Chapter 1

Rewarding for Avoiding the Peak Period: A Synthesis of Four Studies in the Netherlands

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Abstract Charging road users for ‘bad behaviour’ may be used to improve mobility and alleviate congestion. Rewarding road users for ‘good behaviour’ may be used to achieve the same objective, however it sends out a positive instead of a negative incentive, and will therefore be more easily accepted by travellers confronted with such pricing policies. In the Netherlands, experiments have been conducted in order to investigate travel behaviour when people are rewarded for avoiding the peak period by car. Furthermore, some real life rewarding projects were defined in order to positively influence traffic conditions in situations where road works may temporarily worsen the traffic conditions. This paper presents outcomes of these studies. It is found that in all four case studies the (volunteering) travellers are willing to adjust their departure time significantly for some modest monetary rewards. Also route and mode shifts were observed. The effectiveness of the rewarding scheme is strongly determined by the setup and the location (definition of peak period, reward level, available public transport, available alternative routes, etc.).

1. Introduction

As many countries battle congestion problems, road pricing has been introduced as an effective tool to manage mobility in several countries world wide, such as Singapore, Sweden, and the UK. Such pricing policies often aim to decrease congestion in cities using a cordon charging system in which the charge is higher during the peak hours. The road users then have the option to change their departure time, to take another route around the city (centre), or to take public transport or other means of transportation. For the interested reader, recent overviews of road pricing policies can be found in Verhoef et al. (2008) and Van Amelsfort (2009).

Road pricing has been a topic of debate for a long time in the Netherlands, but resistance against pricing policies has prevented Dutch implementations of pric-
ing. This resistance could be taken away by an alternative of pricing, namely rewarding. It basically employs an inverse price mechanism, hence sends out a positive message and therefore is more acceptable by many people. Hence, instead of charging road users during the peak hours, one could reward road users for avoiding the peak hours.

Both charging and rewarding, also called push and pull measures, may be used to achieve the same objective, although in many perspectives they are different. In terms of acceptability, rewarding will be seen as more acceptable by most people than charging. With respect to effectiveness, it is not quite clear if charging is more effective than rewarding. Prospect theory would argue that losses have a more emotional impact than an equivalent amount of gains, such that charging should be considered as more effective. However, Schuijtema et al. (2003) argue that some car drivers consider rewarding more effective, since punishment is bad for effectiveness and a positive incentive makes people happy, which contributes to its effectiveness. On the other hand, the effectiveness may be less with rewarding than with charging because of the induced demand that is higher with rewarding than under (optimal) tolling. From an economical point of view, charging (e.g., in the form of a tax) yields revenues, which has generally an indirect positive welfare effect, while for rewards such effects turn into a disadvantage.

In contrast to effects of pricing, the effects of rewarding on travel behaviour have been tested by only few researchers. Nielsen and Sørensen (2008) for example find that providing rewards (as a proxy for testing road pricing schemes) does lead to travellers seeking and choosing alternatives and that the level of the rewards has an effect on the size of behavioural responses as well. The main behavioural responses found were new routes and for "occasional" trips new destinations, time of day (to non-peak) and to some extent, fewer trips. Kockelman and Kalmanje (2005) analyse a credit-based system, in which travellers build up credits for 'good' travel behaviour and can spend credits for 'bad' behaviour.

As of 1996, there have been several studies on the behavioural effects of rewarding travellers for 'good' behaviour in the Netherlands, which consisted of real-life implementations in experiments and projects. This paper aims to combine the results of these studies and to make a synthesis.

The structure of the paper is as follows. First, four rewarding studies will be described in detail, focussing on impact on travel behaviour and traffic conditions. Secondly, a synthesis is made of these outcomes in Section 3. A short final discussion will end the paper.

2. **Rewarding Projects in the Netherlands**

In 2006, a first scientific experiment near Zoetermeer in the Netherlands was conducted in order to assess the effects of (monetary) rewarding travellers for avoiding the peak period (in Dutch called ‘Spitsmijden’). This first project primarily aimed to scientifically investigate the behavioural responses of travellers towards a reward. With only a small number of participants, around 300, it was not in-
tended to solve any congestion problems. This experiment showed that travel behaviour could be significantly influenced by such monetary rewards. In particular, the amount of car travel in the peak by participants was reduced by about 50%. Later, a large scale reward project was launched on the same motorway in which 771 regular car drivers participated. In 2007 and 2008 two other real projects were defined and put into practice with larger numbers of participants (several thousands) with the aim to influence traffic conditions. Construction and maintenance works on two bridges, Hollandse Brug east of Amsterdam and Moerdijk Brug south of Rotterdam, were the reason of initiating two rewarding projects, in which severe congestion was expected due to the road works. By paying volunteering travellers who often use one of these bridges in the peak period a reward for not travelling by car during the peak period, the Dutch Ministry of Transport, Public Works and Water Management aimed to relief the increase of congestion.

The rewarding experiment and real rewarding projects (the four locations in the Netherlands are indicated in Figure 1), have been studied to assess the impact on travel behaviour and traffic conditions, and will be discussed in the next sections.

Fig. 1. Locations of the rewarding experiment and projects in the Netherlands
2.1 Zoetermeer (A12)

The rewarding experiment at Zoetermeer has been described and analysed in Knockaert et al. (2007), Ettema et al. (2008), and Bliemer and Van Amelsfort (2008), to which we refer for more details.

Situation
The A12 motorway from Zoetermeer to The Hague is a heavily congested road in the morning peak.

Goal
The aim of the experiment is not to alleviate the congestion itself, but to scientifically investigate the effects of rewarding for avoiding the morning peak on actual travel behaviour, mainly focussing on departure time shifts and mode shifts.

Duration
The rewarding experiment was conducted from October to December 2006 during 10 consecutive weeks. The participants were also monitored two weeks two week prior and one week after the rewarding period.

Participants
Selected people that travelled frequently from Zoetermeer to The Hague (determined by license plate detection) were asked to volunteer for the experiment. In total 340 people participated, of which 180 people travelled on average 4 or 5 times per week along this segment, 92 traveller on average 3 times per week, and 68 people less than 3 times per week. Half of the participants were middle-aged high educated married couples with children, and only few single young (<25 years) participants.

Rewarding scheme
Two different reward types were identified, and participants could choose their preferred reward. The first option was a monetary reward (232 participants), in which 3 to 7 euros could be earned when the morning peak between 7.30 and 9.30 was avoided by car. Cameras checking license plates and detection equipment for on-board units were placed on all routes from Zoetermeer to The Hague to check whether they indeed were not detected in the morning peak. The amount of the reward changed over time. For three weeks, participants could earn 3 euros each day they avoided the morning peak by car. For another 4 weeks they could earn 7 euros each day, and for yet another 3 weeks they could earn 3 euros if they were not detected in the middle of the peak (8am to 9am) increased to 7 euros if they were not detected at all in the complete morning peak. Participants were put in 6 different groups, each facing a different order of reward amounts. Rewards could only be earned with respect to their reference number of trips per week, i.e. a participant that was observed to travel on average 3 times per week could only earn a reward 3 times a week. Hence, a reward of $5 \times 7 = 35$ euros per week could potentially be earned. Instead of a monetary reward, 108 participants were equipped
with a smartphone with GPS that could also provide real-time traffic information. These participants could keep the smartphone if they avoided the morning peak sufficiently throughout the 10 week period. In this paper, we focus on the participants receiving the monetary reward.

**Impact on individual travel behaviour**

Participants could not change their route in order to earn a reward, as all routes from Zoetermeer to The Hague were monitored. Hence, the only alternatives available are different departure times, different travel modes, and choosing not to travel. With a reward of 3 euros, 46% less trips were made in the morning peak by car. Participants were asked to keep a logbook in order to assess their behavioural changes. Out of all trips previously made within the morning peak (from 7.30 till 9.30) by car, 35% of the trips are made outside the peak hours during the rewarding period, while approximately 10% shifted to another mode, see Figure 2. A small percentage worked from home. Clearly, with a higher reward of 7 euro each day, more trips made by the participants will avoid the peak hours by car, namely 61% of the trips that previously were made by car in the peak hours. A total of 44% of these trips avoid the peak hours, 14% by a different mode, see Figure 3.

![Fig. 2. Behavioural responses Zoetermeer (trip percentages) with €3 reward](image-url)
Slightly more participants worked from home (3% of the trips). The shifts in departure times are illustrated in Figure 4, in which the number of participants passing the A12 motorway is shown over time, before and during the rewarding period. Clearly, most participants shifted to earlier departure times, while only a small number departed later, influenced by office hours. If we compare the effects of the two reward levels, 3 and 7 euros, then obviously the 7 euro reward has a larger effect, but relatively modest. An increase of the reward level with 133% (from 3 to 7 euros) only results in a decrease of the number of trips avoiding the peak hours by car of 33% (from 46% to 61%). It seems that a relatively low re-
ward suffices for most participants to be affected. The third rewarding scheme (in which the participants could earn 3 euros if they avoided the middle of the peak and an increase to 7 euros if they avoided the peak completely by car) had an almost identical impact as the 7 euro reward.

Impact on traffic conditions
As the number of participants was small, changes in traffic conditions were not studied. However, in order to assess the potential of rewarding on a larger scale, a model study was conducted in which a dynamic transport model was used to assess different rewarding schemes with high and low numbers of participants. This model study showed that a relatively low rewarding level with a not too high number of participants yields the best improvements of traffic conditions. Too many participants may worsen the traffic conditions, as the congestion will move to just before the original peak period. Too high rewarding levels are mainly costly and are less efficient per euro, as also observed in the experiment. For more details about the modelling study, we would like to refer to Bliemer and Van Amelsfort (2008).

2.2 Gouda (A12)

As a follow up on the first rewarding for peak avoidance experiment on the A12 (see Section 2.1) a larger scale project was launched, in order to gain more experience with recruiting and handling larger numbers of participants during a longer period and in a more operational setting than in the first experiment.

Situation
The project included two trajectories of the A12: Gouda-Zoetermeer and Zoetermeer-The Hague. Both trajectories are heavily congested, which increased during the project due to road works. Congestion starts earlier on the Gouda-Zoetermeer trajectory than between Zoetermeer and Gouda.

Goal
The project was aimed at gaining more experience with operational aspects of rewarding for peak avoidance, especially when handling larger numbers of participants. In addition, the intention was to investigate how peak avoiding behaviour would evaluate during a longer period. Since numbers of participants are still too small to substantially alleviate congestion, this was not the main target of the project. However, during the project, a third and even larger reward project started on the A12 between Gouda and Zoetermeer (with about 5,000) participants, which likely had an impact on traffic flows and congestion.

Duration
The reward project started 8 September 2008 and ended 29 May 2009, thus including 162 net days. School holidays were excluded from the reward period,
since many participants would not commute on these days and congestion is much less serious.

Participants
Other than in the first rewarding experiment, no minimal frequency was used for selection, resulting in participants who would normally travel only once or twice a week on the trajectory. Participants should travel on either or both of the two trajectories to participate. Participants were recruited using number plate recognition and via six employers in the The Hague region, who actively informed their employees about the rewarding project (through flyers, posters and company email). In total 799 participants were recruited of which 771 remained in the project for the full period. The majority of the participants travelled on the A12 3 or 4 times per week. Participants were in majority highly educated, with medium to high incomes. Most live in couples either with or without children.

Rewarding scheme
Participants could earn a reward for avoiding the peak on each trajectory. Thus participants using both trajectories could earn double rewards. The reward on each trajectory was 4 euros per avoidance. However, based on usual congestion levels, the peak period was defined between 6h30 and 9h30 between Gouda and Zoetermeer and between 7h00 and 9h30 between Zoetermeer and The Hague. As in the first experiment, rewards could only be earned with respect to their reference number of trips per week, i.e. a participant that was observed to travel on average 3 times per week could only earn a reward 3 times a week. Participants were rewarded for avoiding driving the car in the peak not only on the A12, but also on parallel routes in the area. This was to avoid route shifts to secondary roads. To this end, detection cameras were installed not only on the A12 motorway but also on relevant parallel routes.

Impact on individual travel behaviour
The rewards result in a very significant reduction of car use during the peak. Between Gouda and Zoetermeer car use in the peak is reduced by 48-56%, between Zoetermeer and The Hague even by 61%. On a daily level, the number of car trips (either on the A12 or on parallel routes) is reduced by about 30%, suggesting that participants not only shift the timing of their trip but also divert to other travel modes or routes outside the detection area. Week-by-week analyses suggest considerable stability in the responses. For example, detections on the Zoetermeer-The Hague trajectory show a sharp decrease when the reward starts, see Figure 5. After that peak travel remains constant at a lower level, with only minor fluctuations. Avoiding the peak was to a large extent realised by changing the timing of the car trip. A frequency distribution of detection times near Zoetermeer (Figure 6) clearly shows that diverting to earlier times is the dominant response followed by postponement of the trip after the peak. To a lesser extent, participants used other travel modes or worked from home to avoid the peak. The share of car use dropped from 85% to 79% due to the rewards. Especially travelling by train and working from home increase.
Impact on traffic conditions
Given the number of participants, reducing congestion was not a major aim of the project. Nevertheless, the observed reductions in car trips (up to 234 in the morning peak) might have some impact on traffic flows. A welfare analysis that was carried out concluded a positive contribution of the project to the reduction of congestion.

Fig. 5. Number of detected travellers from Zoetermeer to The Hague over months

Fig. 6. Number of detected travellers from Zoetermeer to The Hague during morning peak

2.3 Hollandse Brug (A6)

The rewarding project Hollandse Brug has been described and analysed in Ministry of Transport, Public Works and Water Management (2009a,b), to which we refer for more details.
Situation
Construction works (repairs and extension with a peak lane) on the bridge “Hollandse Brug”, which connects the province Flevoland with the mainland in the south, was expected to cause a lot of inconvenience for commuters from Almere to Amsterdam. Trucks were not allowed to travel on the bridge during the first stage of the construction works, as research pointed out that the weight of the trucks was a potential danger to the bridge construction. The existing three lanes in the south direction were made narrow during the construction period, in which one lane was part of the year in use as a lane in alternating directions or a bus lane, and the maximum speed was decreased to 70 km/h. For travellers between Almere and Amsterdam there is only one other route alternative (motorway A27), which is a detour of up to about 25 km, or 17 minutes (free-flow travel time).

Goal
The objective of the peak avoidance project was to avoid an increase of the congestion levels (queues) on the bridge in the direction of Amsterdam during road construction works, which means a reduction of 1,000 to 1,500 in the morning peak period (6am to 10am). This reduction was to be achieved by mobility management (peak avoidance monetary rewarding project, free public transport, and vanpools), and some traffic management measures (route guidance, dynamic route information panels with travel times for an alternative route and by ferry boat).

Duration
The duration of the peak avoidance project was effectively twelve months, from September 2007 till October 2008, excluding six weeks of summer holidays.

Participants
Several weeks prior to the construction works, 18,931 unique license plates were detected. Travellers who were detected at least three times a week (4,100 travellers) were invited to participate in the peak avoidance rewarding project, in which they get a monetary reward for avoiding the morning peak. If they participated in this rewarding project, they were not entitled for free public transport. This yielded 1,433 participants (32%). Halfway the peak avoidance project there was another invitation round in order to increase the number of participants, as in March 2008 the bridge became accessible for trucks as well. Another 6,800 travellers with an average of 1.5 to three trips per week during the morning peak were invited as well, resulting in an additional 1,442 participants (21%). In the end, this resulted in 2,975 participants in the peak avoidance project who could receive a monetary reward.

Rewarding scheme
A reward of 4 euro per work day can be earned by participants who avoid the morning peak period (6am to 10am) by car. An additional 2 euros are rewarded if the participant does not travel by car at all on the bridge that day. Only a maximum number of rewards could be earned each week, depending on the number of trips on average made by the participant as observed from the license plate data-
base. The maximum reward to be earned by a participant is therefore 5 x (4+2) = 30 euros per week.

**Impact on individual travel behaviour**

Given the rewarding scheme, expected behavioural changes are that participants will choose a different departure time (avoiding the morning peak, mainly travel earlier), changing mode, or changing route or destination (not travelling over the bridge at all). As mentioned, the latter two were stimulated by an extra reward of 2 euros. Participants of the peak avoidance project travelled on average 2.1 times per week on the bridge. During the rewarding period, this number decreased to 1.3 times per week, which is a 40% decrease in the number of trips. The behavioural responses underlying this reduction of 40% are summarized in Figure 7, obtained from questionnaires. In most of these trips the participants changed their departure time to avoid the morning peak, primarily shifts to departure time just before 6am, yielding a reward of 4 euros per day. The shifts in departure time before and during the rewarding scheme are depicted in Figure 8. Travellers mostly leave 15 to 30 minutes before the peak period from home to avoid the bridge during the peak period, or they leave at 10am so they are sure to arrive at the bridge after the morning peak. Many trips (22% of all trips) completely avoided the bridge, earning a reward of 6 euros per day, of which 9% of all trips were along another route, 7% of the trips were made by a different mode (primarily to public transport, and 1% used the bicycle), and 6% of all trips were not made anymore (mainly due to working from home).

![Fig. 7. Behavioural responses Hollandse Brug (trip percentages)](image-url)
Impact on traffic conditions

Analyzing license plate data for the first half year, a reduction of approximately 1,250 car trips of the 1,433 participants per week was observed, which is equivalent to a reduction of 250 cars per morning peak, which is 1.5% of the total flow. After the second invitation round, this reduction was 425 cars per morning peak, about 2.6% of the total flow. Analyzing loop detector data, the total reduction in traffic flow was 1,349 (7% of total flow), hence the contribution of the peak avoidance monetary rewarding scheme was 32%. Free public transport passes accounted for 24% of the decrease in flow, and 43% was due to self regulation (non-participants adjusting their behaviour). During construction works, in which narrow lanes and a maximum speed of 70 km/h were introduced, the capacity of the bridge dropped. Before the start of the construction works, the queue length was approximately 5.6 km (trucks were not allowed on the bridge). This queue length remained unchanged after the construction works started, hence the reduction of cars in the morning peak successfully contributed such that the queue length did not increase. Halfway the project, trucks were allowed again on the bridge, which led to an increase of the queue length of 8km. After the construction works and the peak avoidance project was finished, the queue length was 7.6 km, hence the queue length was only slightly increased in the second half year of the construction works.

2.4 Moerdijk Brug (A16)

The rewarding project Hollandse Brug has been described and analysed in Ministry of Transport, Public Works and Water Management (2008), to which we refer for more details.
Situation
Maintenance works on the bridge “Moerdijkbrug” on the A16 motorway, which is the main connection between Rotterdam to Breda in the south of the Netherlands and Belgium. Two alternatives routes exist (via motorway A29 or A27), which both are large detours (22 km or 20 minutes free-flow and 26 km or 14 minutes free-flow extra, respectively, from Rotterdam to Breda). During the maintenance works, the initial three lanes were still available, but narrow and with a speed restriction, decreasing the capacity of the bridge. Additional congestion was expected due to these road works.

Goal
Similar to the “Hollandse Brug” project, the peak avoidance project here also aimed to avoid significant increases of the congestion levels in the south direction due to road works in the evening peak period (3pm to 7pm). Besides a monetary reward when participants avoided the evening peak, also park & ride facilities were extended to stimulate the use of public transport (train), and route information panels with travel times of alternative routes were used.

Duration
The peak avoidance project was introduced from April to July 2008 (2.5 months).

Participants
Similar to the “Hollandse Brug” project, automated license plate detection was used to invite (frequent) travellers to participate and to check whether they avoided the peak or not. In total 2,703 people (76% was male) voluntarily participated in the project, and could earn a monetary reward for each day they avoided the evening peak (relatively to their average weekly usage of the road). Approximately 95% of the participants travelled 3 or more times per week over the bridge.

Rewarding scheme
Car drivers could earn a reward of 4 euros per day when they avoided the bridge in the south direction during the evening peak (3pm to 7pm). Therefore, travellers who daily use the bridge could potentially earn 20 euros per week, depending on how often they pass the bridge on average per week.

Impact on individual travel behaviour
Due to the monetary reward, participants are expected to choose different departure times (avoiding the evening peak, mainly departing later), change mode (use the train or park & ride, buses are not available on this route), or choose a different route or destination. In order to find out how travellers changed their behaviour, a survey was conducted. Out of all participants, 66% of the travellers indicated that they changed their behaviour, 23% did not change their behaviour (yet), and 11% changed initially but not anymore. Reasons for not adjusting their travel behaviour were that the queues were not that long (9%), respondents could not earn as much as they expected (14%). In total 54% of the trips of the participants avoided the evening peak. The 1,784 participants who did change their behaviour changed to
other routes (28% of all trips), changed departure time (15%), worked more from home (6%, in most cases just 1 day per week), car pooled (3%), or travelled by public transport (2%), see Figure 9. People who changed their departure time mainly chose to depart later (37%) than earlier (19%), while many sometimes departed earlier and sometimes later (44%). On average, people departed 95 minutes earlier or 87 minutes later. The change in departure patterns before and during the rewarding period is shown in Figure 10. Clearly, many participants avoided the evening peak, primarily by changing to later departure times. Route shifts are mainly made towards the A29 motorway (73%), which yielded the smallest detour. Route choice was influenced by dynamic route information panels with route travel times for the different route alternatives, which was determined using license plate recognition. The park & ride facility did not contribute significantly to the use of the train. The main reasons given for not using park & ride were not being able to get to the destination by public transport (58%), preference of not being dependent on public transport (54%) and an increase in travel time (41%). Also people who were invited to participate but decided not to participate were surveyed. Without any monetary reward, 22% of the travellers indicated that they did change their travel behaviour, mainly because the construction works were announced and extra delays were expected. The participants and non-participants showed similar behaviour when they decided to change, with a slightly higher rate of departure time shifts and a bit less route shifts for non-participants.

![Diagram](image-url)

**Fig. 9.** Behavioural responses Moerdijk Brug (trip percentages)
Impact on traffic conditions
Using loop detector data and license plate recognition the traffic flows and travel times have been analyzed in order to determine whether the rewarding project was successful in achieving the goal of no increases in congestion during maintenance works. The number of bridge passages by participants has decreased with 54%, which is in total a decrease of 865 vehicles per evening peak. In total there was a decrease of on average 920 vehicles in the evening peak (which is 4.6% of the total amount of traffic), compared to the situation without rewarding. Hence, the participants are almost entirely responsible for the decrease in traffic. A small number of non-participants have also avoided the bridge in the evening peak, perhaps due to the dynamic route travel time information. During the rewarding period, the travel time from Rotterdam to the bridge decreased with 2.5 to 5 minutes in the evening peak. Therefore, the project was successful and the goal achieved.

2.5 Follow-up Projects
Since the peak avoidance rewarding projects have been successful, several new projects have been proposed in the Netherlands. Here we provide a brief list of new peak avoidance projects that are currently being done or will soon start.

In October 2009, a peak avoidance project is starting on the A15 motorway near Rotterdam. The aim of this project is a reduction of traffic in the morning peak of 5% during 3 consecutive years, as road works on the A15 will increase congestion levels. Approximately 2,500 people are envisaged to participate carrying a mobile phone with a GPS device. If a participant is not detected in a corridor around the A15 during the morning peak period from 6am to 9am, the participant can receive a reward of 5 euros.
Road works will also start on the A325 motorway between Arnhem and Nijmegen at the end of 2009. In order to maintain a high level of accessibility of the city of Nijmegen, rewards of 4 euros are given to people who avoid crossing the bridge Waalbrug by car in one of the peak periods, 7am to 10am, and 3pm to 7pm. The project runs from early September till mid December 2009. After that, a larger scale rewarding project will run on 65km of freeways and main arterials in and around Arnhem and Nijmegen, which does not look at passages at a certain point, but considers the distance travelled. A maximum of 7.5 euros can be earned each day. This project will start mid 2010.

Also in Eindhoven is a peak avoidance project in preparation, in which about 2,000 participants will be rewarded for avoiding the peak period. The details of this project are yet unknown.

3. Synthesis of Effects of Rewarding

In this section we give an overview of outcomes of the peak avoidance experiments and projects. We combine the results and aim to provide expected behavioural responses to a monetary reward.

Table 1 lists the experiments and projects, together with the monetary incentive and the resulting behavioural changes.

<table>
<thead>
<tr>
<th>Location</th>
<th>Reward</th>
<th>Departure time shifts</th>
<th>Route shifts</th>
<th>Mode shifts</th>
<th>No trip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zoetermeer</td>
<td>€3</td>
<td>35%</td>
<td>--</td>
<td>10%</td>
<td>1%</td>
</tr>
<tr>
<td>Zoetermeer</td>
<td>€7</td>
<td>44%</td>
<td>--</td>
<td>14%</td>
<td>3%</td>
</tr>
<tr>
<td>Hollandse Brug</td>
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<td>16%</td>
<td>9%</td>
<td>7%</td>
<td>6%</td>
</tr>
<tr>
<td>Moerdijk Brug</td>
<td>€4</td>
<td>15%</td>
<td>28%</td>
<td>5%</td>
<td>6%</td>
</tr>
</tbody>
</table>

The departure time shifts are most notable in the Zoetermeer experiment, in which the share of participants adjusting their departure time is more than double the share observed in the projects at Hollandse Brug and Moerdijk Brug, even with a slightly lower reward of 3 euros. This can easily be explained by the fact that the peak period in Zoetermeer was defined as a two hour period (7.30 to 9.30), whereas the other two projects defined the peak period by four hours (6am to 10am, and 3pm to 7pm). Hence, it was for the participants much easier to earn the reward, as only small departure time adjustments were required. The increase in departure time shifts at an increased reward level of 7 euros is modest. It would seem more effective to have more participants with a small reward than fewer participants with a high reward. Another reason for the relatively high number of departure time adjustments in Zoetermeer is the fact that no reward can be earned by changing route. If a participant would like earn the reward but keep driving his or
her car, then either the departure time or the route could be adjusted. Offering no route alternatives implies that such people can only choose to change their departure time.

**Route shifts** were expected in the Hollandse Brug (with one main route alternative available) and Moerdijk Brug (with two main route alternatives available) projects. In both projects the alternative routes implied significant detours and extra travel time. The single alternative at Hollandse Brug, which passes other congested roads, was not an option for most participants. The alternative route also saw an increase of 57% in the number of trucks due to the prohibition of trucks on the Hollandse Brug. The Hollandse Brug is used by a lot of traffic from Almere to Amsterdam, which is a rather short distance; hence the detour taking the other route is relatively high. This in contrast to traffic crossing the Moerdijk Brug, which is used by many long distance travellers, for which the two alternative routes offered good options (even though their detour were about the same as in Hollandse Brug) with not too much congestion. Also, route information was provided in the Moerdijk Brug case. All these reasons explain the significantly more route shifts (28%) at Moerdijk Brug compared to Hollandse Brug (9%), even though in the latter case the participants received a reward of 6 euros, 2 euros more than at Moerdijk Brug.

Depending on the situation, departure time shifts or route shifts are most preferred. If the shoulders of the peak period are also quite busy, it may not be a good idea to try to force even more people towards the shoulders, as this may just shift the (congestion) problem in time. On the other hand, if alternatives routes are already busy, then forcing people towards these routes may shift the (congestion) problem in space. Hence, one should be careful defining the rewarding scheme in time and space. In Zoetermeer the morning peak period was defined starting at 7.30. Analysing traffic data reveals that the congestion starts already at 7am or before. Since only few people participated in this experiment, no impacts on traffic were expected. However, if the rewarding scheme would have been implemented with more participants, then the additional vehicles on the road before 7.30 would have likely caused extra congestion and therefore be counter effective. If route alternatives would have been rewarded in Zoetermeer, then many vehicles might have chosen the secondary roads towards The Hague and likely cause traffic problems there. The peak avoidance projects on the bridges avoided such problems by defining a long peak period, and the bridges as location made sure that there were no secondary roads in the neighbourhood; the only available alternative water crossings were at other motorways. However, particularly in the Hollandse Brug case, the alternative motorway is also heavily congested.

**Mode shifts** are mostly made when good alternatives exist. In and around Zoetermeer is a very good public transport system, including trains and buses to surrounding cities. Several public transport alternatives for car trips crossing the Hollandse Brug are available (train, buses), but not all destinations can be that easily reached. For avoiding the Moerdijk Brug only a bus connection may be available for many origins and destinations. The availability of public transport alternatives dictates the use. In Zoetermeer, shifts to public transport are clearly visible. Also in the Hollandse Brug project these are visible, although to a lesser extent because people could also choose for a free public transport pass, such that they
are not included in the peak avoidance participants. In the Moerdijk Brug project only 2% shifted to public transport, however additionally 3% car pooled. However, it is clear that most participants prefer using the car and changing route or departure time instead of changing mode.

The option to make no trip, for example by working from home or cancelling the activity, is select by a small by still important number of participants. In both the Hollandse Brug and Moerdijk Brug project this choice was made by 6% of the participants. In the Zoetermeer experiment this percentage is much lower, probably due to the fact that it was easy for the participants to adjust their departure time.

With respect to reward levels, the different studies are difficult to compare as the situations are very different. In Zoetermeer, in the same setting, a significant increase in reward level did not lead to a large increase in behavioural changes. It seems that a reward of 3 or 4 euros is sufficient for most people to adjust their behaviour. Perhaps even lower reward levels could be used, however this has not been tested.

Summarising, by introducing a peak avoidance rewarding scheme with a reward of 3 or 4 euros, about 50% of the trips made by participants will avoid the peak period by car. About 10% chooses public transport or other modes of transport in case high quality public transport is available. In case of a long peak period (4 hours), about 15% chooses to change their departure time, while half the period double the number of departure time shifts can be achieved. The route shifts vary widely, depending on the transport network. About 6% of the people will choose to refrain from making a trip, e.g. by working from home. Higher reward levels yield higher shifts, however these are relatively minor.

4. Discussion

In this paper we have investigated a couple of real life cases of rewarding car drivers for avoiding the morning peak. We focussed on the behavioural changes, and to a lesser extent on the impact on traffic. To conclude: rewarding works. People are sensitive to monetary incentives, either by charges or by rewards (although the response to losses or gains can be different, see e.g. Kahneman and Tversky, 1979).

When voluntary participants are faced with a reward of around 4 euros each time they avoid the morning peak by car, they shift approximately half of their trips to other departure times, to other routes, other modes or decide not to make a trip at all. The first two changes seem most preferred, as in the last two cases the participants the choice of not using the car has to be made.

An important aspect that is not discussed in more detail in this paper is the population of participants. Car drivers that volunteer for the rewarding projects are usually flexible in terms of working hours. People that travel every day in the morning peak by car and are flexible in terms of working hours, routes, or modes are most preferred participants. However, only roughly one-third of the travellers
travel 5 times per week on the same stretch, while again about one-third of the 
travellers travel 1 to 4 times per week, and again about one-third travels less than 
once per week. By monitoring the roads with cameras and detecting using auto-
mated license plate recognition, the people with the most passages can be invited 
to volunteer first. As in some cases hardware needs to be installed in the car, or 
phones with GPS devices need to be handed out, each participant has a fixed cost. 
In cases of high fixed cost, it may be better to have less volunteers and increase 
the reward (to trigger more behavioural changes), than to have more volunteers 
with a small reward.

In the experiments and projects described in this paper not all participants trav-
elled 5 times per week, but many also just twice a week for example (and of 
course they could then only earn a reward twice per week at maximum). If a re-
ward decreases the number of car trips in the morning peak made by participants 
by half, then clearly one needs much more than double the number of participants 
in order to get this reduction of 50%. For example, if one would like a reduction of 
100 car trips in the peak period, then roughly 400 to 500 participants are needed.

Another important aspect is finding parties that will pay the reward. In most 
projects so far this has been the (national, regional, or local) government, which 
uses the rewards as an instrument to alleviate congestion. Other business cases 
have also been proposed, varying from credit-based systems that are budget neu-
tral, to active participation of employers.

Finally, rewarding strategies should be carefully thought through. If the re-
warding scheme is merely shifting the congestion to other time instants or other 
routes, it is perhaps very effective but inappropriate. On the other hand, not off-
ering many alternatives (e.g., very broad peak periods, large detours, insufficient 
public transport) will be ineffective. For each situation another rewarding scheme 
may be optimal.

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References

model case study investigating effects on traffic conditions, Trasporti Europei, in press.
Ettema, D., J. Knockaert, and E.T. Verhoef (2008) Using incentives as traffic management tool: 
empirical results of the ‘Peak Avoidance’ experiment, Proceedings of the 87th Annual Meet-
ing of the Transportation Research Board, Washington DC, USA.
Kahneman, D., and A. Tversky (1979) Prospect theory: an analysis of decision under risk, 
Econometrica 47, pp. 263-292.
Knockaert, J., M. Bliemer, D. Ettema, D. Joksimovic, A. Mulder, J. Rouwendal, and D. van 
Amelsfort (2007) Spitsmijden: Experimental design and modelling, Report Transumo Spits-
mijden, The Netherlands.
Ministry of Transport, Public Works and Water Management (2008) Evaluatie verkeershinder-
beperkende maatregelen Moerdijkbrug, Report COG006/HRE/0055, Centre for Transport and 


