road pricing schemes. First of all, people may feel that paying for congestion is irrational and inappropriate, because they may prefer to pay for things they wish to acquire rather than for things they wish to avoid (i.e., traffic congestion). Also, many drivers see themselves as victims of congestion rather than as fellow culprits. Furthermore, many people believe that pricing is ineffective in reducing congestion because pricing will not discourage them from using the car, especially when employers subsidize tolls and/or there are no viable alternatives. And, finally, many people believe that the average consumer is disadvantaged. Furthermore, Eriksson et al. (2006), suggest that people's subjective perception of fairness lies at the heart of the perceived (un)acceptability of road pricing schemes.

If we focus on traffic congestion rather than on changing the entire car taxing system, an incentive/reward for avoiding peak hour travel could achieve a behavioural response similar to that of pricing (Ettema and Verhoef, 2006; Ettema et al., 2010; Ben-Elia and Ettema, 2011a). The basic idea is to reward travellers who are willing to shift to earlier or later departure times or to alternative modes of travel or activities (i.e. teleworking). Thus, overall penalization of drivers through tolling is avoided and overall welfare is improved by reducing peak demand. Research in behavioural psychology shows the benefits of rewarding over punishments (Kahneman & Tversky, 1984; Geller, 1989). As positive reinforcement devices, rewards have been applied extensively to strengthen motivation in various settings (such as work environments) and for various purposes (educational achievements, medical effectiveness, environmental protection, etc.). However, within the context of travel behaviour, the concept of rewards has thus far played a minor role. Punishment and enforcement (such as policing, felony detectors, fines etc.) have been documented more widely than rewards (e.g. Rothengatter, 1992; Schuitema, 2003, 2010). Given the fact that payment is more prevalent throughout society than rewards and given the fact that travel behaviour has been for the most part subjected to and influenced by microeconomic theories (McFadden, 2007), it is not surprising that the behavioural rationale of many demand-based strategies aimed at managing traffic congestion is based on negative incentives that associate the act of driving with punishment (in the form of tolls or increased parking costs).

In contrast to road pricing, there is little empirical international evidence concerning the influence of peak rewarding systems on individual travel decisions. Rewards have been applied in a travel context mostly in short term studies involving the provision of temporary incentives such as free public transport tickets (Fujii et al., 2001; Fujii and Kitamura, 2003; Bamberg et al., 2002; Bamberg et al., 2003; Currie, 2010). For the most part, the results of these studies are inconclusive as behaviour returned more or less to what had been before the incentives were given. In other cases which are not really considered as reward – discounts were provided for tolls (Burris and Pendyala, 2002; Senbil and Kitamura, 2008) or the cost of congestion charges is reimbursed such as the Washington State's Pudget Sound experiment (Bae and Bassok, 2008) or the AKTA experiment in Copenhagen (Nielsen and Sørensen, 2008).

3. Data and methodology

3.1 Data

We use two different independent empirical data sets. Because road pricing has not been implemented in the Netherlands, no relevant databases are as yet available. Fuel price data may exist, but does not take account of time differentiation, which is often an important component in the discussion about rewarding and road pricing. As far as we know, also no relevant databases are available for other countries, at least with regard to universal pricing measures like kilometre charges (see also Ubbels, 2006). This is why a stated preference survey approach was selected to study the impact of road pricing on people's driving behaviour. With regard to rewards we use data collected from 'Spitsmijden' (translated freely as peak avoidance) - a pilot experiment aimed at investigating the potential effects of rewards on commuter behaviour during morning rush hour. For comparative reasons, and because of ease of access, we decided only to use data pertaining to the Netherlands.

Road pricing

A survey among 562 Dutch respondents was conducted to gain insight into short-term (i.e. trip related) and longer-term (i.e. work and residential location) behavioural changes as a result of road pricing and to observe people's attitudes towards different types of road pricing measures. 288 respondents were car commuters who drive to work by car twice a week or more and face a delay of 10 minutes or more during each trip at least twice a week. The other 274 respondents were people selected only on the basis of owning a car. Car commuters were selected because they are the kind of drivers who face congestion problems regularly, which means they are directly affected by pricing measures aimed at reducing congestion. The other respondents were added to broaden the scope of the sample and to study the behavioural effects of groups other than regular car commuters (in peak periods). The data were collected in 2005 by TNS NIPO, a Dutch company specialized in collecting (and analyzing) data. They have a (national) panel of around 60,000 respondents at their disposal. A periodical screening questionnaire was used to select people with the right characteristics for our computer aided personal interview (CAPI). Targets were set for all the surveys with respect to the number of respondents required. The respondents were not selected based on where they live within the Netherlands. However, because a majority of them are regular 'congestion drivers', and the most severe traffic problems occur in the south-western part of the Netherlands, around 70% of the respondents live in that region. No attempt was made to 'oversample' respondents from other regions.

Since the policy involves introducing a nationwide kilometre charge in the Netherlands, with a differentiation of the charge based on time of day and possibly location, as well as on the environmental characteristics of cars, three different kilometre charging alternatives were selected and presented to the respondents (see Table 1). The charge levels (on average) are in line with the original Dutch plans[3] and, although they may appear low, the costs for the average car driver in the Netherlands (estimated at 17,000 vehicle kilometres-travelled per year) may add up substantially on an annual basis. Respondents indicated intended changes in their short-term trip patterns for three purposes: commuting, social purposes (visits) and 'other'. A hierarchical survey approach was applied. After the presentation of the three price measures, the respondents were asked first of all whether or not they intended to make any changes to their commuting behaviour: change nothing, increase the number of trips or reduce them. Respondents indicating they would change nothing were asked no further questions regarding their short-term commuting behaviour. If respondents replied they would increase the number of trips, they were asked to indicate how many more commuting trips they would make on a weekly basis. Making more trips due to road pricing may strongly relate to the value of time. Due to behavioural changes, time gains may occur in the peak period, which may induce some people, who have a high valuation for travel time gains, to drive more often during the peak. This effect is expected to be small. Respondents indicating they would reduce the number of car trips were asked how many of their current car trips they were prepared to adjust in a four week period[4]. Subsequently, they had to divide these trips among several alternatives: public transport, slow traffic (i.e. walk or cycle), other motorized mode of transportation (owned by the respondent), carpool, travelling at other times, teleworking or not making a trip at all. Respondents could not allocate more trips than they intended to reduce. Moreover, the option 'travel at other times' could only be selected in cases where a time-differentiated charge was included. In the case of the other two trip purposes (social and other), the same procedure was followed. The only difference relates to the first question. Respondents could not choose to undertake more trips with respect to visiting or other trips. The reason for this is merely that it was regarded as rather unlikely and illogical that people would undertake more of these trips due to road pricing; time gains specifically occur in the peak periods, where commuting is the dominant trip motive.

Rewarding

The Dutch “Spitsmijden” experiment is, thus far, the largest systematic effort to analyse the potential of rewards as a policy instrument aimed at changing people's travel behaviour. The experiment was conducted by a public-private partnership consisting of three universities, private firms and public institutions. Its purpose was to collect a large sample of empirical or revealed preference (RP) data regarding the effects of a reward on daily commuting behaviour during the morning rush-hour. The pilot study was launched in October 2006 and its research object was the heavily congested Dutch A12 motorway stretch from Zoetermeer westbound towards The Hague. During a period of 13 consecutive weeks, 341 recruited volunteers (221 men and 120 women) living in the town of Zoetermeer, a satellite city of The Hague, and who were prior observed to commute by car at least 3 times per week, participated in a scheme whereby they would receive daily rewards, either monetary (between € 3 and € 7) or in the form of credits allowing them to earn a Smartphone. These figures were estimated based on an initial stated preference exercise. 232 participants chose the monetary reward, while 109 chose the Smartphone. Participants could avoid peak-hour travel, here defined between 7:30-9:30 AM and earn a reward, either by driving at off-peak times (before or after the peak), switching to another mode of transportation (cycling, public transport or carpooling) or by working from home. Since only the monetary reward is comparable to the road pricing study, we refrain from further discussion of the Smartphone variant. Interested readers can find more information in Ettema et al. (2010) and Ben-Elia and Ettema (2011a). Most of the participants have good education levels (university degree), are either cohabiting or with children. Incomes are also above the national average (see also Table 2).

Data was collected during the “Spitsmijden” experiment in three stages. The first and third stages consisted of surveys. The second stage consisted of the actual experiment. In the first stage, participants completed a web-based *preliminary survey*, which was aimed at gathering information regarding their stated-behaviour: home to work locations, travel routines and usual daily commutes. In addition, information was collected about their personal characteristics, household composition and factors that could influence their response to the rewards, such as flexible work schedules, family obligations, the availability of alternative modes of transportation, their attitudes towards alternative modes of transportation, etc (and see Ben-Elia and Ettema, 2011a, for a full description of the survey results).

The second stage, the actual experiment, lasted 13 weeks (weeks 3-12 involved the rewards). It consisted of tracking the participants' revealed (i.e. observed) behaviour. Detection equipment was used including in-vehicle transponders and electronic vehicle identification (EVI) as well as backup road-side cameras at the exits from Zoetermeer to the A12 motorway and on other routes leaving the city. This equipment made it possible to detect all cars during the course of the day, minimizing the ability of participants to cheat by trying to access alternative routes. In addition, the participants were instructed to fill in a daily web-based logbook, recording whether or not they had commuted to and from work (and if not, why not), which mode of transportation they had used and at what time they had made their trip. This information was used to provide insight into situations in which participants were not detected by the EVI. It was necessary in these cases to know whether they had used some other form of transportation (public transport or bicycle) or whether they had not commuted due to vacation, illness, etc. The first two weeks were without the rewards (pre-test). The data collected during the pre-test was used to establish the *reference travel behaviour*. The final week (post-test) was also without rewards. Participants who opted in favour of a monetary compensation were the subject of three consecutive reward "treatments" lasting 10 weeks in all: a reward of € 3 (lasting three weeks), a reward of € 7 (lasting four weeks) and a mixed reward (lasting three weeks) of up to € 7 - of which € 3 for avoiding the high peak (8:00-9:00) and an additional € 4 for also avoiding the lower peaks (7:30-8:00, 9:00-9:30). The order of the reward "treatments" followed a blocked randomization design that allocated participants to the 6 possible treatment order schemes.

Another important feature of the design was the participants' allocation to reward classes on the basis of their behaviour during the pre-test. For the participants who chose the monetary reward, the reward class defined the maximum number of rewards they could receive each week (1, 2, 4, 5). The underlying rationale was that not all participants drive during the peak-hour five days per week. That is, it was not the intention that participants would significantly increase off peak travel by car just in order to gain the reward, thereby offsetting the potential reduction in peak trips with a greater relative increase in off peak trips. Therefore they could only be rewarded in relation to their initial peak driving weekly frequencies which acted as a ceiling to the number of eligible rewards per week. That is, a participant who travelled in the pre-test only 4 times per week could only be rewarded for not travelling in the peak the first 4 days but not the last one. This would discourage any possible manipulation of the reward scheme for personal gains. Consequently, each participant was allocated to one of four possible classes, and remained there throughout the rest of the experiment. A majority of participants belonged to classes A (5 trips a week) and B (4 trips a week), with the remainder falling into classes C (2 trips a week) and D (1 trip a week), and see the report (in English) by Knockaert et al. (2007) (available from the authors by request)

The third stage of the study was the *evaluation,* in which questions were asked about the participants' subjective experience during the the experiment. On the one hand, this dealt with their retrospective assessment of the adjustments in their behaviour (was it easy / difficult to adjust travel behaviour and how). On the other hand, other questions were asked about their experience with the organization of the trial (provision of information, performance of the project's back office, etc.). Further details can be found in Ben-Elia and Ettema (2011a).

3.2 Comparability considerations

Our main aim is to gain insight into the relative effectiveness of road pricing and rewarding schemes in terms of influencing the behaviour of car drivers. However, the comparative potential of each policy is influenced by several characteristics, some of which can be controlled, while others cannot. We accounted for certain considerations in respect to the differences between the two data sources to increase the salience of the comparability exercise.

First, there is the issue of comparing different data sets originating from different methods of data collection. For the rewarding system, longitudinal revealed preference (RP) data regarding behavioural change was collected, whereas in the road pricing study, stated preference (SP) was applied for data collection. Revealed preference (RP) studies have the advantage that they observe what actors actually do, which means that their actual behaviour is being studied. This may make the outcomes more reliable. However, as noted by Louvière and Timmermans (1990), there is no concrete proof regarding the predictive advantage of RP-based behaviour models compared to those based on SP. RP and SP models of travel behaviour are often compared in transport research on the basis of values of time. Although the coefficients from two sets of data are not directly comparable, the values of time (VOT) i.e. the ratio of time and cost, is comparable since the ratio cancels out scale factors (Wardman, 1988). Van Ommeren and Fosgerau (2009) suggest that RP studies tend to show, at times, higher VOT's than stated preference studies. However, their conclusions are based on the trade-off between wages and commuting time and not on the more commonly applied trade-off between commuting time and commuting costs common in transport studies. In contrast, Wardman (1988), asserts that SP models provide a reasonable account of individuals' actual choices. In our case, however, the reliability of the SP outcomes, here – Tillema's (2007) road pricing study – depends on the extent that the 'hypothetical' situation is perceived as realistic by the respondents. Although road-pricing has not (yet) been implemented in The Netherlands, there has been extensive media attention to this policy measure over the years. This suggests that there is a high likelihood that the majority of respondents had already heard or were informed about road pricing before the empirical research started, implying that they were able to confidently interpret the measures that were presented to them. Moreover, realism was further improved by tailoring the measures (and their financial consequences) to the specific personal situation of each respondent (e.g. on the basis of the annual mileage, current car taxations).

Second, regarding the configuration of the pricing measure - Spitsmijden (i.e. the rewarding scheme) aims at encouraging car users to drive outside of the (morning) peak hour, which means that the measure mainly tries to influence when people drive. By contrast, in the SP road pricing study, different types of charging measures were included (see Table 1), one of which was a time-differentiated kilometre charge (Measure 3). Consequently, we compare only the behavioural changes of the time-differentiated kilometre charge with those of Spitsmijden.

Third, regarding Spitsmijden we use only the data of participants, who could earn the monetary reward. In our opinion, the other type, where participants could obtain a Smartphone, is less suitable for comparison to the road pricing study given that it involves an in-kind reward that has different instrumental and affective qualities compared to money (see Ben-Elia and Ettema, 2011b, for a discussion on the psychological differences between different reward types). Price/reward levels appear to be comparable in both cases. As noted earlier, the reward case included different reward levels per day. The overall average reward over the total period amounts to approximately € 5 per trip. The road pricing case included three different regimes per vehicle-km: 6 cents, 12 cents and 24 cents. Given the average commuting distance in the SP sample of about 34 kilometres, this would imply that the price of an average peak trip would increase by almost € 5, which is in line with the average reward level.

Fifth, although the road- pricing study included also trips for different purposes, we only make use of the data relating to commuting trips in the comparison to Spitsmijden which focused solely on commuting to work. Last, we also checked sample differences with regard to several (socio-economic) characteristics (see Table 2). Generally speaking, the characteristics of the two samples are fairly in line with each other and do not seem to undermine the comparative potential.

3.3 Method

Because of the differences in measuring the behavioural changes in both data sets, we only compared the changes at an indicative aggregate level. We specifically looked at the effectiveness of the two measures in terms of the extent to which they change people's travel behaviour and the alternatives to car driving chosen. We do so by means of descriptive analysis, measuring effectiveness on the basis of changes in people's driving behaviour during peak hours.

The comparison of alternatives people choose is somewhat complicated by the differences in measuring changes in travel behaviour used in the two studies. As indicated above, respondents in the SP (road pricing) experiment had to state how many (peak) car trips, as a consequence of road pricing, they would change in a four week period. Subsequently, they had to divide these trips among other travel alternatives (e.g. public transport, travelling at another time), which means that the change in the alternatives is either zero or positive. Conversely, in the RP (rewarding) experiment, people's actual behaviour was measured before, during and after the introduction of the rewarding regimes. Because people's behaviour changes on a daily basis and not all the participants reported they were travelling to work each day, the aggregated total number of work trips is not constant throughout the experiment. Consequently, the total number of trips in the RP experiment is normalized according to the pre-test total number of trips[5], whereas the distribution of alternatives in each regime category was set relative to the original Spitsmijden data, making the absolute sum of all (positive and negative) changes equal to 100%. Accounting for these modifications, the results are presented as relative change. We subtract the peak-driving alternative and examine the relative change in respect to all other travel alternatives. The latter allowed for a better comparison to the road-pricing figures. Next, we explore how the alternative selection is affected by the height of the charge level/rewards. Finally, we compare the influence of some socio-economic determinants. We note that the comparison of the SP and RP results is made at an aggregate level, i.e. trip changes due to both measures applied to the total sample.

4. Results

4.1 Effectiveness and chosen alternatives

The effectiveness of rewarding or pricing measures is determined by the diversion of car trips (in percentages) away from peak hours. As mentioned in section 3.2, in the case of road pricing, respondents had to divide the car trips among various alternatives, whereas for the reward scheme, changes in actual behaviour before and after the introduction of the reward were measured. The results in terms of relative changes at an aggregate, level are presented in Figure 1, which presents the net-relative changes in trip alternatives (excluding the peak driving alternative) for road pricing and for the peak avoidance reward. The changes in the number of car trips are divided among the various alternatives (the absolute sum of changes equals to 100%).

The results in Figure 1 show that, both for road-pricing and for the reward scheme, the most popular alternative to peak driving is driving at off-peak hours. The shares are higher for the reward scheme (almost 70%) compared to road pricing (almost 50%). This difference may have to do with the variable car costs becoming so high with increasing price levels in the road pricing case that even travelling in the cheaper off-peak period becomes quite expensive in comparison to non-driving alternatives. The pricing measure is constructed in such way that off peak charges also increase (see Table 1). This can never occur in the case of Spitsmijden", where any change in behaviour away from peak hours is rewarded as long as the participant is eligible according to the reward class designation.

Switching to public transport is the second most popular alternative. Here, the shares are roughly the same (i.e. around 20%). The same is true with regard to carpooling (i.e. around 4%). There are some differences with the other alternatives, such as teleworking or cycling, which occur more often in the road pricing case. One explanation is the difference in average commuting distances in the two samples. The respondents in the reward scheme pilot all reside in Zoetermeer[6] and most of them work in The Hague[7], at an approximate distance of 20 km, which is relatively long for cycling. The average commuting distance in the road pricing data set is even higher (34 km). However, around 20% of the respondents face a commuting distance that is less than 10 km, which means that, for them, cycling is a more realistic alternative. As reported by Ben-Elia and Ettema, (2011a), cycling was considered unrealistic by the majority of the participants (in the reward case), mainly due to distance. Also, people who felt that cycling was a viable alternative during the pre-test stage may have had second thoughts later on as they gained more experience. There is in fact evidence suggesting that people used the pre-test stage to explore different alternatives, as indicated by almost a third of the participants in the post-test evaluation survey. The weather should also be taken in account as the pre-test took place in September, while the actual reward experiment was conducted in late autumn, which is usually considerably wetter and windier. Wind speeds were found to be negatively associated with choosing non-driving alternatives (most likely in connection to cycling).

Accounting for all three reward levels, around 37% of all car trips (relative to all car trips inside and outside peak hours) are diverted from the peak period. By comparison, road pricing resulted in a reduction of 15%. In line with what is suggested in the psychological literature, it would appear at first sight that rewards are more effective than charging in changing people's commuting behaviour. However, we need to keep in mind that people participated on a voluntary basis in the reward experiment. It was a self-selected group, which is different from the road pricing sample, in which people volunteered to fill out the questionnaire without the need to actually commit to their chosen behaviour. This is likely to have an effect on peak avoidance figures. In the case of Spitsmijden, for instance, around 40% of the people who were asked to take part in the pilot experiment indicated a willingness to do so. In addition, people who take part in these kinds of experiments are more likely to be motivated to change their behaviour anyway. For example as discussed in Ben-Elia and Ettema (2011a), a large share of the participants stated they have quite flexible working schedules and this factor was also significant in increasing the likelihood of behaviour change. By contrast, participants in the road-pricing survey may be less likely to be in favour of the measure but still respond to it. If we take these effects into account, the differences in the outcomes may well be smaller. Also the earlier described presence of a small km-price in the off peak period in the case of the road pricing measure, may have influenced the relative effectiveness, as higher price levels lead to lower shares of travelling outside of the peak period with the time-differentiated kilometre charge (see also Figure 3). Moreover, the difference in outcomes may also partly be due to the geographical reach of both measures. The reward scheme focuses on one specific highway (The westbound stretch of the A12 connecting Zoetermeer and The Hague), whereas the road pricing measure is more universal. This may also imply that in the case of the reward scheme it is easier to imagine the exact consequences, which may have increased its relative effectiveness. In the case of road pricing visualizing the impacts may be harder, because all roads are priced and because the charge itself is marginal (i.e. per km). Finally, general differences in respondents' appreciations between the stated preference and revealed preference data in the two experiments may well have influenced the results, although we do not have clear indications if and in what direction this could occur.

4.2 The influence of price/reward levels

As described in section 3.1, the influence of price/reward level variations was tested both for road pricing and for the reward scheme. We explored the influence of price/reward levels on the effectiveness (i.e. the change in the number of car trips during peak hours) and on the alternatives people selected.

We first examined the marginal effect of price/reward changes. With regard to the time-differentiated km-charge, the results (see Figure 2) suggest that there is a lack of substantial sensitivity of the respondents with regard to the measure. Although the highest price level results in higher levels of change, there is only a slight, albeit significant, increase (Poisson regression; $\alpha \leq 0.05$) compared to the lowest price level. Also, the increase in peak avoidance with increased pricing levels is not consistent, since the intermediate pricing level has the lowest effect. As far as the reward experiment is concerned (Figure 2), the change in people's commuting behaviour increases as the reward level increases. However, as is the case for road-pricing, the relative effectiveness decreases when the reward is higher (results of repeated measures ANOVA do not show significant statistical contrasts between reward levels, $p>.05$). To a degree, this may be explained by a 'shock' effect of the implementation of road pricing or a reward system.

Psychologists also refer to diminishing sensitivity as a robust effect when people respond to different conditions (Kahneman and Tversky, 1979). Thus, the lowest level has the greatest marginal effect, while, although increasing the price/reward level will continue to affect people's behaviour, the relative size of the effect will decrease (i.e. negative marginal effect).

Next, we examined whether the price/reward level has an impact on the alternatives people selected. With regard to the reward scheme, the height of the reward seems to have little impact on the choice of alternatives (see Figure 3). Ben-Elia and Ettema (2011a), who applied a discrete choice modelling framework, assert that the main effect of the rewards is to reduce peak-driving. However, the choice of alternatives is to a large extent influenced by factors other than the reward levels, including socio-economic factors such as gender and education; constraints and flexibility in scheduling work and home activities; the differences between people's usual behaviour and the change in their behaviour (e.g. usual departure time and the start of their work day), while cognition also plays a role – attitudes regarding the alternatives and perceptions regarding the effort in change of behaviour, and - most interestingly - travel information usage.

The same does not hold true for road pricing (see Figure 3), where the results suggest that, although travelling by car outside peak hours remains the dominant alternative, the frequency declines with price level, whereas other alternatives, especially public transport and taking the bike, become more attractive. A likely explanation of this outcome is that, as described earlier, with increasing price levels, the variable car costs become so high that even travelling in the cheaper off-peak period becomes too expensive in comparison to other alternatives. In contrast, the reward is awarded per day and the traveller's characteristics are more influential in influencing how to gain the reward but not the level itself.

4.3 The influence of other factors

Unfortunately, the inherent differences between the two databases precludes us from comparing the influences of many interesting factors already mentioned in respect to Spitsmijden, such as the impact of travel information, and people's usual behaviour and attitudes. We can only make some comparisons to the effects of certain socio-economic factors and working flexibility, which were found to be important in both studies: gender, education level and the possibility to work from home.

In both studies, it is apparent that men are more likely (or have the intention) to change their behaviour as a consequence of road pricing or peak rewarding in comparison to women. One idea that has been suggested in social studies in relation to people's daily routines is time poverty (Palma et al., 2009), which suggests that women are more constrained when it comes to the time at their disposal compared to men, mainly for domestic reasons. Dutch mothers often leave work early in the afternoon to pick up children from nurseries (Schwanen, 2007). This limits their ability to change their schedule (e.g. to start work later). Their existing time tables may already be designed to maximise their time efficiency, which may mean that women have a lower incentive to change their existing commuting behaviour. With regard to education, the effects turned out to be somewhat contradictory. Respondents with higher education levels (university degree or equivalent) are more inclined to change their behaviour as a consequence of road pricing. By contrast, this group showed a lower tendency to change their behaviour with the reward scheme. This difference may be explained by household income as well as certain inherent differences in the two studies. In the road pricing study, we found that people with higher incomes, while controlling for education level, were less inclined to change their behaviour (see Tillema, 2007). In the reward study, the influence of income and its interaction with education level was tested but was found not significant. It is more likely that education is masking the income effect which itself is undetected directly due to the high rate of abstention on the income level question. Therefore, education level may have (partly) acted as a proxy for income: people with higher education levels will, generally speaking, be more affluent. Diminishing sensitivity to money would suggest that affluent travellers would not likely make a considerable change in their schedule for a small amount of cash money. Hjorth and Fosgerau (2008) assert that when comparing travel prospects composed of time and costs, loss aversion is evident in both. However, the loss aversion in the time dimension is more acute, resulting in asymmetrical values of time which are higher when perceiving travel time losses. Thus, if a reward changes commuter behaviour, the time losses should be perceived as relatively small e.g. for commuters with more flexible work schedules.

With respect to the third factor (possibility to work from home), similar effects were found in both experiments; respondents who have more opportunities to work from home are more inclined to change their commuting behaviour. In addition (at least in the reward case), it appears that people who can work from home are also more inclined to leave home at a later hour.

5. Conclusions

5.1 Conclusions

In this paper, we conducted a careful and relatively conservative comparison of two congestion management strategies: a time-differentiated kilometre charge (i.e. road pricing) and a peak avoidance reward scheme in terms of their effect on commuter behaviour. We have investigated specifically three points:

1. the effectiveness of both measures in changing people's commuting behaviour during peak hours;
2. the influence of the price/reward measures on the alternatives they chose, and
3. the extent to which changes in behaviour are influenced by the price/reward level and by some other exogenous respondent-related factors.

The conclusion is that the reward measure appears to be somewhat more effective in persuading people to travel outside peak hours, which would suggest that rewarding them may be more effective than charging (i.e. punishing) them. This would be in line with the principles of behavioural psychology. Notwithstanding, certain critical differences in the design, methods and procedures applied in the two separate studies suggest more caution and the need for further research before concluding that, policy-wise, rewards are more influential in reducing peak congestion than charging.

First self selection of participants in the reward study could well have attracted the more motivated ones and those that had less difficulty in changing behaviour to gain the reward. In contrast, respondents in the road pricing study had fewer vested interests and are more varied which suggests they would be more representative of the average commuter. Second, in the road pricing case, a charge was assigned also during off-peak hours, whereas in the case of the rewards, in most cases, off peak travel was always rewarded and distance travelled had no impact on getting the reward. This may well have resulted in an underestimation of the overall effectiveness of road pricing compared to rewards. Third, differences in the geographical scope could have contributed as well. The road pricing scheme was designed as a generic, universal scheme, compared to the reward scheme, which was more region specific and targeted to one corridor. Fourth, differences between the stated preference and revealed preference procedures for data collection in the two experiments may have influenced the results. Accounting for these effects and uncertainties, the effectiveness of rewarding and road pricing may not differ that much. Nevertheless, due to the initial success of Spitmsijden 1 i.e. the rewarding pilot study, a further investigation (Spitsmijden 2) was carried out in The Netherlands on the basis of a unique monetary reward (4 Euro/day), involving a larger group of participants (more than 4,000), in a larger catchment area, and over a much longer time period (more than one year).

Regarding the chosen alternatives to peak driving, the results suggest both measures have similar effects: travelling by car in the off-peak period seems to be the most popular alternative, followed by public transport. In the case of rewards, these alternatives appear to be more popular than they are in the road-pricing situation, where other alternatives, such as working from home or cycling, are chosen more often. This may also have to do with the design of the kilometre-charge, with the average commuting distances in the sample and the low charge assigned to off-peak travel as well.

With respect to the price/reward levels, the results indicate that the initial 'shock' effect creates the biggest impact on people's behaviour, while later increases led to relatively smaller changes. This result was also used to set the reward level in subsequent reward schemes at € 4 per day. In relation to other factors, we could only compare for a limited number of effects. It is apparent that any change of behaviour is associated with gender, income and people's ability to work from home.

There are some drawbacks to the analysis presented in this paper regarding the comparison of the two measures. Specifically, the differences in the empirical instruments being used (stated preference survey versus a longitudinal field experiment), as indicated earlier, allowed only to compare the outcomes of the two policies at an indicative level. In future research, it would be interesting to create a joint experiment in which both rewarding and road pricing measures are included. This would allow us to compare the measures in detail, in terms of their effectiveness and level of acceptance. Such an experiment would ideally be carried out on a large scale (i.e. a large area and respondent sample). However, it may be hard to find volunteers for a pricing experiment, so this will at best be a semi-pricing measure where money is taken from an a priori provided budget. Moreover, it would be important to make the pricing measure more comparable by not pricing the off-peak period, as was done in the experiment discussed in this paper, or reducing the reward given to off peak travel and increasing it for not driving either by change of mode or teleworking. In order to learn more about issues such as acceptability and behavioural strategies, (stated preference) surveys and more in-depth qualitative approaches, such as focus groups or semi-structured interviews, could also provide useful opportunities for comparing reward-based and pricing measures in more detail.

5.2 The applicability of a rewarding scheme versus charging

Finally, we discuss some more general considerations of pricing versus rewarding. Important questions remain with regard to the practical applicability of both policy measures and about the way they depend on specific situations. If effectiveness in reducing peak-hour traffic, and, as a consequence, traffic congestion, is the main policy objective a peak avoidance reward system may be preferable to road pricing, although, as outlined above, further research is needed to eliminate factors that limit comparability. The same may also be true when it comes to public acceptance, which appears to be hard to achieve in the case of road pricing. However, the congestion charges in London and Stockholm have shown that public acceptance increases once people experience the benefits of a system (for instance in the form of travel time gains) (see e.g. Schuitema, 2010). The issue of acceptance also played an important role in the Dutch debate.

Generally speaking, public acceptance of a reward-based system is likely to be higher (Van Delden and Cluitmans, 2009). Furthermore, a recent survey of firms also has shown positive attitude among employers towards a reward-based scheme (Vonk Noordegraaf and Annema, 2009). However, rewarding car drivers may well lead to resistance among people that already show 'desired' behaviour because they are not rewarded, for instance people who use the public transport system. One of the disadvantages of a reward system has to do with its long-term feasibility, due to the fact that it is likely to entail high operational costs (see, e.g., Van Delden and Cluitmans, 2009). The question as to who will pay is bound to play a role. Is it the general tax payer, the employer, the average car driver? And what effect will such a decision have on public acceptance? Moreover, traffic simulation models show that, if too many people change their behaviour at the same time, this may result in an over extended peak period (Bliemer and Van Amelsfort, 2008). However, as a short-term measure, rewarding has been shown to be a useful solution especially for specific local situations involving lane closures or road/bridge overhaul (Bliemer et al., 2009; Dicke-Ogenia et al., 2009). In these situations, alternatives are limited, and without influencing (peak) demand, serious traffic congestion problems would have occurred. Another option is to apply reward measures in anticipation of more structural solutions to congestion problems, such as increased road capacity and improvements in the public transport system. In this context, the Dutch government has decided to provide several heavily congested regions with earmarked budgets to implement reward schemes and other initiatives, such as mobility management programs.

On a regional or national scale, however, a form of road-pricing may be more viable. In the Netherlands, for instance, the concept of road pricing is seen as part of a systematic change in people's travelling habits, by replacing fixed taxation by a usage-based cost structure. The original plan, which has been mothballed for now, is based on the principle of budget neutrality, which means that the government does not expect to collect more money as a result of the usage-based approach. Nevertheless, it is an approach that does not enjoy a broad popularity among the Dutch public. Most people simply call its effectiveness into question. Most people feel it is merely another form of taxation that will not actually change people's behaviour and that will only increase the cost of travelling, which is already expensive as it is.

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Tables and figures

Table 1: Different pricing measures and alternatives within the questionnaire

Measure	Alternative
1. km charge (flat) on all roads	A: 3 € cent/km, abolition of car ownership taxes
	B: 6 € cent/km, abolition existing car taxation (purchase and ownership)
	C: 12 € cent/km, abolition existing car taxation (purchase and ownership) and revenues used for building new roads
	D: 3 € cent/km, revenues used for lowering income taxes
	E: 6 € cent/km, revenues used for lowering income taxes
	F: 12 € cent/km, revenues used for lowering income taxes
2. km charge on all roads (partly time differentiated)	A: 2 € cent/km with a morning and evening peak time toll/point charge (time dependent and stepwise)
	B: differentiated according to weight of the car, revenues used to abolish existing car taxation (4, 6, 8 € cent/km for respectively light, medium weight and heavy cars)
3. km charge on all roads (time differentiated)	A: 2 € cent outside and 6 € cent/km within peak periods, abolition of car ownership taxes
	B: 4 € cent outside and 12 € cent/km within peak periods, abolition existing car taxation
	C: 8 € cent outside and 24 € cent/km within peak periods, abolition existing car taxation and building new roads
	D: 2 € cent outside and 6 eurocent within peak periods, revenues used for lowering income taxes
	E: 4 € cent outside and 12 € cent within peak periods, revenues used for lowering income taxes
	F: 8 € cent outside and 24 € cent within peak periods, revenues used for lowering income taxes

Table 2: Sample characteristics for some basic variables

	Pricing	Reward
Gender (men)	61 %	65 %
Age		
25-percentile	32	37
50-percentile	37	45
75-percentile	46	51
Education (bachelor or higher)	44 %	58 %
Household income (net monthly)		
<1500 €	9 %	5 %
1500 €-3000 €	38 %	42 %
3000 €-4500 €	28 %	25 %
>4500 €	18 %	5 %
Not willing to say	7 %	23 %
Household type (with partner)	73 %	78 %
Cars (% of households with 2 cars)	45 %	45 %
Average number of days per week of commuting to work	5	5
Able to work from home	22 %	25 %

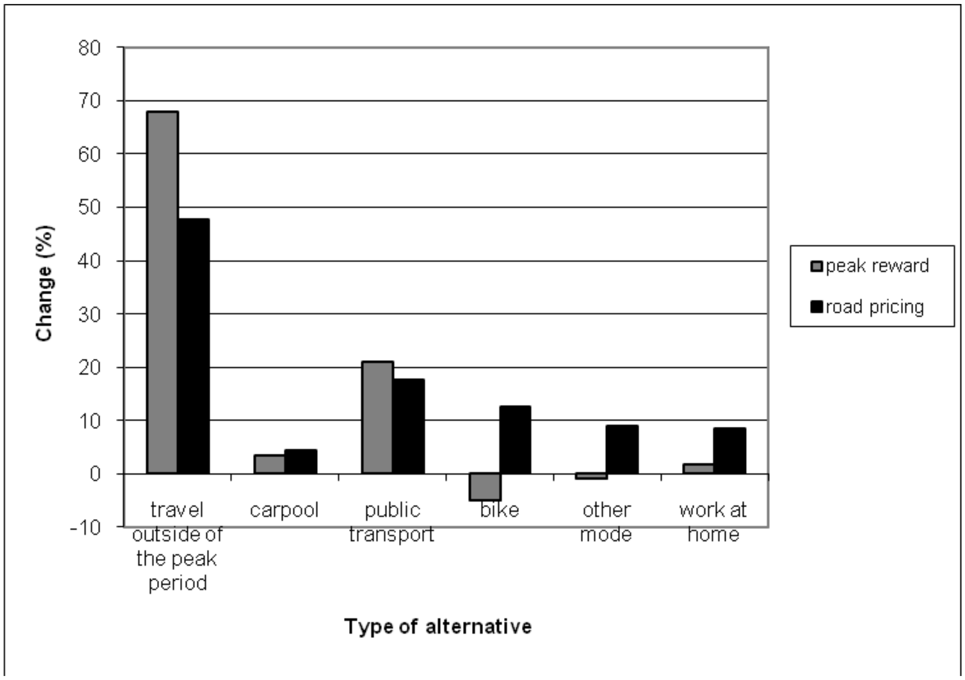

Figure 1: Change in the (car) trip alternatives as a consequence of road-pricing and a peak avoidance reward*

*(the absolute sum of positive and negative changes is equal to 100%)

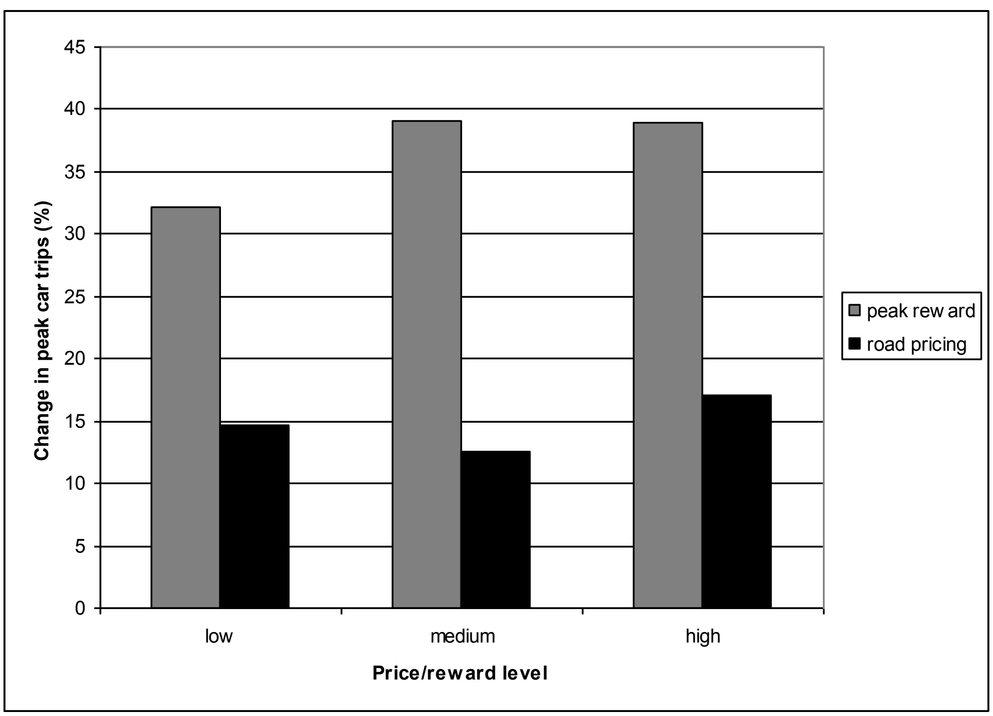

Figure 2: Change in peak car trips as a consequence of road-pricing and a peak avoidance reward (% relative to all car trips)

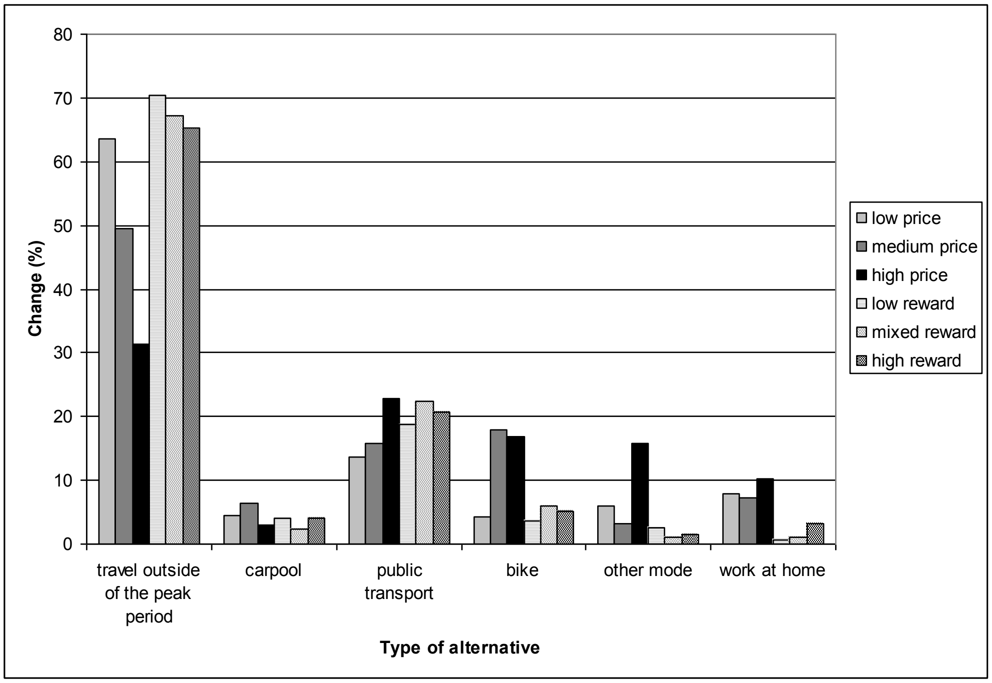

Figure 3: Change in trip alternatives as a consequence of road-pricing and a peak avoidance reward differentiated towards price/reward level*

* the sum of changes is equal to 100%

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[1] The interested reader can find more (general) information about how motivation works and the role of pleasure and pain in Higgins (2012).

[2] Technical implementation problems are the fact that tolls have to be able to vary constantly in a perfect way such that the external costs can be accounted for in a perfect way. Therefore, tolls have to vary constantly on the basis of traffic intensity, but also on the basis of, for example, the amount of pollution caused by individual vehicles.

[3] Although the data was collected in 2005, the Dutch government decision to implement a nationwide kilometre charge was taken in 2007. However, some details about the plan were already known in 2005, because it was partly based on a govermental policy advisory committee, which published their report "Pay Differently for Mobility" in 2005. This makes some of the measures in our data collection rather comparable to the measures that were proposed by Dutch government in 2007.

[4] The four week time span was used to assure a reasonably high number of trips such that the division of adapted future trips among various alternatives could be made more easily than would be the case if we were to have used a weekly framework.

[5] In principle, the option 'work at home' is also expressed in the number of trips. This means that working at home on a certain day is equal to 1 car trip in the morning peak. If due to the reward the total number of off-peak trips compared to the pre-test period decreases by, for instance, a number 5, and no other alternatives are chosen than 'work at home', than the normalization procedure implies that the 'work at home' alternative increases by 5 (i.e. 5 times option 'work at home' during the peak period).

[6] Zoetermeer is a medium-sized city in the south-western part of the Dutch Randstad area (around 120,000 inhabitants).

[7] With around 485,000 inhabitants, The Hague is the third largest city of the Netherlands.