Road pricing vs. peak-avoidance rewards: a comparison of two Dutch studies

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Abstract

The aim of this paper is comparing two congestion management schemes – road-pricing and peak avoidance rewarding and their impacts on changing commuter behaviour based on two very different Dutch studies. The road-pricing study is stated-preference based whereas rewarding was investigated in the context of a longitudinal field experiment. Given the substantial differences in data sources and analytical techniques applied beforehand, the comparison is conducted at an indicative level. In line with psychological theory, rewarding seems to be more effective in diverting commuting trips from the peak period. 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 and long run implications of these findings on the implementation policy of both measures are further discussed.

Key words:

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

1. Introduction

Road transport is an essential service in any society. Goods have to be transported between manufacturers and consumers and passenger transport, both private and public, allows people to participate in activities at different locations and during different time intervals. The benefits of transport are many and varied: an efficient transport system is a major contributor to economic growth, competitiveness, employment and well-being. An efficient transport system is highly dependent on the infrastructure and on the service level of the infrastructure. Socio-economic and demographic changes and (global) economic developments have increased mobility (demand) and have put pressure on the service level of the infrastructure. Traffic intensities are increasing every year and the road supply can often not handle the increasing demand for travel. For an extensive overview of congestion (data, factors influencing congestion, etc.) see Bovy (2001) and Bovy and Salomon (1999). This trend can be seen in urbanised areas all over the world (European Commission, 2006a, 2006b). Time losses, as a consequence of congestion, have a negative economic impact. Moreover, congestion has an impact (both positive and negative) on road safety, emissions and noise (ECMT, 1999; Mayeres et al., 1996). In addition, even with cleaner and quieter vehicles, overloading results in increasing frequency of incidents, interrupted vehicle flow and uncertainty regarding travel times (Lomax and Schrank, 2003).

The main problem causing congestion is that too many drivers are trying to make their trips more or less at the same time periods (e.g. the morning peak). Previously, the peak demand was accommodated by building new infrastructure and increasing supply[1]. However, in recent year it has been recognized that supply boosting induces an increase in demand which later on will result in a cyclical process of additional capacity increases (Goodwin, 1996). The cost-effective alternative, is to modify travellers behaviour to a certain extent. Spreading the peak demand over a larger time interval could result in considerable time savings and may well reduce uncertainty and external costs of congestion. However, convincing travellers to change their daily schedules is far from easy to accomplish. System based solutions such as ITS (intelligent transport systems) and ATIS (advanced travel information systems) are designed to provide detailed information to road users on travel conditions and unexpected delays. Experimental studies suggest that providing more accurate pre-trip information results in shift of departure time (e.g. Mahmassani and Liu, 1999; Srinivasan and Mahamassani, 2003). However, it is not at all clear that more information is beneficial from a welfare point of view. Partial information can actually result in an increase of overall travel time and user costs in the system (Arnott et al., 1999; Ettema and Timmermans, 2006; Ben-Akiva et al., 1991). Demand-based solutions, such as road pricing, have been suggested as well to (Shiftan and Golani, 2005). Pricing policies have been considered or even implemented in different urban areas around the world. Reducing congestion (costs/effects) seems to be an important reason for implementation (see e.g. Ministry of Transport, Public Works and Water Management, 2006; European Commission[2], 2001; Tfl, 2003; Phang and Toh, 1997). Several examples of attempts to implement road pricing include (see also Ubbels

[1] See also the policy process called "predict-and-provide paradigm" (Banister, 2002).
[2] The importance of internalising externals costs can also be found in the document "European transport policy for 2010: time to decide".

and De Jong, 2009): the electronic road pricing scheme in Singapore, the congestion charge zone in London, the introduction of the German *Maut* system for lorries, the successful experiment in Stockholm, and the unsuccessful experience in Glasgow. Today, the introduction of some kind of road pricing, is considered in many European countries, either at the urban scale or at the national scale. The Dutch government has decided to implement a nationwide kilometre-charge, starting with a charge for lorries in 2012 and with a differentiated (i.e. by time, place or environmental costs) kilometre charging system for cars and trucks in 2018[3].

In contrast to pricing, there is substantial evidence that people respond more favourably and are more motivated to change behaviour when rewarded rather than punished (Kahneman and Tversky, 1984; Geller, 1989). Thus, the potential of rewards as a base for congestion management policy is well worth considering if based on robust behavioural foundations. In The Netherlands the notion of using rewards to achieve desired outcomes in travelers' behaviour has been recently implemented in the context of the Spitsmijden programme (Ettema and Verhoef, 2006; Knockaert et al., 2007; Ben-Elia & Ettema, 2010), thus far, the largest systematic effort to analyze the potential of rewards as a policy mean for changing travel behaviour.

In this paper we aim to make some comparisons between road pricing and rewarding with respect to their effects on commuter behaviour. We do this on the basis of two different and independent empirical data sets. Regarding road pricing, we make use of a stated preference study (SP) among car commuters, undertaken in 2004 (Tillema, 2007). With respect to rewards we use the data collected in 2006 from a 13 week revealed preference pilot experiment called 'Spitsmijden' (translated freely as peak avoidance), which investigated the potential impacts of rewards over commuters' behaviour during the morning peak-hour (Ben-Elia and Ettema, 2010). More specifically, we focus on the effectiveness of both measures in changing car trips in the peak period, look at the influence of the pricing measures on the alternatives chosen, and study to what extent these changes are influenced by the price/reward level. This may lead to some initial insights into the impacts of 'punishing' and 'rewarding' systems on commuters' behaviour and may prove useful to the applicability of such congestion management schemes in both the Dutch and international contexts.

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, which can be found in the theory of pricing, 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 to price and internalise these externalities. Among economists a widely accepted benchmark solution in the regulation of road transport externalities is the first-best pricing (i.e. Pigouvian marginal external cost pricing; Pigou, 1920). As outlined in the 1920's (Knight, 1924; Pigou, 1920), a toll which reflects the true marginal cost of travel is implemented on the congested facilities, resulting in a

[3] The resignation of the Dutch cabinet in February 2010 has (at least for now) 'mothballed' the initative for a nationwide kilometre-charge.

reduction in the number of travellers at peak periods and thus improved 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, congestion costs, caused by trips made by a driver. With first-best pricing it is assumed that optimal charging mechanisms are available, allowing regulators to set perfectly differentiated taxes for all road users and on all links of the network; that first-best conditions prevail throughout the economic environment to which the transport system under consideration belongs; and that all the road users as well as the regulator have perfect information on traffic conditions and tolls at their disposal (see also Verhoef, 1996; Ubbels, 2002; Simon, 1982; Tversky and Kahneman, 1974). Apart from the fact that these assumptions cause almost unsolvable difficulties in terms of technical implementation[4], 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, which is why second-best pricing issues, based on less utopian assumptions, have received ample attention in literature (Verhoef, 2000; Ubels, 2006).

Second-best schemes have been suggested to circumvent the difficulties in implementing first-best solutions (Small and Verhoef, 2007). Policy-makers have different design 'buttons' with regard to constructing second-best transport pricing measures. Pricing measures can vary on the basis of the price level, the level of differentiation applied, 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 (for implementation): single lanes, single roads and different geographical levels, such as local, regional, national or international scales. 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 management/control of road infrastructure, or to finance particular (traffic) policies (ibid). Due to the different design options numerous pricing alternatives can in theory be designed.

The Dutch government decided to implement a nationwide kilometre charge, starting with a charge for lorries in 2012 and with a differentiated (i.e. by time, place or environmental costs) kilometre charging system for cars and trucks in 2018. In the current situation car taxes in the Netherlands are rather fixed. Road pricing is aimed to internalise (some of the) external costs of traffic by letting the user pay. A car driver who drives more kilometres also has to pay more. The system is meant to be budget neutral for the government, meaning that the road pricing system must not generate more revenues than in the current situation. Therefore, fixed taxes on car use will gradually be phased out. Moreover, by means of further differentiation of the road pricing measure, for

[4] Technical implementation problems are 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 the vehicles.

instance with respect to time (i.e. higher peak charge), the government hopes to spread the peak demand more evenly in order to reduce traffic congestion problems.

However, if the primary aim of road pricing would be to reduce traffic congestion instead of changing the whole car taxing system, an incentive/reward for avoiding peak hour travel could achieve a similar behavioural response to that of pricing (Ettema and Verhoef, 2006; Knockaert et al., 2007). The basic idea is to reward those travellers who are willing to shift to earlier or later departure times or alternative modes of travel or work (i.e. telework). Thus, overall penalization of drivers through tolling is avoided and overall welfare is improved by reducing peak demand.

There is quite some empirical evidence regarding the effectiveness of implemented road pricing and toll schemes around the world (see, e.g., Verhoef et al., 2008; Ubbels, 2002; TfL, 2003). Ubbels and De Jong (2009) give an insight into the effectiveness of road pricing by reviewing studies of 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 focused on congestion pricing and did not consider the well known toll roads as existing in, for instance, France and Italy. They conclude that road pricing projects, where there are alternative routes and where the charges are likely to vary considerably by time of day, will probably cause substantial changes in route choice and departure time choice. Other effects (for instance, mode choice, car occupancy, trip frequency, car ownership) might occur as well, but are likely to be of minor importance in the short run. Although the different cases worldwide seem to be rather effective in changing car driver's behaviour, the specific effects differ 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, as planned in the Netherlands, has been implemented.

Research in behavioural psychology asserts 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 diverse purposes (educational achievements, medical effectiveness, environmental protection, and many others). However, in the context of travel behaviour, rewards are poorly represented. Punishments and enforcement (such as policing, felony detectors, fines etc.), have been more widely documented than rewards (e.g. Rothengatter, 1992; Schuitema, 2003). The relative salience of negative motivational means reflects, to a large extent, a disciplinary bias. Given that travel behaviour has been to the most part subjected and influenced by 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, through learning, the act of driving with punishments (such as tolls or increased parking costs).

Inspite of its appeal to policy makers, road pricing is controversial and its behavioural implications are still not well understood. As suggested initially by Vickrey (1969), optimal pricing requires the design of variable tolls, making them quite complex for drivers' comprehension (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). Moreover, rewarding is likely to be more acceptable than pricing. Harms and Van der Werff (2009) give several explanations for the (more) negative perception of road pricing schemes. First of all, people may perceive paying for congestion as something irrational and inappropriate because they may expect to rather pay for things they wish to acquire than for things they wish to avoid (i.e., traffic congestion). Also many drivers see themselves as victims of congestion and not as contributors. Furthermore, many people believe that pricing is ineffective in lessening congestion because pricing will not discourage them from using the car, especially if employers will subsidize tolls and/or if there are no attractive travel alternatives. And, finally, many people believe that the average consumer is disadvantaged. Furthermore, Eriksson et al. (2006), also suggest subjective perceptions of fairness are at the bottom of the public's acceptability of road pricing schemes. In contrast to road pricing, there is hardly any empirical international evidence about the influence of peak rewarding systems on individual travel decisions. The few examples where rewards have been applied in a travel context are short term studies involving the use of a temporary free bus ticket as an incentive to reduce car driving. To most parts, the results of these studies are inconclusive (see Fujii et al., 2001; Fujii and Kitamura, 2003; Bamberg et al., 2002; Bamberg et al., 2003). The experiment run in Washington's Pudget Sound cannot really be regarded as reward-based as it involved congestion pricing despite the participants being fully reimbursed, thus having no real out-of-pocket expenses (Bae & Bassok, 2008). Therefore the lessons provided by Spitsmijden (and see next section for details) are exceptionally valuable and unique for future policy consderations of rewarding measures.

3. Data and methodology

3.1 Data

As mentioned earlier, we use two different and independent empirical data sets. Because road pricing has not been implemented in the Netherlands, there is no database of observed responses to road pricing. As far as we know, the same is true for other countries, at least with regard to universal pricing measures such as kilometre charges (see, also Ubbels, 2006). This is why a stated preference survey approach was adopted to study the impact of road pricing on the decision to change car driving behaviour. Regarding rewards we use data collected from 'Spitsmijden' (translated freely as peak avoidance) - a pilot experiment which aimed to investigate the potential impacts of rewards for avoiding the morning rush-hour over commuters' behaviour.

Road pricing

A survey among 562 Dutch respondents was conducted to gain insight into short (i.e. trip related) and longer-term (i.e. work and residential location) behavioural changes caused by road pricing and to be able to observe attitudes towards different types of road pricing measures. 288 respondents were commuters who drive to work by car two times a week or more and face a delay of 10 minutes or more with each trip at least twice a week. The other 274 respondents were people possessing a car. We selected car commuters 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 be able 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. We used a periodical screening questionnaire to select people with the right characteristics for our CAPI-questionnaire (i.e. computer aided personal interview). Targets were set for all the surveys with respect to the number of respondents required. The respondents were not chosen 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 percent of the respondents live in that region. No attempt was made to 'oversample' respondents from other regions.

Since the policy is to introduce a nationwide kilometre charge in the Netherlands with differentiation of the charge by time and possibly by location, as well as to 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 existing Dutch plans and, although at first sight they may appear to be 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 their intended changes in their short-term trip patterns for three purposes: commuting, social (visit) and an 'other' category. A hierarchical survey approach was applied. After the presentation of each price measure the respondents were asked first whether or not they intended to make any changes in their commuting behaviour: change nothing, increase the number of commuting car trips or to decrease them. Respondents indicating they would change nothing were asked no further questions regarding short-term commuting. If respondents replied with increased car-trips they were asked to indicate how many more commuting trips they would make on a weekly basis. Respondents choosing to decrease their car trips were asked how many of their current car trips they were prepared to adjust in a four week period[5]. Subsequently, they had to divide these adjusted trips among several alternatives: public transport, slow traffic (i.e. walk or cycle), other motorized mode (owned by the respondent), carpool, travelling at other times, teleworking or not making a trip at all. Respondents could not divide more trips than they intended to change. Moreover, the option of 'travel at other times' could only be selected if a time-differentiated charge was presented. In the case of the other two trip motives (visiting 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 choice is merely that it was regarded as rather unlikely and illogical that people would undertake more of these trips due to pricing.

[5] 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.

Rewarding

The Dutch 'Spitsmijden' experiment is, thus far, the largest systematic effort to analyze the potential of rewards as a policy mean for changing 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. A pilot study was launched in October 2006. The study area 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 woman) living in the town of Zoetermeer, a satellite city of The Hague, participated in a scheme whereby they would receive daily rewards, either of money (between 3-7 €) or of credits to earn a Smartphone. 232 participants chose to receive a monetary reward ("Money") and 109 the Smartphone reward. Participants could avoid peak-hour travel, 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 travel mode (cycling or public transport) or by working from home. Since only the monetary reward is comparable with the road pricing study, we refrain from further discussion of the Smartphone variant. The interested readers can find further information in Knockaert et al., 2007 and Ben-Elia and Ettema, 2010). 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, after recruitment, participants completed a web-based *preliminary survey*. This survey gathered information regarding their stated-behaviour: home to work locations, travel routines and usual daily commutes. In addition, they filled in information about their personal characteristics, household composition and factors that could influence their response to the rewards such as flexible work schedules, family obligations, availability of alternative means of transport, attitudes towards alternative modes and more.

The second stage was the actual experiment, lasting 13 weeks (of which weeks 3-12 were with rewards). It consisted of tracking participant's revealed (i.e. observed) behaviour. Detection equipment using in-vehicle installed transponders and electronic vehicle identification (EVI) as well as backup road-side cameras were installed at the exits from Zoetermeer to the A12 motorway and on other routes leaving the city. This equipment allowed detecting each and every car passage during the course of the day, minimizing the ability of participants to cheat by trying to access alternative routes. In addition, participants were instructed to fill in their daily web-based logbook. They recorded whether or not they had commuted to work (and if not, why not), which means of transport they used and at what slot time they made their trip. This information was used to gain insight into situations in which the participant was not detected by the EVI. It was necessary in these cases to know whether they had used some other means of transport (public transport or bicycle) or whether they had not made a commute due to vacation, illness, etc. The first two weeks were without reward (pre-test). The data collected during the pre-test was used to determine participants' *reference travel behaviour*. The final week (post-test) was also without rewards. Those participants who opted for money were

the subject of three consecutive reward "treatments" lasting 10 weeks in total: 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 avoiding also the lower peak shoulders (7:30-8:00, 9:00-9:30). The order of the reward "treatments" followed a block design which allocated participants roughly randomly to the 6 possible schemes.

The third stage of the study was a *posterior evaluation survey*. In this survey questions were asked about the participant's subjective experience during the course of the experiment. This dealt, on the one hand, with their retrospective assessment of behaviour adjustment (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.).

Another important feature in the design was the participants' allocation to reward class determined by his or her (reference) 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 rationale was that not all participants drive during the rush-hour five days per week. The aim was to discourage any possible increase in the number of commuting trips during off-peak periods that were not offset by existing rush-hour trips. Based on the information above, each participant was allocated into one of four possible classes. Once determined these classes were fixed throughout the rest of the experiment. The majority of participants belonged to classes A (5 trips/week) and B (4 trips/week) and the minority to classes C (2 trips/week) and D (1 trip/week).

3.2 Comparability considerations

As described before, in this paper we aim to gain greater insight into the effectiveness of both road pricing and rewarding schemes for influencing the behaviour of car drivers. However, the comparative potential is influenced by several characteristics some of which can and others which cannot be controlled. An important example of the latter is that for the rewarding system we make use of longitudinal revealed preference (RP) data, whereas for the road pricing part we collected stated preference (SP) data regarding behavioural change. Revealed preference (RP) studies have the advantage that they observe what actors actually do (or did), meaning that actual behaviour is studied. This may make RP outcomes more reliable. However, as noted by Louvière and Timmermans (1990) there is no significant proof regarding the predictive ability of behaviour models based on RP compared to SP counterparts.

Several additional choices are made to increase comparability. First, regarding configuration of the pricing measure - Spitsmijden (i.e. the rewarding system) aims at stimulating (part of the) car users to drive outside of the (morning) peak period, which means that the measure mainly tries to influence the timing of driving. In 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 the behavioural changes of this measure with those of Spitsmijden, but only in the case participants received a monetary reward. Second, we only use the road-pricing

data regarding commuting trips. On the one hand, changes in commuting trip patterns are the main aim of congestion management strategies. On the other hand, the price/reward heights in both cases seem to be rather comparable. As noted, the reward case included different reward levels per day - low value: 3 €; mixed reward: 3 and 7 €, high reward: 7 €. 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 commute distance 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 height of the reward. Third, we also checked sample differences for several (socio-economic) characteristics (see Table 2). Generally speaking, characteristics of both samples are rather in line and do not seem to undermine the comparative potential.

Because of the differences in measurement of the behavioural changes in both data sets, we only compare the trip changes and the selected alternatives on an indicative level. We specifically look at the effectiveness of both measures in the sense of the extent to which they change current car driving behaviour, and regarding the type of alternatives that are being chosen. We do this by means of descriptive analysis. One indicator that we use is the diverted percentage of car trips in the peak period. In the case of road pricing the peak is charged more heavily than the off-peak period, with the aim of spreading demand more evenly. Regarding the rewards, participants only received rewards when they avoided travelling by car in the morning rush hour. Therefore, car trip change in the peak period appears to be a good measure for comparing the effectiveness of both policy measures.

The comparison of the alternatives that people choose for current car driving behaviour is somewhat complicated by the difference in measuring changes in travel behaviour. As indicated before, respondents in the SP experiment had to state how many (peak) car trips they would change in a four week period as a consequence of road pricing. Subsequently, they had to divide these trips over alternatives (e.g. public transport, travelling in another time period), which means that the percentage change in the alternatives is either zero or positive. Conversely, in the RP (rewarding) experiment, actual behaviour was measured both before, during and after the introduction of the rewarding regimes. As participant behaviour changes on a daily basis and not all reported they were travelling to work each day, the number of work trips is not constant throughout the experiment. Consequently, the number of trips was normalized according to the pre-test total number of trips whereas the distribution of alternatives in each regime category was set relative to the original Spitsmijden data. Thus the absolute sum of all (positive and negative) changes is equal to 100 percent. Accounting for these modifications the results are presented as relative change in two manners. First, incorporating all alternatives - including the peak-driving option. Second, subtracting the peak-driving alternative and examining the relative change in respect to all other travel alternatives. The latter allowed a better comparison to the road-pricing figures. Next we explore how the alternative selection is affected by the height of the charge level/reward. Finally, we compare the influence of some socio-economic determinants.

4. Results: pricing versus peak rewarding

4.1 Effectiveness and chosen alternatives

The degree of effectiveness of rewarding or pricing measures is determined by the diversion of car trips (in percentages) away from peak-hour driving. As mentioned in section 3.2, in the case of road pricing, respondents had to distribute the car trips over different 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) are presented in Figure 1 and Figure 2. Figure 1 presents the relative change of all travel alternatives due to the peak reward (note, the sum of all percentages is equal to 0). Figure 2 presents the net-relative changes in trip alternatives (excluding the peak driving alternative) both for road pricing and the peak avoidance reward. The changes in car trips are divided over the different alternatives to peak driving (the absolute sum of positive and negative changes is equal to 100 percent.

The results in Figure 1 demonstrate that the majority of trips are diverted from driving in the peak period to driving in the off-peak period. Thus most participants continued to drive their cars, though at other times. In addition, there is also a moderate increase in public transport use, whereas changes in other alternatives are minuscule. Unexpectedly, there is slight decrease in cycling with rewards whereas a small increase was observed in the case of road pricing (see Figure 2). The latter may be associated with the difference in commuting distance spreads in the two samples. The respondents in the rewarding pilot experiment all reside in Zoetermeer[6] and mostly work in The Hague[7] with an approximate average trip length of 20 kilometres. This is a rather big distance for cycling. Whereas the average commuting distance in the road pricing data set is even larger (34 kilometres), still around 20 percent of the respondents have a commuting distance of shorter than 10 kilometres. As a result, the bike is a more realistic alternative in the road pricing case. Moreover, cycling was regarded by the vast majority of participants (in the first survey) as unrealistic for commuting to work, mainly due to distance (Ben-Elia and Ettema, 2010). Moreover, there could have been an increase in cycling use in the pre-test which decreased later on as participants might have realised cycling was not very attractive after all. In fact there is evidence to suggest exploration (i.e. self-experimentation) with possible alternatives had in fact taken place during the pre-test as indicated by almost a third of the participants in the second survey. Another issue to reckon with is weather effects. The weeks the rewards were provided were in the late autumn, whereas the pre-test was in September. In a choice model Ben-Elia and Ettema (2010) also found that wind speed is negatively associated with travel by non-auto alternatives during Spitsmijden.

The results in Figure 2 demonstrate that for both road-pricing and rewarding the most popular alternative to peak driving is driving at the off-peak. The shares are higher for rewarding (almost 70%) compared to road pricing (almost 50%). Switching to public transport is the second most popular alternative. Here the shares for rewarding and road-

[6] Zoetermeer is a medium-sized city in the southwestern part of the Dutch Randstad area (around 120,000 inhabitants).
[7] The Hague is with around 485,000 inhabitants the third largest city of the Netherlands.

pricing are quite comparable. The same can be observed for carpooling. Some differences appear in other alternatives, such as working from home (tele-work) or cycling, which are chosen more often in the road pricing case. As noted above the negative effect on cycling is probably related to distance and exploration.

Accounting for all three reward levels, 37 percent of all car trips (relative to all car trips both inside and outside the peak) are diverted from the peak period. In comparison the calculation for road-pricing provides a reduction of 15%. As also suggested by psychological literature, it seems that rewarding appears to be more effective than punishing in changing travellers behaviour. However, the effectiveness is also likely to be influenced by the fact that only volunteers participated in the reward experiment. Those that participate in such an experiment are likely to be people that are more able to change their behaviour. As noted by Ben-Elia and Ettema (2009) in a study among non-participants, flexibility at work and at home had a detrimental effect on the willingness to participate in the reward scheme. Furthermore, in the experiment itself, participants statements regarding work time flexibility had an influence on their change of behaviour. In contrast, the participants in the road-pricing survey, may be more varied and not likely to consist a-priori of strong proponents of the measure.

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 rewarding scheme. We explored the influence of price/reward level on effectiveness (i.e. the number of peak car trips changed) and on the types of alternatives that are selected.

We first examined the marginal effect of price/reward changes. With regard to the time-differentiated kilometre-charge, the results (see Figure 3) suggest lack of substantial sensitivity of the respondents to the measure. Although the highest price level results in a higher trip change, there is only a slight, but significant increase (Poisson regression; $\alpha \leq 0.05$) compared to the lowest price level. Regarding rewards (Figure 3), we do indeed find a trend towards greater changes in car trips when the rewards increases. However, as is the case for road-pricing, the relative effectiveness decreases when the reward is higher (results of repeated measures ANOVA does not show significant contrasts, between reward levels, $p>.05$). This may partly be explained by a 'shock' effect of the implementation of the reward. Psychologists also refer to diminishing sensitivity as a robust effect when people respond to different conditions (e.g. Kahneman and Tversky, 1979). Thus the lowest level has the greatest marginal effect on peak driving, while increasing the level of price or rewards results in less peak driving but the rate of decrease is declining (i.e. negative marginal effect).

Next, we analyzed whether price/reward level also influences the alternatives that are chosen. Regarding rewarding, the height of the reward hardly seems to influence the choice of alternatives (see Figure 4). Ben-Elia and Ettema (2010), 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 influenced by different factors whereas the reward levels are not a significant factor. Mainly these factors include socio-economic

factors like gender and education; constraints and flexibility in scheduling work and home activities; the differences between usual behaviour and the change of behaviour (e.g. usual departure time and start of work time); 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 is not true for road pricing (see Figure 4). The results suggest that although travelling by car outside of the "pricy" peak period remains the dominant alternative, the frequency declines with price level, whereas other alternatives, especially public transport and biking, become more attractive. A possible explanation is that with increasing price levels the variable car costs become so high that even travelling in the cheaper off-peak period is judged to be too expensive in comparison to driving. This can never occur in the case of rewards as any change of behaviour away from peak driving is rewarded.

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 impact of travel information, habitual 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. These are: gender, education level and possibility to work at home.

In both studies it is apparent that men are more likely (or have an intention) to change their behaviour as a consequence of road pricing or peak rewarding in comparison to women. Possibly working women are more time-constrained than men since they often combine work with caring tasks. One idea that has been suggested in social studies in relation to daily routines is time-poverty (Palma et al., 2009). Time-poverty suggests that women are more constrained in time compared to men for various reasons, mainly household tasks and child raising obligations. Dutch women quite 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. Current trip patterns may already be specifically tailored to be able to carry on tight schedules. This might well mean that women have a lower incentive to change current car commuting trips. Regarding education, we found somewhat contradictory effects. Respondents with a higher education level (university degree or equivalent) are more inclined to change their behaviour as a consequence of road pricing. In contrast, this group showed a lower tendancy for behaviour change in the case of reward. This difference may be explained by household income as well as certain inherent differences in the two studies. In the road pricing study a multivariate model included both education level and households income (see Tillema, 2007). People with a higher income (and controlling for education level) were less inclined to change their behaviour. In the reward study, the influence of income was not tested since many participants refrained from providing their real incomes; and hence education level may have (partly) acted as a proxy for income: people with a higher education level, generally speaking, have a higher income.

With respect to the third factor - possibility to work at home -, similar effects were found; respondents that have more opportunities to work at home, are more inclined to change their car commuting behaviour. In addition (at least in the case of rewards) it is suggested that working from home is also connected to some extent with later departure from home. Thus one can work from home during the morning hours and only in the midday depart to the required work place.

5. Conclusions

We aimed in the paper to conduct a careful and relatively conservative comparison of two congestion management strategies: a time differentiated kilometre charge (i.e. road pricing) and rewarding peak-hour avoidance (i.e. rewarding) with respect to their effects on commuter behaviour. Specifically, three points of comparison were made:

1. the effectiveness of both measures in changing car trips during the peak period;
2. the influence of the price/reward measures on the alternatives chosen, and
3. the extent these changes are influenced by the price/reward level and by some other exogenious respondent-related factors.

The rewarding measure appears to somewhat more effective in diverting commuting trips by car from the peak period, suggesting that a reward scheme could well be more effective than a punishing (i.e. pricing) system. This may indeed be true at least on the basis of psychological principles. Due to the success of the reward pilot study, a further investigation (Spitsmijden 2) is now being carried out in the Netherlands on the basis of monetary rewards, involving a larger group of participants (more than 3,000), in a larger catchment area, and over a much longer period of time (almost one year).

Regarding the alternatives chosen, 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 rewarding these alternatives appear to be more favourable than in the road-pricing situation, where, in contrast, other alternatives such as work at home or cycling are more often chosen. This may also have to do with the configuration of the kilometre-charge and with the spread of the commuting distance in the sample. Moreover, in the road pricing study, the off-peak period is also charged (albeit with a lower price than the peak period). This off-peak charge may motivate people more strongly than in the peak rewarding system to look for non-driving alternatives. In addition, the road-pricing sample contained a higher percentage of respondents with a reasonable cycling distance, which may well have influened its attractiveness. With respect to price/reward level, results indicate that the highest impact is achieved by the ‘shock’ effect of introducing the measures, whereas higher charges/rewards result only in slightly higher peak-hour aversion. This result also configurated the future rewarding level which is set as a fixed € 4 per day. With respect to other factors, we could only compare for a limited number of effects. It is apparent that the change of behaviour is associated with gender (men are more flexible) and income (higher incomes are less responsive) and flexibility regarding work at home.

The presented analysis has some shortfalls regarding the comparison of the two measures, especially the large difference in the empirical instruments (stated preference survey versus a longitudinal field experiment). Consequently, as described before, we could only compare the outcomes on an indicative level. It would be interesting in future research to create a joint experiment in which both rewarding and road pricing measures are included simultaneously. This would significantly increase the possibilities to correctly and scientifically compare the measures in detail, both regarding effectiveness in changing behaviour and acceptance. Ideally, such an experiment would be in the form of a large scale (i.e. a large area and respondent sample) field experiment. However, this would be also quite costly. Therefore, (stated preference) surveys and more in-depth qualitative approaches, such as focus groups or semi-structured interviews, could well provide useful opportunities to compare both rewarding and pricing measures in more detail (and see Ben-Elia et al., 2010a also presented in this conference).

As a final point we present some of the policy implications of pricing versus rewarding. Important questions remain regarding the practical applicability of both policy measures and about how this depends on the specific situation. If we only look at effectiveness in decreasing peak-hour travel, and, as a consequence, traffic congestion, a peak avoidance rewarding system may be preferred above road pricing. The same may also be true in relation to public acceptance, which appears to be hard to achieve in the case of road pricing. However, the congestion charging scheme in London and the Stockholm charging system have demonstrated that public acceptance increases once people experience the benefits of the system (for instance in the form of travel time gains). This issue of acceptance also plays an important role in the Dutch debate. The Dutch government decided to implement a nationwide kilometre-charge, starting with a charge for trucks in 2012 and with a differentiated (i.e. by time, place or environmental costs) kilometre charging system for cars and trucks in 2018. However, massive public resistance against the plan, in combination with the resignation of the cabinet in February 2010 (for a totally different reason), have for the time being 'mothballed' the initiative.

Generally speaking, public acceptance for a rewarding system is likely to be higher (Van Delden and Cluitmans, 2009). Furthermore, a recent survey of firms also has shown positive attitude amongst employers towards the reward scheme (Vonk Noordegraaf and Annema, 2009). However, rewarding car drivers may well lead to resistance among people that already show 'favourable' behaviour because they are not rewarded, i.e. public transport users grumbling about their ineligibility to get a reward. Despite the pro's, peak rewarding has a large disadvantage, regarding its long-term feasibility. Broad implication of such a measure would likely lead to high operation costs (see, e.g., Van Delden and Cluitmans, 2009). The question of who pays the rewards will certainly come up. Is it the general tax payer, the employer, the average car driver? And what effect would such decision have on acceptance? Moreover, some concern, based on traffic simulation models, indicated that should too many people start changing their schedules to gain a reward the traffic situation would be significantly worsened resulting in an over extended peak period (Bliemer and van Amelsfort, 2008), However, as a temporary measure in the short-run 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, route alternatives are limited, and without influencing (peak) demand, serious traffic congestion problems would have occurred. Consequently the Dutch government has decided to provide the Provinces (regional governments) earmarked budgets to implement reward schemes in such cases.

At a regional or nationwide 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 towards car usage, whereby current fixed car taxes would be replaced by more variable out-of-pocket charges relative to actual usage (e.g. charge per kilometre). The plan is based on the principle of budget neutrality meaning that the government does not collect more money via the kilometre-charging system than via the current fixed car taxes. Nevertheless, this system of paying more directly for car usage in not expected to enjoy a high acceptance rate of the vast majority of the Dutch public. As far as the media is concerned there is a large degree of scepticism by the majority of the Dutch public as to its effectiveness. Most see it as another kind of tax that would not really change behaviour and would only increase the cost of travel which already is expensive.

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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 and 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	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 basis 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 %

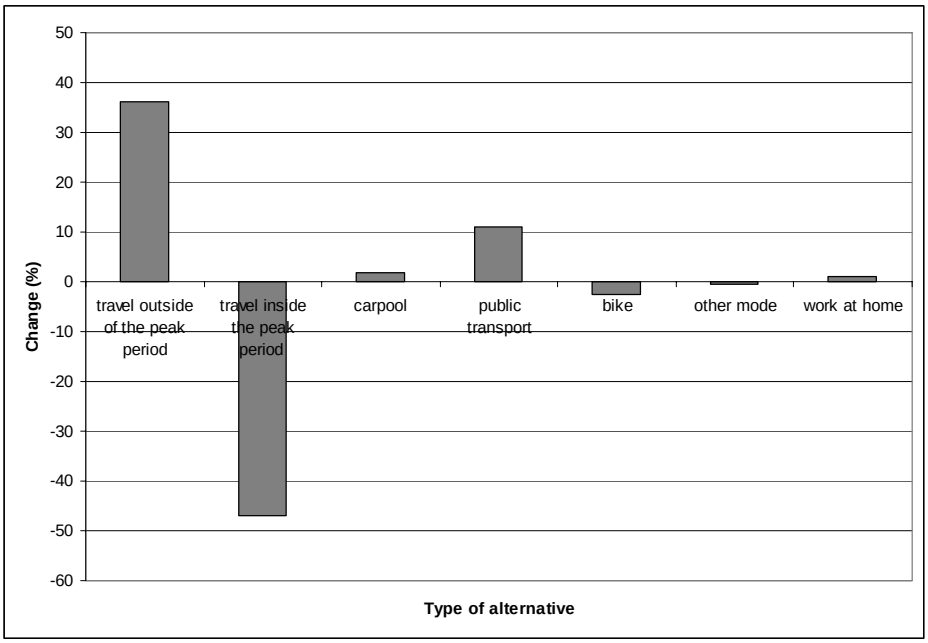

Figure 1: Change in the trip alternatives as a consequence of a peak reward (% relative to all trip changes)

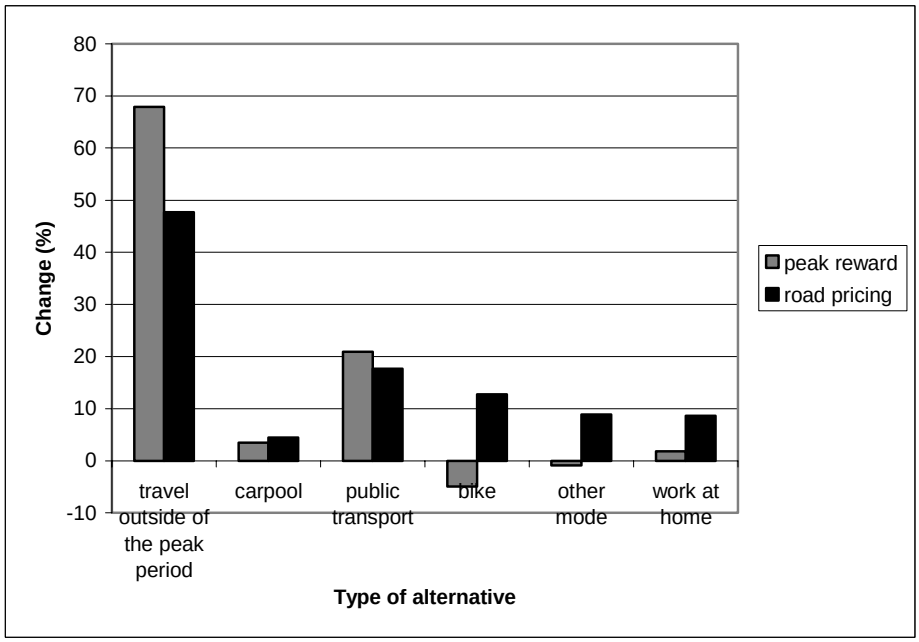

Figure 2: Change in trip alternatives as a consequence of road-pricing and a peak avoidance reward*

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

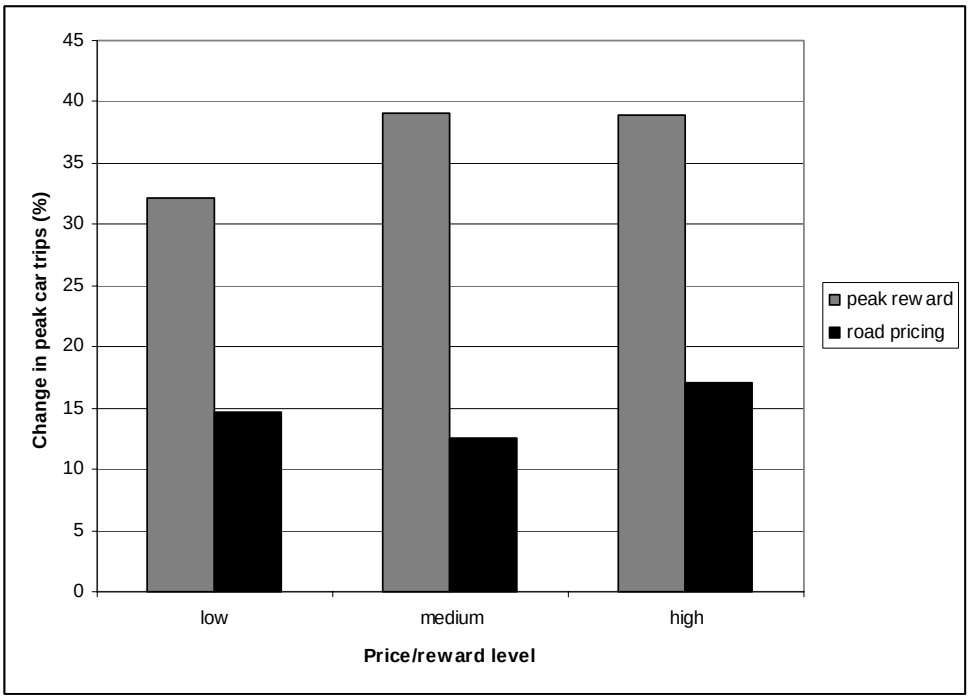

Figure 3: Change in peak car trips as a consequence of road-pricing and a peak avoidance reward (% relative to all car trips)

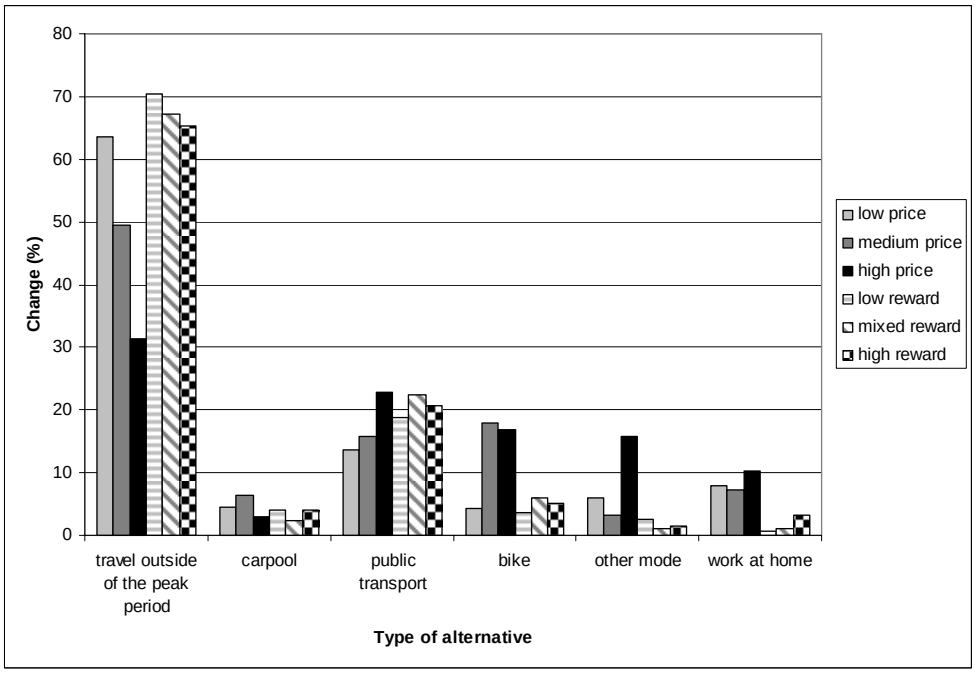

Figure 4: Change in trip alternatives as a consequence of road-pricing and a peak avoidance reward differentiated towards price/reward level*

* the sum of changes is equal to 100%