Introducing Spitsmijden – Experiments with peak avoidance incentives in the Netherlands

Executive Summary

The aim of this paper is to review peak hour avoidance incentives in the Netherlands, which are collectively referred to as the "spitsmijden" experiments. Locations of these experiments are illustrated in Figure 1.

Figure 1: Locations of spitsmijden experiments in the Netherlands (extracted from Bliemer et al (2010))

In these experiments, financial incentives of between 2 to 7 Euros per day were offered to selected travellers if they avoided travelling at peak times. Initial results suggest the incentives have had a major effect on travel behaviour, with approximately 20-50% of participants either changing their departure time, switching routes, or shifting to another transport mode.

In addition to their effectiveness, the voluntary nature of peak avoidance incentives means they are more positively received than traditional road pricing schemes, which use negative price signals to achieve the same outcomes. Peak avoidance incentives do suffer from several drawbacks, of which the most important is the likelihood that induced demand will, in the long run, neutralise de-congestion benefits. Peak avoidance incentives also have negative impacts on public finances – raising the question of how they are to be funded.

In our opinion, peak hour incentives have extremely high potential when used to manage localised instances of non-recurring congestion – such as that associated with road works, large events, and seasonal patterns. Lessons from the spitsmijden experiments have implications that extend beyond just road congestion. Similar, targeted incentives could, for example, be offered to encourage peak spreading from public transport users.

The remainder of this article is structure as follows: First we provide a background to the concept of peak avoidance incentives; second we summarise and interpret key results from the spitsmijden experiments; and finally we identify potential issues with peak avoidance incentives.

1. The Concept of Peak Avoidance Incentives

Time-of-use road pricing schemes have long been proposed as a way to reduce congestion (Vickrey, 1963). These schemes typically involve charging an additional toll (i.e. using a negative price signal) to those people who travel in congested areas, so as to internalise the external social costs of congestion (Donovan, 2010). Time-of-use road pricing schemes have been implemented in a small but growing number of cities worldwide, and (ex-post) studies generally find they generate considerable economic benefits (Eliasson, 2007).

In spite of their benefits, many road pricing schemes are scuppered (or at least interminably delayed) by stiff public opposition. Some of this opposition reflects the (perceived) injustice of having to pay for the use of roads that were previously "free" to access. Other, more worthy, objections note that time-of-use pricing schemes frequently have high collection costs (typically 30-50%), which greatly reduces the degree to which revenue can be recycled into new transport projects (Parry & Bento, 2001).[1]

In the Netherlands, public and political debate on road pricing schemes has raged since the concept was first mooted in 1988 (Noordegraaf, Riet, & Annema, n d). The previous Dutch Government subsequently committed to the implementation of a national road pricing scheme for commercial vehicles from 2012, with private vehicles being incorporated from 2018 onwards. Nonetheless, uncertainty remains over whether subsequent governments will have the political fortitude to follow through on this commitment.

In light of this uncertainty, researchers in the Netherlands have continued to develop alternative congestion reduction schemes (referred to as "spitsmijden") that use positive, rather than negative, price signals to manage congestion. This sees travellers receiving a financial reward for reducing vehicle trips in peak periods. Results suggest positive price signals can motivate large changes in travel behaviour from reasonably large numbers of participants.[2] The structure and results from these studies is discussed in the following section.

2. Spitsmijden experiments, both past and present

The locations of the spitsmijden experiments discussed in this review were illustrated previously in Figure 1. All of these experiments are located in proximity to the congested roads providing access to some of the largest cities in the Netherland (Bliemer, Dicke-Ogenia, & Ettema, 2010).

All four spitsmijden experiments appear to have caused considerable changes in travel behaviour, as summarised in Table 1. In summary, the introduction of a peak avoidance incentives appears to cause a 50% reduction in peak vehicle trips made by study participants, of which the majority comes about through

[1] While "revenue recycling" is an important determinant of the public acceptability of road pricing schemes, "revenue sourcing" is equally important to the public acceptability of peak avoidance incentives. That is, meeting the costs of funding the incentives requires careful consideration to ensure that they are sufficiently efficient and equitable.

[2] Road pricing schemes would do well to note that voluntary nature of spitsmijden experiments. We see no reason why road pricing schemes could also offer alternative 'pricing' plans. The current pricing system would then sit exist alongside more sophisticated, but voluntary, time-of-use pricing plans. Incentives could then be used to encourage sufficient numbers of travellers to switch to the more sophisticated pricing plans.

changes in departure time. Approximately 10% of the travel reduction is associated with a shift to alternative transport modes, mainly public transport. When a long peak period (4 hours) is defined, the number of study participants that change their departure time declines considerably. The number of participants choosing to shift route varies widely, depending on the transport network. About 5% of participants choose to refrain from making a trip, e.g. by working from home. Offering higher rewards does appear to yield larger shifts in travel behaviour, however diminishing marginal returns are also evident. In the case of the Hollandse and Moerdijk Bridge experiments (which involved a much larger number of participants), the changes were sufficiently large to cause meaningful reductions in travel time.

Table 1: Summary of results from four spitsmijden experiments (adapted from Bliemer, Dicke-Ogenia, & Ettema (2010))

Location	Incentive	Modifications to travel behaviour			
		Departure time	Route changes	Mode shifts	No trips
1. Zoetermeer	€3	35%	-	10%	1%
2. Gouda	€7	4%	-	14%	3%
3. Hollandse Brug	€4-6	16%	9%	7%	6%
4. Moerdijk Brug	€4	15%	28%	5%	6%

Further details on the individual experiments are summarised in the appendix. Dutch researchers have interpreted the effects on travel behaviour of peak avoidance incentives as follows:

- *Departure time shifts* – these are extremely high in the Zoetermeer experiment, primarily because the avoided peak was much shorter (0730-0930) than the other projects and also because route changes were expressly prohibited. Shifts in departure time not as popular in experiments that specify a longer peak period, such as 0600-1000.
- *Route changes* – the Hollandse Brug and Moerdijk Brug experiments actively encouraged route changes. In the Hollandse Brug experiment the potential alternatives were considerably longer as a proportion of the total travel time between Almere to Amsterdam, which explains their limited uptake. In the case of the Moerdijk Brug project, real-time information signs were used to encourage long distance travellers to use alternative routes.
- *Mode shifts* – a relatively small proportion of the changes in travel behaviour were associated with increased use of alternative transport modes. The Gouda experiment is the notable exception, which reflects strong connections (both trains and buses) to surrounding cities. People invited to participate in the Hollandse Brug experiment also had the opportunity to choose free public transport (instead of receiving the incentives), which is likely to reduce the degree of mode shift observed for this study.
- *No trips* – A small but nonetheless important proportion of participants elected to make no trip. Many of these chose to instead work from home one day per week.

Somewhat enamoured with these successes, Dutch researchers have subsequently embarked on several new projects (adapted from Bliemer et al. 2010, p. 15-16):

- In October 2009, a peak avoidance project started on the A15 motorway near Rotterdam. The project aims to reduce traffic in the morning peak by 5% during 3 consecutive years, during which time congestion is expected to increase in response to major road works. Approximately 2,500 people will participate by way of GPS enabled mobile phones. If a participant is not detected in a corridor around the A15 during the morning peak period from 6am to 9am, they receive a reward of 5 Euros.
- From early September till mid December 2009, road works start on the A325 motorway between Arnhem and Nijmegen. To maintain accessibility to Nijmegen, a reward of 4 Euros is available to participants who avoid crossing the Waalbrug Bridge during the morning (0700-1000) and evening (1500-1900) peak periods.

- In mid 2010 a larger and more comprehensive peak incentives project will be implemented on 65km of highways and arterial roads in and around Arnhem and Nijmegen. This project will not look to reduce traffic at a particular point, but instead consider the total distances travelled by participants during peak periods. A maximum reward of 7.5 Euros can be earned each day.

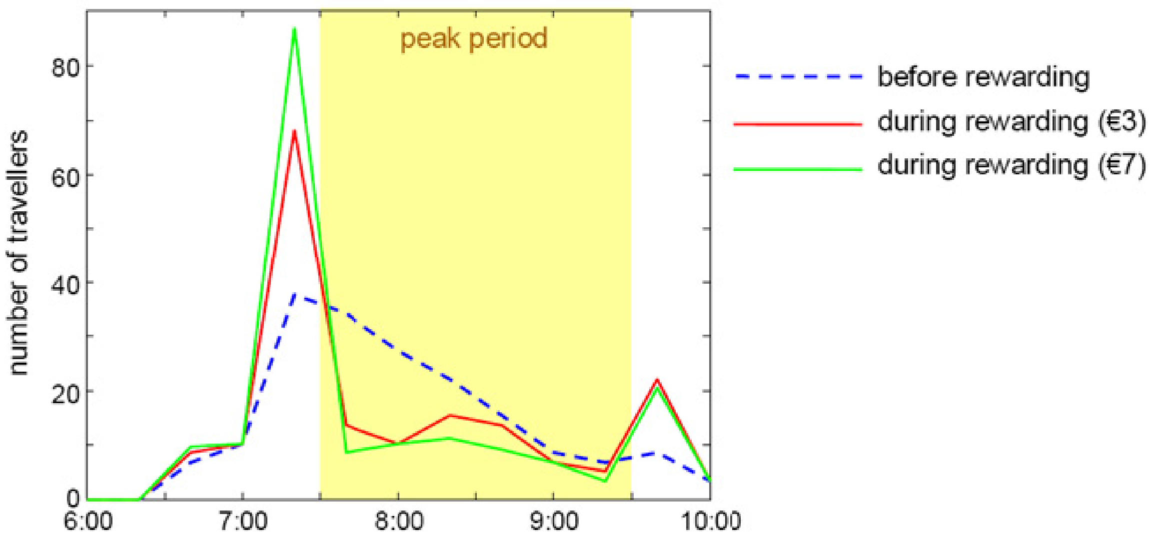
Results for these projects will be available in the near future. The increasing scale and duration of the projects is likely to reflect growing confidence and experience with the effectiveness of peak avoidance incentives.

3. Potential issues with peak hour avoidance incentives

Notwithstanding their general success, there are several potential issues with peak hour avoidance incentives.

The first major issue is that peak hour avoidance incentives can be a victim of their own success. That is, they may be so successful at encouraging changes in departure time and routes that may just shift congestion to the shoulder periods. This risk is clearly illustrated in the figure below, which shows a peak in departure time before 0630 for the Zoetermeer experiment.

Figure 2: Number of detected travellers from Zoetermeer during morning peak (Bliemer, Dicke-Ogenia, & Ettema, 2010)



In a similar way, incentives that encourage people to use alternative routes may only be effective if these are themselves relatively uncongested. If route alternatives were rewarded in the Zoetermeer experiment then vehicles might have chosen another, already congested route to The Hague. The peak avoidance projects on the Hollandse and Moerdijk Bridges avoided such problems by defining a long peak period.

Issues have also been noted with the rewards levels. The context for each experiment is very different, which restricts our ability to draw strong conclusions. But we do note that in the Zoetermeer experiment two rewards were offered, but the higher reward level (7 Euros) was unable to cause much further change in travel behaviour compared to the 3 Euros reward. Modelling suggest that a combination of moderate rewards (3-4 Euros per day) and large number of participants are likely to be more effective than concentrating high rewards on a smaller group (Bliemer & Amelsfort, 2010).

The issue with reward levels also highlights the negative implications of peak avoidance incentives for public finances. We also note that the peak avoidance incentives are not horizontally equitable – in that they do not reward people equally for the same behaviour. That is, those people who do not currently travel in peak periods are not rewarded, while those that do are. The large scale application of peak avoidance incentives will therefore require the development of robust and equitable funding models.

Other potential issues with peak hour incentives include:

- Induced demand – normal road pricing schemes effectively increase the costs of travelling in the peak period for all users, thereby curtailing the demand curve at a point where it corresponds more closely with the external social costs of travel. Accurately priced roadways are generally not subject to induced demand effects, because higher costs will not generally attract new demand. Peak hour avoidance incentives are different in that they increase the costs of travelling for a selected segment of the demand curve (i.e. a selected subset of travellers). By removing this demand from the network, the costs of using road space (i.e. congestion) are lowered, which will in turn attract new drivers. Thus, peak hour avoidance is unlikely to be effective on a large scale in the presence of large induced demand effects (Rouwendal, Verhoef, & Knockaert, 2010).
- Barriers to set-up costs – upfront time and funds are required to first identify potential participants and second secure their ongoing involvement in the project. Key cost items include license plate recognition technology and inductance loops. Costs are also incurred in ongoing monitoring and data collection. The use of license plate recognition technology for several months of weeks before the survey may raise privacy issues in some jurisdictions.
- Cheating – Some aspects of the experiments appear vulnerable to cheating. For example, because the rewards are tagged to the use of a particular vehicle, households with access to several vehicles may simply use another vehicle (that is not associated with the project) to travel during peak times.

It is likely that issues with set-up costs, privacy, and cheating can be effectively managed through good project design. Issues with induced demand are more problematic. The induced demand effect suggests that peak hour avoidance incentives are best-suited for achieving targeted congestion reduction improvements in response to specific short-term events, such as lane closures. They may also have a role in reducing congestion associated with major events and/or seasonal patterns (as often occurs at major holiday destinations).

In general, we suggest that peak avoidance incentives are viewed as a complement to, rather than a replacement for traditional road pricing schemes. Peak hour avoidance incentives could be introduced in advance of road pricing schemes, so as to increase public awareness of potential travel behaviour changes. Moreover, we see no reason why traditional road pricing schemes could not adopt the same voluntary approach that characterises the spitsmijden experiments. This would see time-of-use pricing plans being offered in parallel with the existing system, where incentives are used to encourage people to switch to the new system. In this way, exposure to time-of-use road pricing would be voluntary, rather than compulsory.

Further information on the spitsmijden experiments are available in the references indicated below, while a summary of the four experiments review in this study is provided in the appendix to this paper.

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Appendix – Details on the spitsmijden experiments

1. Zoetermeer	Key Attributes	Effects on Travel Behaviour
Situation	A12 motorway from Zoetermeer to The Hague is heavily congested in the morning peak.	All routes from Zoetermeer to The Hague were monitored, which meant that participants were not able to earn the rewards simply by changing route. The only alternatives available to participants were change in departure time, different transport modes, or choosing not to travel altogether. Two levels of reward were offered to participants, namely 3 and 7 Euros, which were earned in relation to the average number of trips made by vehicles prior to the incentive scheme. The group of participants offered the 3 Euros reward per day generated 46% fewer car trips in the morning peak. The 46% reduction was achieved by 35% of participants travelling outside peak hours, 10% shifting to another transport mode, and the balance working from home. The group of participants offered the reward of 7 Euros generated 61% fewer car trips in the morning peak, where 44% of participants travelled by car outside of peak hours and 14% used a different mode
Goal	Scientifically investigate the effects of rewarding people for avoiding the peak, especially effects on departure time and mode shifts.	
Duration	Conducted from October to December 2006 over 10 consecutive weeks. Participants were monitored for two weeks prior to the experiment and one week after the rewarding period.	
Participants	Number plate recognition was used to identify people who travelled frequently from Zoetermeer to The Hague, who were then invited to volunteer for the experiment. A total of 340 participants were involved in the experiment.	
2. Gouda		
Situation	A12: Gouda-Zoetermeer and Zoetermeer-The Hague. Both directions are heavily congested, which actually increased during the project due to road works.	All participants in the project were offered 4 euros per peak vehicle trip avoided, where the trip reduction was measured in comparison to their average weekly travel patterns in the weeks prior to the experiment. In this experiment the peak period was defined as 0630-0930 between Gouda and Zoetermeer and 0700- 0930 between Zoetermeer and The Hague. Again, all alternative routes were monitored so changes in routes were not rewarded. Car use in the peak was reduced by 52% and 61% between Gouda and Zoetermeer and Zoetermeer and The Hague. Week-by-week analysis indicates that this trip reduction was stable over time. The reduction in peak vehicle trips was to a large extent realised by changes in departure time. Diverting to an earlier departure time was the dominant response, although the number of participants that postponed their trip until after the peak was not insignificant. Overall car mode share dropped from 85% to 79% during the experiment, as participants increased their use of train and working from home. Economic analysis carried out after the experiment concluded that the reduction in car trips (up to 234 in the morning peak) was welfare enhancing.
Goal	Gain more experience with operational aspects of peak avoidance incentives with larger numbers of participants and evaluate how people respond to peak avoidance incentives over a longer period.	
Duration	Experiment run from 8 September 2008 to 29 May 2009, where rewards could be earned on a total of 162 days. School holidays were excluded from the reward period.	
Participants	Number plate recognition was used to identify potential participants. Six local workplaces informed employees about the rewarding project (through flyers, posters and company email). A total of 799 participants were recruited, of which 771 were retained in the project for the full period.	
3. Hollandse Brug		
Situation	The "Hollandse Brug" is the bridge that connects the province Flevoland with the mainland in the south). Maintenance work on the bridge demanded that lanes were narrowed and the maximum speed was decreased to 70 km/h, which was expected to cause a lot of congestion between Almere and Amsterdam. Only alternative route (motorway A27) involved a detour of up to about 25 km.	A reward of 4 Euro per day was offered to participants who avoided travelling across the bridge in the morning peak period (6am to 10am). An additional 2 Euros was offered for participants that did not travel at all on the bridge that day. The average participant previously used the bridge 2.1 times per week. During the experiment this decreased to 1.3 times per week, which is a 40% decrease per participant. 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. 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 using the bridge altogether - of which 9% were made using an alternative route, 7% were made by a different transport mode (predominantly public transport), while 6% of all trips were averted (mainly due to working from home). The targeted reduction in vehicles using the bridge was achieved once the experiment was expanded to 2,800 participants. For the first half year, a reduction of approximately 250 cars per morning peak (1.5% of the total flow) was achieved. After the second invitation round, a reduction of 425 cars per morning peak or (2.6% of the total flow) was achieved. 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% (i.e. 2.6%/7%). Free public transport passes accounted for 24% of the decrease in flow, and 43% was due to self regulation (i.e. non-participants adjusting their behaviour).
Goal	Avoid an increase of the congestion levels (especially queues) on the bridge in the direction of Amsterdam during road construction works, which required a reduction of 1,000 to 1,500 vehicles in the morning peak period (6am to 10am). Reduction achieved by a combination of mobility management (peak avoidance monetary rewarding project, free public transport, and vanpools).	
Duration	The duration of the peak avoidance project was effectively twelve months, from September 2007 till October 2008, excluding six weeks of summer holidays when congestion levels are reduced.	
Participants	Number plate recognition was used to identify potential participants prior to works beginning. 4,100 travellers were invited to participate in the experiment, of which 1,400 agreed. An additional 1,400 participants were recruited halfway through the project, bringing the total number of participants to just over 2,800.	
4. Moerdijk Brug		
Situation	Maintenance works on the bridge "Moerdijkbrug" on the A16 motorway (the main connection between Rotterdam to Breda in the south of the Netherlands and Belgium) was expected to cause considerable congestion. While two alternatives routes are available (via motorway A29 or A27), both involve large detours (22km and 26 km respectively).	Participants 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). Participants who used the bridge daily could potentially earn 20 Euros per week, depending on how often they used the bridge in a normal week. Participants were 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, and 11% changed initially but later reverted to their previous travel patterns. In total 54% of the trips of the participants avoided the evening peak. Of the 1,784 participants who did change their behaviour changed to other routes (28% of all trips), 15% changed departure time, 6% worked more from home, 3% car pooled, 2% travelled by public transport. People who changed their departure time mainly chose to depart later (37%) than earlier (19%), while many sometimes departed earlier and sometimes later (44%). The park & ride facility did not contribute significantly to the use of the train. 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. Data (collected from loop detectors and license plate recognition) suggests the incentives contributed to a decrease of 865 vehicles per evening peak of a total reduction of 920 vehicles. Travel time from Rotterdam to the bridge decreased by 2.5 to 5 minutes in the evening peak.
Goal	The experiment 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). In addition to the experiment, additional park & ride facilities were provided on the approach to the bridge to stimulate the use of public transport (train).	
Duration	Experiment ran from April to July 2008 (2.5 months).	
Participants	Automated license plate detection was used to identify frequent travellers. A total of 2,703 people (76% was male) voluntarily participated in the project, where they 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 involved in the experiment previously travelled 3 or more times per week over the bridge.	