# DIFFERENT

## User Reaction and Efficient Differentiation of Charges and Tolls

DELIVERABLE D4.2

# PSYCHOLOGICAL CONSTRAINTS OF USER REACTIONS TOWARDS DIFFERENTIATED CHARGING

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## EXECUTIVE SUMMARY

In the transport sector differentiated pricing is increasingly used to influence behaviour in order to manage users' demand for infrastructure capacity. However, there is a likely conflict between the theoretical desirability of highly differentiated pricing structures and the ability and the motivation of users to respond effectively to them. The aim of this report is to investigate empirically the question up to what degree of complexity people are able and willing to understand, and respond to, differentiated transport charging structures. Based on the theoretical background given in Deliverable 4.1 this report focuses on psychological factors influencing users' responses towards differentiated pricing. Therefore several hypotheses and research questions concerning cognitive, motivational, personal and situational factors on users' responses have been formulated.

Within the theoretical framework the relationships between differentiated charges, psychological constraints and behavioural adaptation have been described with the help of the Stimulus-Organism-Response-Model (SOR-Model) of human behaviour. The analysis of theoretical knowledge has identified potential psychological determinants of user reaction, which can depend on cognitive, motivational, personal or situational factors.

Research in cognitive psychology already provides knowledge about the cognitive limits of users faced with a differentiated charging scheme. Thus the perception and the knowledge of prices play an important role for user reaction. Whether people can understand a pricing system and its communication depends on their prior knowledge and experience with principles of differentiated charging in various domains of life. Furthermore there is always the question on psychological costs of behavioural adaptation. The higher these costs are, the less likely a change in travel behaviour as a reaction to differentiated charging becomes (cognitive comfort). If the differentiation becomes too extensive for individuals to understand, people tend to base their behaviour on a simplified mental model of the price structure, thus use heuristics. Processing a large amount of information is also restricted by people's limited attention and mental capacity to process information. Even if a differentiated charging system is designed in a way that people would be able to understand it, they may not be willing to do so. Therefore, apart from the cognitive aspects, a central motivational factor that might influence user reaction toward differentiated pricing is acceptability. Several factors have been identified, which contribute to the acceptability of transport pricing measures (e.g. personal goals, problem perception, perceived effectiveness, perceived fairness, etc.). Furthermore, there is a range of other motivational factors, which may have an impact on consumer decision, like for example disengagement or personal involvement. Inter-individual differences in the ability and willingness of people to deal with extensive information are due in part to cognitive abilities and motivation, but there are also some personal and situational factors that have to be taken into account when analysing consumer reaction to differentiated prices. Therefore user's age, gender, education and income have to be considered when analysing consumer reaction on differentiated prices. People's ability to understand highly differentiated pricing systems depends further on situational aspects such as time pressure and trip purpose.

To test theoretical assumptions data from 10 case studies have been analysed, whereby user responses within cars sector, freight operator sector and passenger sector (ferry and railroad) had been considered. According the empirical results conclusions are deduced and, finally, based on conclusions recommendations for effective introduction of differentiated pricing schemes are given.

Results from field experiments and surveys indicate that the degree of differentiation affects user's information processing and thus their handling of differentiated pricing. Further, several aspects of pricing schemes seem to affect the likelihood of behavioural adaptation as response to schemes. For example, people have more difficulties in dealing with differentiated prices if schemes contain distance based elements. On the other hand people have fewer problems if differentiation elements are built on already existing cognitive structures and/or on elements people are familiar with. Moreover the results provide considerable evidence that effectiveness of pricing schemes depends on personal price thresholds: a low price level associated with high complexity indicates a low likelihood of behavioural changes. The findings also indicate that the price level and the understandability of charging schemes interact to influence users' response: When prices are perceived to be very low (even if not precisely known), people tend to ignore the price altogether; when prices are perceived to

be low but uncertain (and thus potentially high) people tend to over-respond to the actual price; when prices are perceived to be high but uncertain (and thus potentially low), people tend to under-respond to the actual price. The results furthermore suggest an effect of the modus of payment: Pricing schemes which are presented as a loss system are more effective concerning behavioural adaptation than pricing schemes that highlight a gain perspective.

Although results from case studies do not provide direct evidence regarding effects of the degree of differentiation on user's responses towards pricing schemes, they however indicate important influences of cognitive and motivational aspects on users' handling of differentiated pricing schemes and how these psychological aspects moderate user responses towards differentiated prices. Findings from the case studies suggest that motivational factors, particularly acceptability of pricing measures, affect people's likelihood and willingness to respond towards differentiated charges. Some evidence suggests that the more people support the principle of road user charges the more likely they are to say that they will adapt their behaviour to charges, other evidence suggests that initial acceptance can lead to a more cursory consideration of scheme features and perhaps a less reliable intimation of likely response. The interrelation of acceptability and user responses seems to be moderated by situational factors and users perception of these factors. These results indicate the importance of the users' opportunities to respond adequately to the charging schemes. Hence, the effectiveness of charges will strongly depend on whether people perceive that they are able to adapt their behaviour and whether they will perceive a supportive situation. Otherwise, if users perceive that the charging schemes restrict their travel behaviour and / or freedom of action, individuals might experience psychological reactance. Reactance is an intense adverse motivational state and leads to attempts to restore one's behavioural freedom by direct and indirect ways (Miron & Brehm, 2006). It is assumed that reactance is reduced more likely through indirect reactions because of situational and social constraints that restrict direct behavioural reactions. One option for an indirect restoration of perceived behavioural freedom is refusing to act, and thus, undesirable and contrary effects like reluctance to engage with the prices and failure of behavioural adaptation will become probable (see also section 4.1.2).

Negative impacts deriving from highly differentiated pricing systems are more likely in the personal travel sector than within transport companies, which are faced with differentiated pricing. In contrast to personal travel sector, logistics and freight operators seem to act more rationally. Dealing with differentiated charging schemes belongs obviously to business routines and is allocated as a necessary task to specific organisational structures within transport companies.

In addition to examination of data from field surveys and field experiments three laboratory experiments in controlled environments have been conducted. These three computer-based experiments were designed especially for the DIFFERENT – project and aimed at exploring factors affecting public perception of the complexity of differentiated road charging schemes, their willingness and ability to predict the charges that would apply to specified journeys and their behavioural responses to those charges. Regarding the impact of degree of price differentiation (spatial and temporal) on behavioural responses almost identical results appear within the three experiments. The time to calculate the charges for using a specific road, errors in this calculation as well as perceived difficulty of the differentiated schemes and uncertainty about correct price estimation increase drastically with increasing level of differentiation. So far it can be confirmed that differentiated pricing structures affect user responses. Although it has not been possible to identify a specific threshold of complexity, the considerable problems respondents had in handling a system with two time bands and three charged zones provide first indications about the existence of such a threshold. Moreover, the results indicate that besides cognitive also motivational factors and especially acceptability have impacts on user responses towards differentiated prices. Some findings need further replication but in general it has become obvious that, especially in case of highly differentiated prices, a negative attitude towards road pricing in general is associated with perceived problems in understanding any given charging scheme. Further the results suggest that people prefer rather simple tariffs over highly differentiated ones. The more differentiated the scheme was, the more negatively it tended to be perceived.

Another interesting finding is that older people apparently have more problems in handling the differentiated schemes – they need more time to calculate the charges, are less confident about the accuracy of their calculation and perceive the differentiated schemes as more difficult compared to

younger people. Concerning gender it appears that men claim greater certainty in calculating travel expenses, less difficulty in understanding the schemes but less willingness to adjust their route and travel times to avoid exposure to charges

Finally from the findings of this report, and in the interest of achieving an effective introduction of differentiated pricing, the following recommendations have been derived:

a.) **Do not introduce unnecessary differentiation.** The more complex pricing schemes are, the more difficulties in dealing with them will occur. Thus, unexpected behavioural responses or failure of behavioural adaptation might become more likely.

b.) **Build gradually on existing differentiation.** Differentiations people are familiar with provide advantages concerning behavioural adaptation according schemes. If the design of pricing schemes is built on already existing cognitive structures, they will ease the dealing with them and counteract the perception of complexity by users. Also, during the introduction phase of road pricing, low levels of differentiation (or even undifferentiated prices) are recommended to ensure better understanding and habituation to the new situation. When road users have become familiar with the new situation a successive differentiation of the charges can occur.

c.) **Avoid differentiation elements which are not in line with an easy human information processing.** For example**,** avoid elements which:

- vary non-linearly (e.g. if price is an non-linear increasing function of speed),
- vary unpredictably (e.g. with price as a function of current congestion),
- are not clearly observable (e.g. with price based on current emissions),
- are based on values which are not readily known (e.g. with prices expressed per km – because people do not have good knowledge of journey distances),
- are based on spatial divisions which may not be widely known (e.g. with cordons or zone boundaries which do not follow well-known boundaries), and
- which imply complex cross-linking to other elements (e.g. with different time bands applying in different zones - people have difficulties dealing with variables which are linked and interact with each other).

d.) **Do not expect precise calculation of charges that were designed to provide complex pricing signals.** Results show that precise calculation of prices at least within individual transport sector is unlikely. People prefer a prediction of prices (by heuristics) which will prove satisfactory at a certain level with regard to necessary cognitive effort to a precise prediction by accurate calculation. This is particularly true if the differences between the price levels are low – people will not think it worth the effort to calculate the precise value. As a generalisation, one should expect under-response to complex prices in high-price domains and over-response to prices in low price domains (unless the expected price is so low that it is ignored completely).

e.) **Make pricing schemes familiar to users by assistance and helpful advice.** Results indicate that as people become more familiar with pricing schemes they become better able (and willing) to deal with them.

f.) **Provide adequate information and advice about the price structure of the charging schemes.** This is to help users see/understand the underlying “pattern” and thus make the details easier to recall (especially in case of highly differentiated prices).

g.) **Provide information to stress the justification for the scheme** (e.g. information on benefits, use of revenue, protection for vulnerable groups, scientific justification, political support). This is to make the scheme seem more acceptable to users and so increasing their understanding and willingness to engage.

h.) **Provide (and publicise) opportunities to change behaviour according to the differentiated charging schemes.** Perceived opportunities for users to respond according pricing schemes are essential to avoid psychological reactance and failure to engage.

i.) **Cross sectional transfer of charging scheme principles** and thus expectations in behavioural changes **should be carefully and critically checked** and always unique characteristics of specific transport mode should be taken into consideration.

It should be noted that the conclusions derived from the results presented are restricted by methodological issues of case studies. The majority of results are characterised by correlative design and, strictly speaking, do not allow causal relationships to be inferred. Some case studies were not specifically designed to allow examination of the effect of the degree of differentiation on user response and, thus, the confounding effects of other variables may obscure the effect of differentiation. It is furthermore acknowledged that case studies from sectors other than the car driver sector are clearly underrepresented and partly marked by small sample sizes. These case studies do, however, provide interesting results and further research activities would be useful to broaden and enlarge insights into user responses towards differentiated pricing. Further studies should also attempt to decompose the causal relations between the socio-demographics factors and their interdependencies to clarify how they influence user reactions towards differentiated charging.

# 1 THEORETICAL BACKGROUND

## *1.1* A BRIEF OVERVIEW OF RELEVANT PSYCHOLOGICAL THEORY

### 1.1.1 An Application of the Stimulus – Organism – Response – Model

In the transport sector differentiated pricing is increasingly used to influence behaviour in order to manage users' demand for infrastructure capacity. To describe behavioural changes induced by prices, economists use the concept of price elasticity. Price elasticities characterise the extent to which people change (consumer-) behaviour following a change of prices. Elasticities are able to describe quantitative changes in behaviour. They can for example describe the extent, to which motorists drive more or less after the introduction of road pricing while cross elasticities can describe the extent, to which people might change their amount of driving following a change in the attributes of alternative modes. However, elasticities are not able to describe sufficiently what cognitive or motivational processes are behind these quantitative changes. But this is necessary to understand and predict user reactions to differentiated pricing.

Firstly mobility behaviour is highly habituated in most situations and strongly linked to people's lifestyle. Changes in travel habits may not be possible without changes in daily routines and this may prove difficult or costly and lead to inflexibility even when conditions change. Economists have suggested that transportation tends to be inelastic since it is a derived demand. Exceptions are discretionary travel and some freight shipments (Oum, Waters & Yong, 1992). Psychological research has shown that people often regard themselves as "captive" with respect to their travel behaviour. They feel that their freedom to change their travel arrangements is restricted in various ways.

A second problem is that people have limited mental capacities to process information. That means that their ability to respond to price signals is constrained especially in the case of highly differentiated prices, which change dynamically over time. There are cognitive limitations that restrict the degree of differentiation that people can deal with and thus the degree of differentiation possible. Therefore first-best pricing structures might be a problem as they are often highly differentiated (Bonsall & Shires, 2005). Transport users might have difficulties to predict what price would be payable in a given situation and are thus unable to adjust their behaviour accordingly. Although, by appropriate design of the charging regime and by provision of advance information where people may be assisted to understand and predict the prices, it is not clear whether people will weigh the differentiation criteria of a pricing system in the way intended by the scheme designers. That means if the differentiation becomes too extensive for individuals to understand, people tend to base their behaviour on a simplified, and possibly erroneous mental model of the price structure. A recent report by ITS Leeds commissioned by the UK Department of Transport (Bonsall, Shires, Matthews, Maule, & Beale, 2004) has summarised some of these relevant cognitive aspects for pricing in transport and has drawn on other sectors for empirical evidence of people's response to differentiated pricing schedules. It appears that different individuals have different abilities to understand pricing systems and that this also depends on personal and situational factors. Particular problems may for example arise, if the additional information about price differentiation requires attention from drivers, which distracts them from driving. Many of the aspects that determine people's subjective interpretation of a differentiated charging scheme have been identified in Work-package 4.

But there are not just cognitive aspects that have to be seen as constraints on behavioural adaptation to differentiated prices. Motivational factors play an important role, too. Thus even if transport users are *able* to understand a highly differentiated pricing system and to predict prices in advance, it does not mean that they are *willing* to deal with these charges and to adjust their behaviour – for instance, when people feel that they are treated unfair with a new pricing regime (see Deutsche Bahn case). In this context acceptability is one of the most important aspects and should be considered regarding users´ response to differentiated prices. A lack of motivation leads further to disengagement. That means people do not want to waste effort dealing with the charging system as it is too complicated or

they consider it not relevant for them. This may obviously have consequences for the implementation of a new pricing structure.

Concerning all these facts it is reasonable to consider the question of people's motivation to deal with pricing systems together with their ability to respond to these price signals when looking at users' reaction to differentiated pricing.

In sum, the most important research questions with regard to differentiated user prices in transport are:

- Up to what degree of differentiation are people able and willing to understand and to respond to charging structures?
- Which psychological factors determine the relationship between price differentiation and user reaction?

This report aims to present results of certain case studies concerning psychological factors, which are potential determinants of the relationship between transport policy provisions and behavioural adaptation of transport users. Furthermore it contains the evaluation of the heuristic model, which was developed within Work-package 4 and thus the evaluation of the impact of psychological factors on user responses towards differentiated pricing. The related hypotheses will be evaluated in the light of the theory, the literature review and the results of the case studies. Based on this, conclusions and recommendations for an effective differentiation of charges will be given.

Within the theoretical framework of Work-package 4 an overview of relevant psychological theory is given, describing the relationship between differentiated charges, psychological constraints and behavioural adaptation with the help of the Stimulus-Organism-Response-Model (SOR-Model) of human behaviour. Stimulus (S) in this case means political instruments like price differentiation or the communication of a pricing system. The reaction (R) represents mobility or travel behaviour and the organism (O) symbolises the psychological determinants in terms of cognitive, motivational, situational and personal factors. The analysis of theoretical knowledge has identified many potential psychological determinants of user reaction, which can depend on cognitive, motivational, personal or situational factors. Table 1-1 shows an overview of identified transport policy, psychological and behavioural aspects concerning differentiated pricing, integrated into the SOR-Model.

**Table 1-1: Overview of Transport Policy, Psychological and Behavioural Aspects of Differentiated Pricing as Identified in Deliverable 4.1. (Hoffmann et al., 2006)**

| Stimulus | Organism → | | | Response |
|---|---|---|---|---|
| **Transport Infrastructure Use Charging** | **Cognitive Factors** | **Motivational Factors** | **Personal Characteristics and Situational Factors** | **Behavioural Adaptation** |
| • Price differentiation<br>• Modus of payment<br>• Information provision<br>• Availability / Use of aids and advice systems<br>• Price variability<br>• Enforcement, sanctions, penalties | • Information processing<br>  ○ (price) perception and storage / knowledge<br>  ○comprehension<br>  ○ mental capacity<br>• Reference prices<br>• Heuristics<br>  ○ anchoring and framing<br>• Psychological costs/ Cognitive comfort<br>• Demand on attention<br>• Experiences and expectations | • Acceptability<br>  ○ Personal goals<br>  ○ Problem perception<br>  ○ Perceived effectiveness<br>  ○ Outcome expectations<br>  ○ Perceived fairness<br>  ○ Social norms<br>• Perceived behavioural control<br>• Disengagement<br>• Habits<br>• Economy<br>• Personal involvement<br>• Negative emotions<br>• Trust | • Personality type<br>• Gender<br>• Age<br>• Education<br>• Income<br>• Type of journey<br>• Time pressure | • Higher decisions on mobility and driving behaviour<br>  ○ Residence location<br>  ○ Work location<br>  ○ Leisure activities<br>  ○ Car ownership<br>  ○ Vehicle selection<br>• Mobility behaviour<br>  ○ Modal choice<br>  ○Trip frequency / Trip suppression<br>  ○ Destination choice / Aggregation of destinations<br>  ○ Change in distance<br>  ○ Route choice<br>  ○ Ride sharing / Car Pooling<br>  ○ Change in timing<br>  ○ Compliance rate (errors / violations)<br>• Driving Behaviour<br>  ○ Style of driving<br>  ○ Speed choice |

### *Transport Infrastructure Use Charging*

In which way transport infrastructure use charges are framed by the government, together with infrastructure owners or operators, influences user response to transport prices. There are many possibilities to differentiate prices in the transport sector as prices can vary according to several dimensions and as they depend on different (political) objectives. However it has to be taken into account that the more dimensions are included in one charging system, the more complex a pricing scheme will be. In addition it is not just important to consider the price differentiation itself but also to observe the following factors influencing the efficacy of the pricing signal:

(i) *modus of payment*: paying directly and immediately and the payment that requires significant effort on the part of the user, will have a stronger effect on price perception and therefore on behaviour than indirect charges because they make people more aware of their expenditures;

(ii) *provision of information and advice*: the provision of adequate information (with the help of advice systems for example) is very important to explain the reason, the functioning and the aim of a complex pricing system and to make it comprehensible;

(iii) *stability of the prices and of the price structure*: frequent revisions of a pricing systems or dynamically varying charges are likely to make it difficult for consumers to learn the structure to take it into account in their behavioural choices;

*(iv) enforcement, sanctions and penalties:* if payment of the premium is enforced with large penalties and social disgrace for those who seek to cheat the system then we can expect it to have more effect.

### *Behavioural Adaptation*

Behavioural adaptation occurs as users respond to changes in the transport system. Important dimensions of mobility and driving behaviour are general aspects of transport use like mode choice, length of trip, route choice, time of driving, trip frequency or style of driving. There are various options that people actually employ to reduce their car use; for example, trip chaining, changes in mode choice and departure time etc. As travel behaviour is strongly linked to people's lifestyle, changes in the transport system might influence not only these daily routines but also higher decisions such as vehicle selection, leisure activities and choice of residence (Gärling, Eek, Loukopoulos, Fujii, Johansson-Stenman, Kitamura, Pendyala and Vilhelmson, 2002). Therefore we have to differentiate between behavioural adaptation that refers to short-term-, medium-term- or long-term decisions. The hierarchical structure of mobility behaviour (Schlag, Schade & Risser, in press) describes these three relevant decision- and behaviour-levels (Figure 1-1).

| Behaviour level | | Behaviour content | Environment | Time horizon |
|---|---|---|---|---|
| I | Higher decisions with consequences on mobility and driving behaviour | • Residence choice<br>• Workplace choice<br>• Leisure activities<br>• Car ownership<br>• Vehicle selection | Space structure<br>land use<br>road network<br>traffic supply | long-term |
| II | Mobility behaviour | • Mode choice<br>• Trip frequency<br>• Route choice<br>• Length of trip<br>• Time of driving | | medium-term<br>(routinized) |
| III | Driving behaviour | • Style of driving<br>• Speed choice<br>• ect. | Driving situation | short-term<br>(automatized) |

**Figure 1-1: Hierarchical Structure of Mobility Behaviour (Schlag et al., in press)**

The superior level includes long-term (life-style) decisions which do not directly concern mobility behaviour but which both affect, and are affected by, this behaviour. They include decisions on place of residence or place of work and therefore about spatial relations that have to be managed in future. Decisions on car ownership or on the type of car also belong to this level. Decisions at this stage are made infrequently and with some care and may have long-term consequences and tend to constrain decisions at the lower levels. The medium-term level of mobility behaviour includes mode choice and other decisions which directly affect traffic participation. These decisions refer to concrete trips and to intentions that will influence driving behaviour. The third level describes the short-term aspects of concrete driving behaviour.

Decisions at the first and second level underlie habits and are thus hard to change. Higher order life-style decisions can create objective constraints whereas habituation on mobility behaviour causes subjective constraints, which are seen as unchangeable. Driving behaviour is characterised by strong preferred habits which are supported by automatisms. Thus we see impediments to changes in mobility behaviour on all levels as they are associated with high costs.

But if behavioural changes become necessary, an adaptation occurs normally according to the "cost minimization principle" (Loukopoulos, 2005). This principle states, that people are unwilling to change their basic routines as a result of economic incentives or prices. They prefer the status quo as in other areas of life as well. If changes are necessary they will be kept as small as possible. As small as possible means that people want to maintain the present activity schedule (Gärling et al., 2002). Thus the type of strategy chosen will depend on the "psychological costs" associated with it. A wide range of adaptation alternatives including, for example, more efficient car use, suppressing trips, and switching travel mode are considered. These adaptation alternatives are argued to be implemented sequentially over time according to the cost-minimisation principle beginning first with the less costly and effective alternatives. The cost minimisation hierarchy may vary according to trip purpose. For instance, for work trips it might be easier to switch mode in order to maintain the activity schedule whereas for shopping or leisure trips other strategies such as trip chaining or changing destination will be more appropriate.

### 1.1.2 Cognitive Determinants of Price Evaluation

Research in cognitive psychology already provides knowledge about the cognitive limits of users faced with a differentiated charging scheme. Thus the perception and the knowledge of prices play an important role in users´ reactions. Whether a person can understand a pricing system and its communication depends on their prior knowledge and experiences. Experience with principles of differentiated charging in various domains of life may enhance people's understanding and acceptance of these principles in transport. But it also could be that these experiences are domain-specific and hardly transferable. For example, the introduction of yield management pricing by rail operators in e.g. Germany was met with heavy opposition while airlines use these principles successfully for years. However, it is not clear yet how experience influence user reactions. Furthermore there is always the question on cost of behavioural adaptation. Costs in this context include financial costs, but also psychological effort required to process the relevant information and change behaviour. Thus, the higher these psychological costs, the less likely a change in travel behaviour as a reaction to differentiated charging becomes. Processing lots of information is also restricted by people's limited attention span and mental capacity to process information.

For the purpose of attempting to understand consumer reactions to prices, the short-term memory (STM) and long-term memory (LTM) systems and their respective capabilities are the most critical aspects as both systems have a strong effect on the processes by which consumers acquire and use information such as prices (Jacoby & Olson, 1977). The LTM contains a seemingly unlimited number of symbols representing all stimuli in permanent storage. In contrast the STM system has a severely limited information storage capacity and there is a decay of symbols if one does not rehearse the information. That means that people are able to process only a certain amount of information at a time. When people are provided with too many and complex information (information flooding/overload), as might be the case with highly differentiated prices, capacity is exceeded and

consumers become overstrained. This may lead to poorer decisions as people are unable to understand it and adjust their behaviour accordingly (Engel, Blackwell and Miniard, 1990).

If the differentiation becomes too complex for individuals to understand, people tend to base their behaviour on a simplified mental model of the price structure. In contrast to systematic processing of information the use of such heuristics is a more limited processing mode that demands much less cognitive effort and capacity. There people focus on available information that enables them to use simple rules to formulate their judgements and decisions. This entails only minimal amounts of data collection and analysis. Heuristics are cognitive strategies which are often described as rules of thumb. These mental shortcuts are quite useful as they reduce complex problem solving tasks to more simple judgmental operations but also allow for a much greater chance of error. The results are suboptimal decisions which represent the price of simplification.

Another problem is cognitive comfort. This refers to psychological costs in terms of transaction costs and concerns the effort required to process complex information. People tend to object highly differentiated price structures as processing complex information tends to put them off because they are cognitive misers who do not want to waste effort. This means that they will be looking for ways to economise on their mental effort and, where possible, will tend to rely on heuristics. This is for example obvious in the telecommunication sector, where people often prefer fixed charges (Bonsall et al., 2004).

### 1.1.3 Motivational Factors

Even if a differentiated charging system is designed in a way that people would be able to understand it they may not be willing to do so. Therefore beside the cognitive aspects a central motivational factor that might influence user reaction toward differentiated pricing is acceptability. If users do not accept the system they may not make an effort to understand it. In such cases they may not change their behaviour to the extent they could, or may even resist making any change (consumer resistance to Deutsche Bahn AG's new fare system may be an example of this).

Acceptability is a hypothetical construct that refers to the (affirmative) attitude towards a specific object. Attitudes are relevant before the measure is introduced, i.e. when people are unfamiliar with the proposed concepts. When the measure is introduced, there is the assumption that the previous attitudes, among other things, guide peoples´ behaviour.

Within the heuristic model of acceptability by Schlag (1998) several factors have been identified which contribute to the acceptability of transport pricing measures. For the evaluation of such pricing systems the most relevant issues of acceptability seem to be:

(i) *personal goals*: there might be potential conflicts between different aims (political vs. travellers mobility aims) connected to transport pricing measures, which are crucial for the question of acceptability;

(ii) *problem perception*: the perception of traffic-related problems is a necessary precondition for regarding problem-solving measures as important;

(iii) *perceived effectiveness*: effectiveness refers to the degree to which the aims of the measure can be reached. Whether the proposed measures are perceived as being effective or not determines the acceptability of the measure;

(iv) *outcome expectations*: outcome expectation refers to the advantages and disadvantages that people expect from a pricing scheme for themselves. The more advantages they expect the more motivated to understand and accept the scheme they will be;

(v) *perceived fairness*: perceived justice or fairness are important prerequisites of acceptability. If fairness is tentatively operationalised as personal outcome expectations it is expected that the more people perceive advantages following the introduction of transport infrastructure use charges the more they will be willing to accept it;

(vi) *social norms*: social norms refer to the respondent's assumption about whether his significant others would think that he should accept the strategy. The more favourable the perceived social norm is with respect to a presented pricing strategy, the more acceptable should the strategy be to that individual.

The influence of acceptability on user reactions on prices will become even more important in the near future when people will have access to electronic assistance systems which will be able to calculate even the most highly differentiated prices. In this case user reactions will be less determined by restrictions in cognitive capacity, but even more by the attitude towards the price- and assistance systems including issues such as fairness, trust or social norms.

As described above, acceptability is strongly related to the willingness of users to deal with differentiated pricing systems. The complexity of such a charging system has an impact on user engagement and therefore on user reaction.

Bonsall, Stone, Stewart and Dix (2006) found out that a significant proportion of consumers 'disengage' if they perceive cost structures to be too complex. This disengagement sometimes leads them to delay the decision, avoid purchase, opt for the simplest or least uncertain option (if there are alternatives), or just pay up regardless. Qualitative evidence suggests that a proportion of the population would respond to complex charges by disengaging. This disengagement will sometimes take the form of paying the charge irrespective of its size, and sometimes deciding to adopt an option which avoids exposure to the charge. This could have profound implications for the performance of pricing schemes and for the structure of models used to predict behavioural responses.

### 1.1.4 Personal and Situational Factors

Inter-individual differences in the ability of dealing with complex information are due in part to cognitive abilities but the user's age, gender and education have to be taken into account when analysing consumer reaction to differentiated prices. Concerning elasticities it is often claimed that travellers with higher incomes tend to be less price sensitive than lower-income travellers. For example, Litman (2006) states that real income as well as age has a positive and statistically significant effect on mileage. However, income does not seem to affect the effort a person is willing to take to estimate costs of a trip (Bonsall et al., 2006). Qualitative research by Bonsall et al. (2006) has suggested that there are a number of "behavioural types" with different attitudes, preferences and behaviours, which are reflected via gender more than income. This is a very interesting result. In interviews the existence of three different personality types (or decision-making styles) was discussed: "determined/confident", "cautious", and "trusting" which are very similar to the known distinction into "maximizers" and "satisfiers" (Simon, 1955; Schwartz et al., 2002). 'Determined/Confident' people always try to get the best deal by spending time looking at different options and exploiting the opportunities provided by complex or highly differentiated price structures. 'Cautious' people wanted a good deal but were not able or not prepared to spend time ensuring they got one. They might shop around to an extent but go for something simple because they were put off by complexity. 'Trusting' people took what was on offer because they did not feel they could assess what was available or did not feel it was worth the effort. Some of these respondents characterised themselves as 'lazy', whilst others lacked confidence in their ability to judge deals. As mentioned before the distribution of the three types seems to be related to gender. Males were more likely to want to get the best deal, whereas females were more likely to be happy to take things on trust. But there was no effect for income. In psychological research, income is often seen as being related to acceptability but Schade (2005) found no direct impact of income on acceptability. The desired level of awareness of expenditure varies between people of different income, gender and age and differences also exist regarding the preferred payment method.

Peoples´ ability to understand complex pricing systems depends further on situational aspects such as the time available to deal with relevant information. If people are pressed for time when trying to find out an optimal decision on mobility behaviour regarding the price and their aims, they will have difficulties to process all relevant information to make a good choice. In this case they tend to use heuristics again. Another very important situational aspect is the type of the intended journey as trips

range in their value; emergency-, commuting- or major shopping-trips are higher-value trips and therefore inflexible even when conditions change.

## 1.2 HYPOTHESES AND METHODOLOGICAL APPROACH

Normally, economic theory would expect a positive relationship (monotonically increasing) between price differentiation and the effectiveness of a price signal. I.e., the more differentiated a pricing system is, the more choice is available and the more people will tend to adjust their behaviour and to find the best solution for themselves. However, evidence from psychology and economics suggests that although more choice does provide additional benefits, it also imposes extra costs. Things are getting more and more complicated with additional options. More time and effort has to be invested to find the 'best' solution. As the number of choice increases and things are getting very complicated, it is assumed that the negatives escalate until people become overloaded. There are several constraints on people's response to differentiated prices which depend on cognitive, motivational, personal or situational factors.

The appropriate psychological approach regarding the most important factors and how they influence user response is shown in Figure 1-1. We assume a non-monotonically increasing relationship between the effectiveness of a pricing system (the degree of behavioural adaptation) and the price differentiation. There is a point, beyond which, the more differentiated a price structure, the less behavioural adaptation will occur. This relationship is in line with the effort people are ready to expend dealing with the new pricing system. If the differentiation is low, it is not necessary to make a high effort to understand the pricing system because it is quite easy. With an increasing price differentiation the required effort to handle the pricing structure rises, too. When the pricing system becomes too complicated for people to understand, they will reduce effort (e.g. use of heuristics, c.f. section 1.1) or even start to avoid dealing with the pricing system. Furthermore this relationship is mainly influenced by cognitive and motivational factors. So far it seems that the cognitive capacities of individuals as well as acceptability play an important role because they constrain ability as well as willingness to process information on highly differentiated pricing systems. But it is also important to take personal (socioeconomic) as well as situational factors (time pressure) into account when observing this relationship, because they can have an influence on behavioural adaptation, affecting the cognitive and motivational variables.

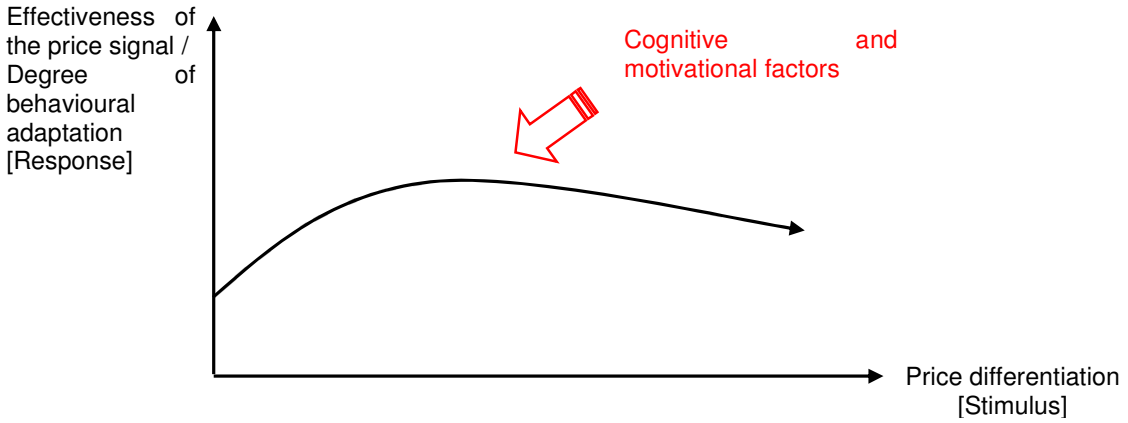



**Figure 1-2: Hypothesised Relationship between Behavioural Adaptation and Price Differentiation – Psychological Approach**

### Hypotheses

The following section presents the developed hypotheses about which degree of differentiation people are able to understand and to respond to charging and which are the psychological factors that determine this degree of differentiation.

According to the analysis of theoretical and empirical knowledge, two categories of hypotheses have been generated: main hypotheses, regarding the relationship between transport infrastructure use charges and behavioural adaptation, and sub-hypotheses, concerning determinants which describe psychological factors that affect behavioural responses on differentiated charges. As there is little empirical evidence, and since much of that what exists is controversial, it will be quite difficult to compose clear hypotheses on every aspect. It is therefore sometimes necessary to prioritise research questions. Furthermore there will be some variables, which have been identified while analysing theoretical knowledge (c.f. Table 1-1), but which are not included in the hypotheses. As it is not possible to observe all of the described aspects within Work-package 4, the focus is on those variables which may be the most important ones.

Thus the following sections include a set of possible hypotheses, which should be tested within this deliverable. But it has to be stated that this was only possible, where appropriate data have been available.

### Main-Hypotheses

As first step main-hypotheses have been formulated, which express the relationship between the independent (user charges) and the dependent variables (behavioural adaptation).

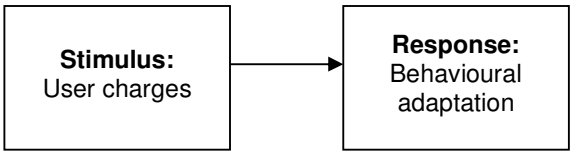



**Figure 1-3: Relationship between Independent and Dependent Variables**

According to the assumed relationship between behavioural adaptation and price differentiation (Figure 1-3) the following hypotheses are formulated:

1. *There is a point, beyond which, the more differentiated a price structure, the less behavioural adaptation will occur.*

As illustrated in Table 1-1 not only the price level and the degree of differentiation might influence behavioural adaptation but also, among others, the modus of payment. According to the prospect theory it is assumed, that pricing schemes that highlight losses are more likely to motivate behavioural changes than pricing schemes which highlight incentives.

2. *Modus of payment has an effect on behavioural adaptation according pricing schemes.*

Furthermore, it is assumed that different elements of differentiation affect users' dealing with pricing schemes in another way and, thus, these elements have different effects on likelihood of behavioural changes. Pricing schemes that use differentiation elements user are familiar with ease users information processing and increases the likelihood of adequate responses towards pricing schemes.

3. *Pricing schemes which include differentiation elements users are familiar with or /and which are in line with easy human information processing increase the likelihood of behavioural adaptation according the schemes.*

### Sub-Hypotheses

The sub-hypotheses concentrate on determinants describing psychological factors that affect and explain behavioural responses on differentiated transport infrastructure use charges. Thus they are focussed on the interfering variables that connect independent and dependent variables (Figure 1-4).

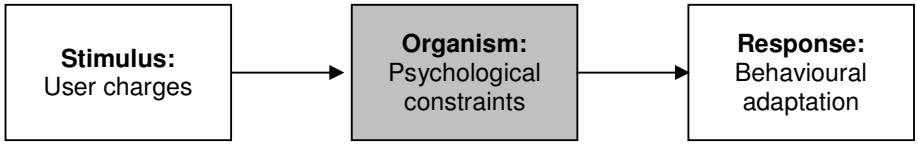



**Figure 1-4: Relationship between Independent and Dependent Variables, Explained by Interfering Variables**

In the following sections the sub-hypotheses are divided into the three different dimensions of psychological constraints: cognitive, motivational and personal / situational factors.

### Cognitive Factors

In section 1.1 it is explained that people have limited cognitive capacities to process information. When a pricing system becomes too complicated, simpler strategies to process information will be used, which are called heuristics. The use of heuristics entails only minimal amounts of data collection and analysis, but they can lead to suboptimal decisions as they allow for a much greater chance of error. Furthermore previous knowledge and experience with similar pricing systems can have a positive effect on understanding.

1) *The occurrence of errors in estimating prices and adjusting behaviour will be a positive function of the differentiation of the price structure.*
2) *An individuals´ ability to understand the charging system and to adjust behaviour will be a positive function of their prior experience of similar price structures.*

### Motivational Factors

Section 1.1 clearly discusses the importance of motivational factors for an analysis of user reaction on differentiated prices. Here especially acceptability of such a measure which its facets, as well as engagement and personal involvement play a major role.

3) *An individuals´ motivation to adjust behaviour will be a positive function of their acceptability of the system.*
    - *Acceptability is a positive function of perceived fairness.*
    - *Acceptability is a positive function of perceived effectiveness.*
4) *An individuals´ motivation to adjust behaviour will be a positive function of their personal involvement.*
5) *An individuals´ degree of engagement will be a positive function of their motivation to adjust behaviour.*

### Personal and Situational Factors

Section 1.1 describes the impact of situational and personal factors on user reaction towards differentiated prices. There have been some interesting assumptions regarding personality, education and income of travellers as well as the type of the trip, which lead to the following hypotheses:

6) *An individuals´ engagement with the charges and their motivation to adjust behaviour will depend on their type of personality.*

7) *An individuals´ motivation to adjust behaviour will be a negative function of their disposable income.*

8) *An individuals´ ability and motivation to adjust behaviour will be a positive function of their education.*

9) *An individuals´ ability and motivation to adjust behaviour will depend on the type of trip: Commute trips tend to be less elastic than shopping or recreational trips.*

### Research Questions

As there are some theoretical predictions of users´ behaviour where there are no explicit hypotheses possible so far, although the relevant variables are seen as important, the following research questions are formulated. Additional hypotheses related to these questions will be developed where possible.

1. *Does a highly differentiated charging system make people avoid such systems?*

It is stated that people often prefer fixed charges because they want to avoid uncertainty in their domestic budget and generally prefer simplicity to complexity because of the lower cognitive effort associated with simple systems. One response to charges which are perceived to be too complicated is simply to seek to avoid exposure to such prices and another is to pay the charges without thinking about them.

2. *How does age and gender influence the ability and motivation to deal with differentiated pricing systems and how does it affect transport behaviour?*

Concerning the relationship between socio-economic factors and transport choices there have been contradictory results. Age- and gender-related travel behaviour should be taken into account when implementing a new charging structure. It is particularly important to consider age-related differences in understanding and acceptability of such a system because elderly people may have problems to understand a highly differentiated pricing system when there are no adequate information or advice systems.

3. *Is the risk of counterproductive effects of price differentiation higher with personal travel than with transport companies?*

Psychological constraints influence individual travellers´ reaction to differentiated prices. In contrast to that it is assumed that logistics and freight operators act more rationally. Therefore negative impacts are expected from highly differentiated pricing systems in the personal travel sector more than in transport companies, which are faced with differentiated pricing. Another important aspect is whether this also applies to smaller companies. So far there is little evidence concerning this.

### Methodological Approach

To test hypotheses and research questions empirical data from several case studies has been examined. A total number of 10 case studies are selected with respect to suitability of answering formulated hypotheses and research question. 7 out of 10 case studies are field experiments / field surveys which consider user responses to differentiated pricing within several transport sectors (car, freight operator, and freight / rail road passengers). In addition to this 3 laboratory experiments have been conducted to examine users' dealing with pricing schemes under more controlled conditions.

provides an overview about the case studies and to the related research questions and hypotheses certain case study aims for examine. Available data do not allow a complete examination of entire

hypotheses set within anyone case study. In some cases hypotheses have been adapted according available data and variables conducted within the case studies.

**Table 1-2: Overview about Case Studies and Considered Factors**

| | CASE STUDIES | Main - hypotheses (Price signal → Response) | Sub - hypotheses | | |
|---|---|---|---|---|---|
| | | Price signal→ behavioural adaptation (Price signal→stated preferences) (Price signal→ handling) | Cognitive factors | Motivational factors | Situational and personal factors |
| 1 | AKTA road pricing experiment | X | | X | X |
| 2 | Newcastle survey | X | X | X | X |
| 2 | Edinburgh demonstration trial | | | X | X |
| 4 | Dft/Grace | X | X | | X |
| 5 | Laboratory experiment Dresden I | X | X | X | X |
| 6 | Laboratory experiment Leeds | X | X | X | X |
| 7 | Laboratory experiment Dresden II | X | X | X | |
| 8 | Survey on Freight operators | X | X | X | X |
| 9 | Kirkcaldy Hovercraft trial | X | | X | X |
| 10 | Yield management Railroad | X | | X | |

# 2 CAR DRIVERS

## 2.1 CASE STUDIES REGARDING CAR USERS RESPONSE TOWARDS DIFFERENTIATED PRICES

### 2.1.1 The AKTA Road Pricing Experiment in Copenhagen

#### *Introduction*

This section presents evidence from a road pricing experiment conducted in Copenhagen. The AKTA road pricing experiment was the Danish part of the EU project PROGRESS[1], where road pricing was examined by various approaches in 8 European cities (AKTA, 2005; Nielsen & Sørensen, 2007). AKTA is a Danish abbreviation for "alternative driving and congestion charging". The purpose of AKTA was to test whether road user charges will change travel behaviour and to examine public acceptability of these charges.

The main part of AKTA was a field experiment where 500 car users volunteered for trying "virtual" road pricing systems between autumn 2001 and spring 2003 by the use of a GPS-technique. Three different pricing schemes were tested, a multiple zone/cordon pricing scheme and two kilometre based pricing schemes with different levels of charging (see Figure 2-1). Since realistic and planned levels of road pricing were tested, the experiment is close to a real scheme. The field trial was complemented with focus group and stated-preference interviews (Herslund, 2007; Nielsen & Vuk, 2007).

This case study is based on the PhD project "Public acceptability and travel behaviour change in response to urban road pricing" (Gehlert & Nielsen, 2007; Gehlert, 2008; Gehlert, Nielsen, Rich & Schlag, 2008) which uses a subset of the original AKTA data. This case study uses the same data subset to investigate the impact of differentiated pricing on public acceptability and travel behaviour. The three different pricing systems implemented in AKTA varied in their:time differentiation,

- spatial differentiation and
- payment mode.

As set out in Deliverable 4.1, we intend to establish whether these differences influence behavioural adaptation. In addition the impact motivational factors and personal characteristics on behavioural adaptation will be analysed. In Deliverable 4.1 public acceptability was identified as a central motivational factor that might influence user reaction toward differentiated pricing (Hoffmann, Schade, Schlag & Bonsall, 2006). Thus in this case study behavioural adaptation will be analysed in relation to public acceptability. Furthermore, income and gender have been identified as important constraints on user reactions to complex price signals. Therefore, behavioural adaptation as well as public acceptability will also be analysed in relation to income and gender.

#### *Research Questions and Hypotheses*

Based on section 1.2 and with respect of available data research questions and hypotheses have been adapted as follows:

**Research Question 1a: How does time differentiation of urban road pricing schemes influence behavioural adaptation?**

Hypothesis 1: More time differentiation leads to more behavioural adaptation.

[1] http://www.progress-project.org/

To analyse this question the pricing scheme with charges in peak hours only will be compared with another pricing scheme and cordon pricing scheme, where the whole day was charged and the charge was doubled in peak hours (see Table 2-1).

Behavioural adaptation will be observed on a short-term level and on a medium-term level (Figure 1-1). On a short-term level changes in driving behaviour and especially in speed choice will be investigated. On the medium-term changes in mobility behaviour will be analysed using objective as well as subjective indicators. Objective indicators are the average trip frequency, trip distance and trip duration measured with the GPS-device in the private cars of the participants. Subjective indicators are the stated adaptation strategies asked in the questionnaire after the experiment.

**Research Question 1b: How does spatial differentiation of urban road pricing schemes influence behavioural adaptation?**

Hypothesis 2: More spatial differentiation leads to more behavioural adaptation.

This question will be analysed comparing the cordon pricing scheme with 11 cordons with the pricing schemes with only 4 pricing zones. Behavioural adaptation will be measured as described for research question 1.

**Research Question 2: How does the payment mode influence the car user's reaction towards urban road pricing?**

Hypothesis 3: A payment mode corresponding to a bonus system is more acceptable than a payment mode corresponding to a malus system.

Hypothesis 4: A payment mode corresponding to a bonus system leads to less behavioural adaptation than a payment mode corresponding to a malus system.

This question will be analysed by comparing participants of one pricing scheme from the first and second round of the experiment with the participants of the same pricing scheme from the third round. As described below the payment mode of the first two rounds of the experiment was equivalent to a bonus system whereas in the third round it was equivalent to a malus system. That means, in the first two round participants received a reward (bonus) if they changed their behaviour. In the third round, they could avoid a punishment (payment) by changing behaviour.

The differentiated reaction towards gains and losses as implemented in a bonus and malus system is described by prospect theory and in particular by the phenomenon of loss aversion (Kahnemann & Tversky, 2000). Loss aversion refers to the tendency for people strongly to prefer avoiding losses than acquiring gains. Some studies suggest that losses are twice as powerful, psychologically, as gains (Thaler, 1980). Loss aversion leads to risk aversion when people evaluate a possible gain and risk seeking when avoiding a possible loss. Thus a difference in user reaction is predicted for the same pricing scheme once framed as gain (the bonus system) versus as loss (the malus system). First it is predicted that people will adapt their travel behaviour more strongly in the malus system than in the bonus system, since losses loom larger than gains. Second, it is predicted that because of the tendency to avoid losses more strongly than to acquire gains people will accept a bonus system over a malus system.

**Research Question 3: How does the acceptability of urban road pricing schemes influence the behavioural adaptation?**

Hypothesis 5: Higher acceptability of urban road pricing leads to more behavioural adaptation.

In Deliverable 4.1 it was hypothesised that motivational factors might influence behavioural adaptation - that even if people understand a differentiated pricing scheme they might not be willing to do so. More specifically, it is hypothesised that a positive attitude towards the pricing schemes leads to more behavioural adaptation.

**Research Question 4: How do personal characteristics in particular income and gender influence the behavioural adaptation and public acceptability?**

Income and gender have been identified as having a potential effect on user reactions to complex price signals. But the influence of these variables on travel behaviour has often just been controlled. Findings from studies where the impact of socio-economic aspects was taken into account do not always agree with each other. Some of them claimed that gender or income do not have an effect at all (e.g. Thögersen 2001, Litman 2006). Some results however reveal that perceptions, attitudes and evaluations towards pricing strategies are influenced only to a very low extent by respondents´ socio-economic status (e.g. Bonsall et al., 2006; Schade, 2005). Thus, in this case study the impact of gender and income is explored but no precise hypothesis is formulated

## *Method*

### Procedure

The metropolitan area of Copenhagen was equipped with a virtual urban road pricing system (see Figure 2-1). The area was divided into four pricing zones with different price levels. The charge per zone increased as car users drove closer to the city centre. Private cars of voluntary test drivers were equipped with a GPS-based on board Unit (OBU) (see Figure 2-2). This GPS-device displayed the virtual cordon rings and zones and dynamically calculated the pricing level. The cars' movements were logged in the system, and a payment was calculated for every trip. The participant could see for a given trip the pricing level (zone), be noticed on zone shift (cordon), and read the cumulated cost of the trip.

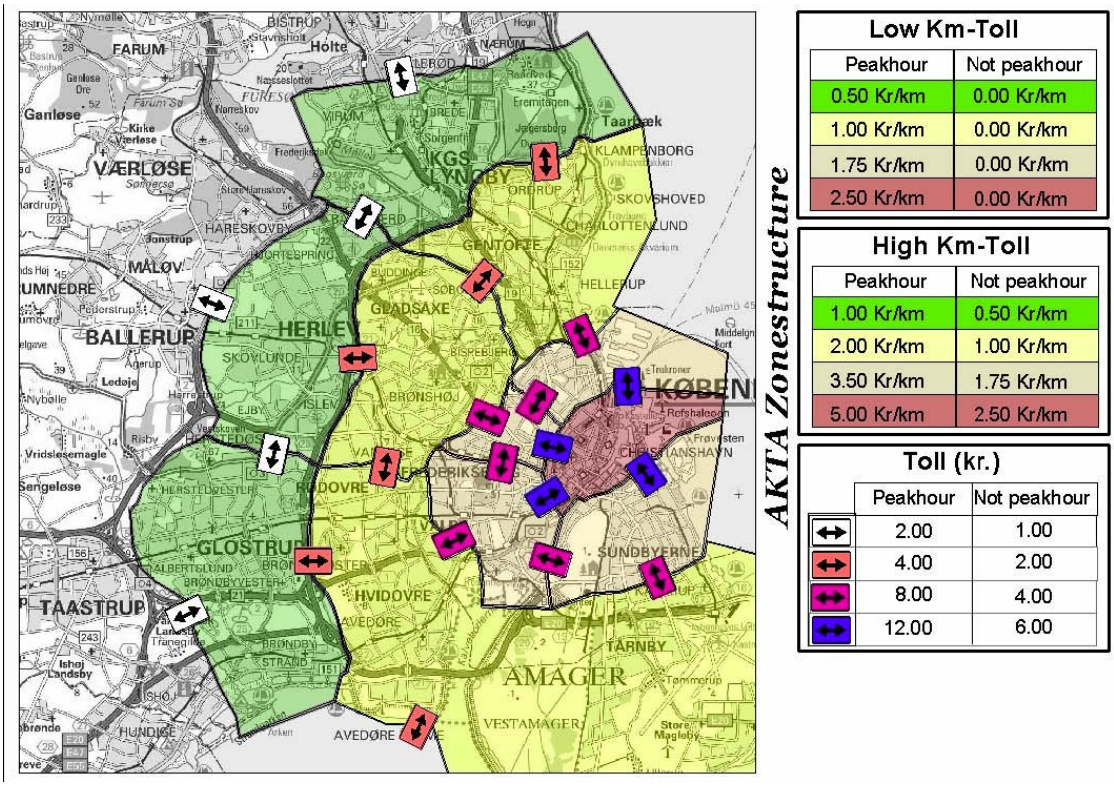



**Figure 2-1: Pricing Zones and Structure (charges in DKK, 1 DKK = 0.13 €)**


**Figure 2-2: GPS-device Simulating Road Pricing**

On that basis three different urban road pricing schemes were designed. Two pricing schemes were distance-based with four different pricing levels per km with the most expensive in the inner city, and the cheapest in the suburbs. The low and the high kilometre toll schemes differ only among by the level of the charges (see Figure 2-1, Table 2-1). The third scheme was a cordon based system with payment for zone border crossings. The pricing was higher at peak than off-peak hours for all scenarios. Table 2-1 summarises the characteristics of the three different pricing schemes.

**Table 2-1: Description of the Three Urban Pricing Schemes[2]**

| | **Low kilometre toll scheme** | **High kilometre toll scheme** | **Cordon pricing scheme** |
|---|---|---|---|
| Type of charge / Calculation basis | Distance-based/ Number of kilometres driven | | Cordon-based / Number of cordon crossings |
| Operation hours | weekdays, all hours | | |
| Spatial differentiation | 4 zones with increasing charges to the city centre | | 11 cordon, with increasing charges to the city centre |
| Time differentiation | Charging only in peak hours | Charging double in peak hours | |
| Level of charge | 0.07€/km - 0.33€/km | off peak: 0.07€/km – 0.33€/km<br>peak hour: 0.13€/km – 0.67€/km | off peak: 0.13€/crossing – 0.80€/crossing<br>peak hour: 0.26€/crossing – 1.61€/crossing |

Peak hours: 7 – 9.30 am and 3 -5:30 pm

The impact of these different pricing systems on travel behaviour was compared with a control period (repeated measurement design). In the control period there were no pricing for road use and the display was turned off such that the participants were not expected to change behaviour at this time. One group of participants for each pricing scheme completed the control period before the pricing scheme and one group afterwards.

The field experiment was carried out in three successive rounds. The design and the duration of the pricing schemes as well as the payment mode differed between the rounds. In the first two round all three pricing schemes were simulated whereas in the third round only the high kilometre scheme was implemented (Nielsen, 2004). The duration of the pricing schemes was prolonged from 4 weeks in the first round to 7 and 10 weeks in the second and third round.

The payment mode was changed in the third round of the experiment as well. After initial analyses of the results from the first and second rounds - especially the responses from the focus group interviews - it was suspected that the original payment mode did not resembled real life conditions under road pricing. That is earning money is not the same as paying money. In the first two rounds the expected payments for the participant's usual driving pattern were estimated. After completion of the field trial

[2] In order to simplify matters, in the following text "high kilometre scheme" and "low kilometre scheme" are used as synonyms for high kilometre toll scheme and for low kilometre toll scheme.

participants were reimbursed the difference between their behaviour in the control condition and their actual behaviour in the pricing condition. Hereby participants were rewarded for (positively) changed behaviour though never facing the risk of additional payment. To validate this in the third round it was decided that all participants were paid money according to their actual travel pattern in their control period. They were then explained that a similar amount would be invoiced after the test if they did not change behaviour.

### Sample

The sample of the AKTA experiment consisted of 500 participants. All participants belonged to one-car families. Household members that were the most frequent user of the car were recruited in order to relate the car movements to individual travel behaviour. All participants resided and/or had their workplace within the road pricing area and had a daily need of transport (Nielsen, 2004).

As stated above, all participants were volunteers. Hence, volunteer biases of the results are not entirely excludable. Voluntary participants might be more interested in issues concerning road pricing and / or approve road pricing measures more strongly than others, thus, biased pre-selections by mentioned matters are possible. Due to this pre-selection it might be further possible that acceptance values are higher and / or behavioural adaptations are stronger within the sample than within the population.

This case study uses a subset of the original AKTA sample. The following participants were excluded from the analysis:

- participants that were exposed to two pricing schemes without a control period;
- participants that did not complete the whole experiment;
- participants where the trip-based car-use data was missing due to technical failure (Nielsen, Kristensen & Würtz, 2003).

The final sample consisted of 252 participants. The sample size and distribution among the three different pricing schemes is shown in Table 2-2.

**Table 2-2: Sample Size and Distribution**

| | Overall | Cordon | High | Low |
|---|---|---|---|---|
| Pricing/Control | 89 | 20 | 34 | 35 |
| Control/Pricing | 163 | 23 | 106 | 34 |
| | 252 | 43 | 140 | 69 |

The socio-demographic characteristic of original the sample is described in Table 2-3.

**Table 2-3: Socio-demographic Characteristics of the AKTA Sample**

| | Overall | Cordon | High | Low |
|---|---|---|---|---|
| Gender (% men) | 68.5 | 65.1 | 70.5 | 66.7 |
| Age (%) | | | | |
| (1) under 30 years | 10.3 | 16.3 | 8.6 | 10.1 |
| (2) 30 -39 years | 25.4 | 25.6 | 29.3 | 17.4 |
| (3) 40 -49 years | 27.8 | 25.6 | 29.3 | 26.1 |
| (4) 50 -59 years | 29.4 | 30.2 | 25.7 | 36.2 |
| (5) 60 years and above | 7.1 | 2.3 | 7.1 | 10.1 |
| Median | 3 | 3 | 3 | 3 |
| Household income in thousand DKK per year (%) | | | | |
| (1) 0 - 99 | 0.4 | 0 | 0.7 | 0 |
| (2,3) 100 - 299 | 6.0 | 18.6 | 4.3 | 1.5 |
| (4) 300 - 399 | 12.0 | 25.6 | 10.1 | 7.4 |
| (5) 400 - 499 | 13.3 | 9.3 | 16.7 | 8.8 |
| (6) 500 - 599 | 24.1 | 9.3 | 27.5 | 26.5 |
| (7) 600 - 699 | 17.3 | 2.9 | 14.5 | 20.6 |
| (8) 700 - 799 | 14.5 | 9.3 | 14.5 | 17.6 |
| (9) 800 - 899 | 6.8 | 2.3 | 5.8 | 11.8 |
| (10) 900 - 999 | 2.8 | 0 | 4.3 | 1.5 |
| (11) 1000 and above | 2.8 | 4.7 | 1.4 | 4.4 |
| Missing (%) | 1.19 | 0 | 1.43 | 1.45 |
| Median | 6 | 5 | 6 | 7 |
| Weekly driving distance in km (M (SD)) | 300.67 (185.13) | 263.51 (140.22) | 266.52 (176.19) | 355.74 (204.80) |

There are significant differences between the participants of the three pricing schemes for the household income and the weekly driving distance ($p < .01$). There are more participants with lower income in the cordon pricing scheme compared to the high and low kilometre pricing scheme. Participants in the low kilometre pricing scheme indicate a higher weekly driving distance compared to the high kilometre and cordon pricing scheme.

### Measurements

Participants completed one questionnaire before and one after the experiment. The first questionnaire was filled in during an information meeting before the actual start of the experiment. The second questionnaire was sent to the participants after the experiment, filled in and mailed back to the investigators.

Public acceptability of four different transport pricing systems was measured before and after the experiment:

- the current Danish car tax system,
- the principle of road pricing,
- a peak-hour charge in the morning and evening peak-hour and
- a package solution including road pricing and the preferred revenue use.

For each of these schemes one question asked to what degree participants regarded them as good systems. Ratings were obtained on a three-point scale (1= good, 2= neither nor, 3= bad).

Behavioural adaptation was measured using the GPS-based device in the private cars of the participants. It logged the coordinates of the car each second. After the experiment was completed this GPS-coordinates were combined to trips (Nielsen, 2004a). Based on this data the following trip indicators were available for the control as well as the pricing condition:

- number of trips,
- trip distance,
- trip duration,
- trip speed and
- trip costs.

Because of the technical implementation of the experiment participants did not drive exactly the same number of days (Nielsen, 2004). Therefore these car-use indicators were qualified for the number of days driven in the control and pricing condition. The trip costs were calculated for the control and the pricing period for comparison, even though participants were shown the charges only in the pricing period. The trip costs were calculated according to the relevant pricing scheme (see Figure 2-1).

The questionnaire after the experiment asked which strategies the participants have used to adapt to the pricing condition. One question asked to what degree participants have employed the following behavioural adaptation strategies:

- reduce car-use,
- trip chaining,
- change departure time,
- car pooling,
- avoid expensive areas,
- switch to public transport,
- use other cars than the GPS-equipped one and
- postpone trips until the end of the experiment.

The first six strategies are common behavioural adaptation strategies to pricing measures whereas the last two strategies are unique possibilities within the experimental setting. They can be regarded as the degree of compliance with the pricing schemes. The ratings were obtained on a four-point scale (1= no, 2= to a lesser degree, 3= to some degree, 4= yes).

A second question asked participants to indicate which route choice principle they were following in the pricing condition (fastest route, cheapest route, shortest route, usual route or super ordinate roads). For this question more than one answer was possible.

### *Results*

In the first section the results for the differences in behavioural adaptation in relation to time and spatial differentiation of the pricing schemes will presented. Following the differences in behavioural adaptation and public acceptability in relation the different payment modes of the high kilometre pricing scheme are described. The next section presents the results of the relationship between public acceptability of urban road pricing and behavioural adaptation. Finally, the impact of personal and situational characteristics on user reactions towards differentiated charging is presented.

### Time Differentiation and Spatial Differentiation

#### *GPS-Based Trip Indicators*

Table 2-4 shows the mean values and the standard deviations for the GPS-based indicators in the control period of the experiment. In the control period participants drove on average per day four and a half trips, with an average trip speed of 40 km/h per day, an average trip distance of 36 km and trip duration of about 55 minutes. It was calculated that participants would have to pay on average 3.20 € per day with this travel pattern.

The comparison of the GPS-based trip indicators between the three pricing schemes indicates differences between the low kilometre pricing system and the other two pricing schemes. Participants in the low kilometre pricing scheme drove on average per day statistically significant longer distances and which took the more time compared to the other two pricing systems ($H(2, N = 252) = 11.17$, $p < .01$; $H(2, N = 252) = 11.73$, $p < .01$).

**Table 2-4: GPS-Based Trip Indicators before the Experiment (*M (SD)*)**

| | Overall | Cordon | High | Low |
|---|---|---|---|---|
| Number of trips | 4.60 (1.91) | 4.23 (1.87) | 4.58 (1.87) | 4.87 (2.00) |
| Trip distance (km) | 36.43 (16.51) | 32.72 (15.53) | 35.03 (16.02) | 41.49 (17.11) |
| Trip duration (min) | 54.16 (20.52) | 49.92 (22.27) | 52.58 (20.32) | 60.00 (18.80) |
| Trip costs[a] (DKK[b]) | 23.83 (15.62) | 19.60 (12.54) | 31.22 (15.49) | 11.46 (5.88) |
| Trip speed (km/h) | 39.84 (7.64) | 38.76 (7.38) | 39.59 (7.44) | 41.03 (8.14) |

[a] calculated according to the relevant pricing scheme
[b] 10 DKK is approximately equal to € 1.34

Table 2-5 presents the mean values and standard deviations of the GPS-based indicators in the pricing period of the experiment and the difference compared to the control period. Overall all participants reduced their trip indicators. Participants reduced their trip costs on average per day by 0.45€. Their average trip distance per day decreased by about two and a half kilometre and the trip duration by five minutes. The average number of trips decreased by 0.32 trips. Only the average trip speed increased slightly by 0.72 km/h. That means, all behavioural effects that are intended with road pricing have been observed.

The descriptive results also indicate differences in behavioural adaptation between the pricing schemes. Participants of the high kilometre pricing scheme reduced their GPS-based trip indicators most, followed by the participants of the cordon pricing scheme. Participants of the low kilometre pricing scheme reduced their GPS-based trip indicators least. Only the number of trips and the trip speed do not follow this pattern. The participants of the low kilometre pricing scheme reduced their average trip speed whereas the participants of the other two pricing schemes increased their average trip speed. For the number of trips the participants of the cordon pricing scheme reduces them least.

**Table 2-5: GPS-Based Trip Indicators in the Pricing Period of the Experiment and the Difference Compared to the Control Group (M (SD))**

| | Overall | | Cordon | | High | | Low | |
|---|---|---|---|---|---|---|---|---|
| | Pricing period | Difference* | Pricing period | Difference * | Pricing period | Difference * | Pricing period | Difference * |
| Number of trips | 4.28 (1.84) | -0.32 (10.51) | 4.24 (1.95) | +0.02 (1.16) | 4.13 (1.84) | -0.45 (1.13) | 4.60 (1.77) | -0.28 (1.00) |
| Trip distance (km) | 33.86 (17.16) | -2.57 (10.51) | 30.54 (12.73) | -2.20 (12.04) | 32.01 (16.65) | -3.02 (10.74) | 39.69 (19.30) | -1.90 (9.02) |
| Trip duration (min) | 49.44 (20.75) | -4.72 (13.79) | 47.47 (19.40) | -2.44 (16.57) | 45.95 (19.54) | -6.63 (13.09) | 57.75 (21.86) | -2.25 (10.98) |
| Trip costs[a] (DKK[b]) | 20.42 (13.43) | -3.41 (9.74) | 16.93 (12.44) | -2.66 (10.11) | 26.08 (13.43) | -5.14 (11.24) | 11.08 (6.24) | -0.38 (3.58) |
| Trip speed (km/h) | 40.56 (8.33) | +0.72 (5.64) | 38.97 (7.63) | +0.16 (6.89) | 41.14 (8.38) | +1.55 (5.65) | 40.40 (8.63) | -0.63 (4.42) |

[a] calculated according to the relevant pricing scheme
[b] 10 DKK is approximately equal to 1.34 €
* compared to control group

A two-way ANOVA using the difference scores between control and pricing condition was used to test for three different sources of variance as well as accounting for the baseline differences between the different experimental groups.

First, a treatment effect was analysed by interpreting the constant term of the ANOVA statistics. This treatment effect indicates whether the implementation of pricing as such leads to a behavioural adaptation. Second, it was analysed whether the three pricing systems yield differentiated effects on the behavioural adaptation. Simple contrasts were calculated in order to test this assumption. To analyse research question 1 - the time differentiation of the pricing schemes - the low kilometre pricing scheme served as the reference category with which the cordon and the high kilometre pricing scheme were compared. To analyse research question 2 – the spatial differentiation of the pricing schemes – the cordon pricing scheme served as reference category with which the high and the low kilometre pricing scheme were compared. Third, the different sequence of experimental conditions needed to be included as another factor (see Table 2-2).

Both analyses yield similar results. The treatment effect is statistically significant for all trip indicators except the average trip speed. That means the implementation of pricing as such lead to significant reduction in the GPS-based trip indicators whereas the increase in the average trip speed is not significant. The test drivers did adapt their mobility behaviour whereas the average trip speed did not change. Furthermore, there were significant differences concerning the sequence of experimental conditions for the average number of trips, the trip duration and the trip costs. The reason for this result is explained in more detail in Gehlert (2008). The effect sizes for all statistically significant effects are classified as small.

Differences between the three pricing schemes over and above the pricing as such were found for the average trip costs and the trip speed. That means there are significant differences in the reduction of the average trip costs and the average trip speed between the pricing schemes. This indicates differentiated effects of the three pricing schemes on these two trip indicators. The question now is whether these differences correspond with the contrasts defined to analyse time and spatial differentiation.

To analyse the effects of time differentiation on behavioural adaptation the low kilometre pricing scheme served as the reference category with which the cordon and the high kilometre pricing scheme were compared. For the average trip costs a significant contrast effect was found for the comparison between low vs. high kilometre pricing scheme ($t(252) = 2.65$, $p < .01$), but not for the

comparison between the low vs. cordon pricing scheme (t (252) = 1.16, n.s.). The same holds true for the average trip speed (t (252) = - 2.45, p < .05; t (252) = - 0.71, n.s.).

To analyse the spatial differentiation of the pricing schemes the cordon pricing scheme served as reference category with which the high and the low kilometre pricing scheme were compared. There were not significant contrast effects, neither for the average trip costs (cordon vs. low: t (252) = -1.16, n.s.; cordon vs. high: t (252) = 0.98, n.s.) nor for the average trip speed (cordon vs. low: t (252) = 0.71, n.s.; cordon vs. high: t (252) = -1.32, n.s.).

So, the contrast tests applied to analyse the differences between the pricing schemes concerning time and space were only significant for the time differentiation and here only for the comparison between the low vs. high kilometre pricing scheme but not for the comparison between the low vs. cordon pricing scheme. The results thus provide no convincing evidence that there is an impact of differentiated pricing over and above the effect of pricing as such.

### *Stated Adaptation Strategies*

The questionnaire that participants' received after the experiment asked whether they had adapted to the road pricing schemes and which strategies they had used. The majority of participants (56.2%) stated that they had tried to save charges during the experiment by adapting their mobility behaviour at least to some degree. There was no statistically significant difference between the three different pricing schemes ($\chi 2$ (2, 233) = 1.37, n.s.).

Participants had mostly tried to avoid the expensive areas followed by trip chaining, changing departure times and the reduction of their car-use (see Figure 2-3). Using other cars than the GPS-equipped one or postponing trips until the end of the experiment have hardly been used. Again, there were no significant differences in the pattern of the adaptation strategies between the three different pricing schemes.

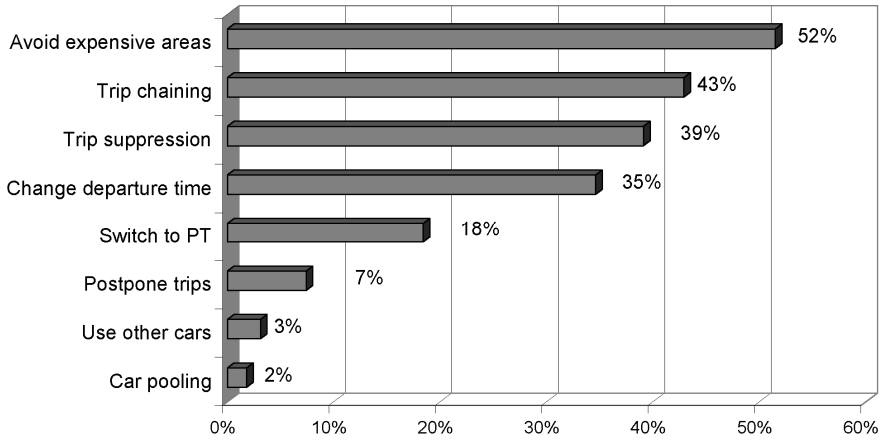



**Figure 2-3: Stated Behavioural Adaptation Strategies (Frequency in %)**

Participants were asked to indicate which route choice principle they were following in the pricing condition (fastest route, cheapest route, shortest route, usual route and super ordinate roads). The majority of respondents did not change their routes (see Table 2-6). Those that changed routes had chosen the cheapest route followed by the shortest route. The descriptive results also show that the participants of the cordon-based pricing scheme have changed their routes more often than in the other two pricing schemes. However, this difference did not become statistically significant ($\chi^2$ (10, 245) = 14.55, n.s.).

**Table 2-6: Route Choice in Response to Road Pricing (Frequency in %)**

| | Overall | Low km | High km | Cordon-based |
|---|---|---|---|---|
| Usual route | 63.5 | 68.1 | 66.4 | 46.5 |
| Cheapest route | 23.0 | 15.9 | 22.2 | 37.2 |
| Shortest route | 17.5 | 17.4 | 17.9 | 16.3 |
| Fastest route | 13.1 | 13.0 | 13.6 | 11.6 |
| Super ordinate roads | 3.6 | 4.3 | 2.9 | 4.7 |

### Payment Mode Differentiation

The differentiated impact of the payment mode will be analysed by comparing participants of the high kilometre pricing scheme from the first and second round of the experiment with the participants of the high kilometre pricing scheme from the third round. Based on prospect theory and the phenomenon of loss aversion it is predicted that people will adapt their travel behaviour more strongly in the malus system than in the bonus system. Furthermore, it is predicted that because of the strong tendency to avoid losses people accept a bonus system over a malus system.

#### *GPS-Based Trip Indicators*

Table 2-7 presents the mean reduction in the GPS-based indicators of the participants of the high kilometre pricing scheme depending on their payment mode. In line with the expectations, there were significant differences in behavioural adaptation between these two groups. Participants of the malus group reduced their trip costs more strongly than participants of the bonus group. Furthermore, participants of the malus group increased their average trip speed in contrast to the participants of the bonus group who reduces their average trip speed.

**Table 2-7: Reduction in GPS-Based Trip Indicators of the High Kilometre Pricing Schemes (*M (SD)*)**

| | Payment Mode | | |
|---|---|---|---|
| | **Bonus** | **Malus** | **U (1, 140), p** |
| Number of trips | -0.23 (1.09) | -0.55 (1.14) | 2205.00, n.s. |
| Trip distance (km) | -2.39 (10.78) | -3.03 (9.87) | 2357.00, n.s. |
| Trip duration (min) | -3.13 (13.73) | -8.61 (13.24) | 2031.00, n.s. |
| Trip costs (DKK) | -1.76 (8.22) | -7.47 (11.85) | **1734.00**** |
| Trip speed (km/h) | -0.49 (5.50) | +3.66 (4.89) | **1300.00**** |

*p < .05, **p < .01

However, in the course of the experiment the participants of the first and second round of the experiment differed in various aspects from the participants of the third round apart from the payment mode. Most notably the duration of the experiment was prolonged from 59 days on average in the first and 46 days in the second round of the experiment to 80 days in the third round. Since participants of the first two rounds represent the bonus payment mode and participants of the third round represent the malus payment mode the differences in the behavioural adaptation could be attributable to the duration of the experiment. To analyse this aspect a covariation analysis with the days driven as covariate was conducted. The results are presented in Table 2-8.

**Table 2-8: Summary of Covariation Analysis on the GPS-Based Trip Indicators for Different Payment Mode**

| | Payment Mode | | Exp. Days driven | |
|---|---|---|---|---|
| | F(2,252) | $\eta^2_p$ | F(1,252) | $\eta^2_p$ |
| Number of trips | 2.61 | .02 | 1.36 | .01 |
| Trip distance (km) | 0.00 | .00 | 0.01 | .00 |
| Trip duration (min) | 1.86 | .01 | 0.02 | .00 |
| Trip costs (DKK) | **5.65*** | .04 | 0.53 | .00 |
| Trip speed (km/h) | **12.57**** | .00 | 0.00 | .00 |

*p < .05, **p < .01

If the impact of the duration of the experiment is held constant there are still significant differences between the payment modes for the average trip costs and the trip speed. That means, the participants in the malus group saved significantly more charges than participants of the bonus group. On the other hand participants in the malus group increased their average trip speed in contrast to the participants of the bonus group who reduces their average trip speed. These differences thus seem to be caused by the different payment mode rather than the duration of the experiment.

### *Stated Adaptation Strategies*

46.4% of the participants in the bonus group stated that they had tried to save charges during the experiment by adapting their mobility behaviour at least to some degree in comparison to 50.7% of the malus groups. This difference is not statistically significant. The same holds true for the stated adaptation strategies. There was no statistically significant difference between the two payment modes (see
Table 2-9). However, there was a significant difference between the two payment modes for the route choice. Participants in the malus group have chosen the cheapest route more often than the participants in the bonus groups. On the other hand participants in the bonus group chose the usual route more often than did the participants in the malus group.

**Table 2-9: Stated Behavioural Adaptation Strategies (Frequency in %)**

| | Payment Mode | | | |
|---|---|---|---|---|
| | Bonus | Malus | $X^2$ | p |
| Avoid expensive areas | 67.5 | 71.7 | 2.78 | n.s. |
| Trip chaining | 53.6 | 67.4 | 1.82 | n.s. |
| Trip suppression | 53.5 | 71.8 | 3.83 | n.s. |
| Change departure time | 59.1 | 55.5 | 3.88 | n.s. |
| Switch PT | 30.2 | 32.6 | 2.89 | n.s. |
| Postpone trips | 18.7 | 17.8 | 4.30 | n.s. |
| Use other cars | 2.3 | 8.7 | 3.91 | n.s. |
| Car pooling | 4.6 | 2.2 | 1.09 | n.s. |
| | | | | |
| **Route choice** | | | 11.66 | .04 |
| Usual route | 76.2 | 61.6 | | |
| Cheapest route | 12.7 | 31.5 | | |
| Shortest route | 19.0 | 17.8 | | |
| Fastest route | 12.7 | 15.1 | | |
| Super ordinate roads | 4.8 | 1.4 | | |

### *Acceptability*

Based on Deliverable 4.1 it was expected that participants would favour a bonus payment mode over a malus payment mode. Table 2-10 illustrates the acceptability change in response to the high kilometre pricing scheme. There were no significant differences between the two different payment modes.

**Table 2-10: Acceptability Change in Response to the High Kilometre Pricing Scheme (Frequency in%)**

| | Negative change (-2; -1) | No change (0) | Positive change (+2; +1) | Difference between payment modes $\chi 2(df=4)$, p | N |
|---|---|---|---|---|---|
| Current Danish car tax system | 26.6 | 45.7 | 27.8 | 12.99, $p < .05$ | 162 |
| Road pricing | 14.2 | 56.8 | 29.0 | 1.81, n.s. | 162 |
| Peak hour charge | 13.0 | 55.6 | 31.5 | 4.70, n.s. | 162 |
| Package solution | 15.7 | 54.2 | 30.1 | 0.61, n.s. | 163 |

The only exception is the acceptability change of the current Danish car tax system. There were significant differences between the bonus and the malus mode.

Figure 2-4 illustrates this result. Participants of the malus mode changed their opinion about the current Danish car tax system more often as well as more strongly than the participants of the bonus mode.

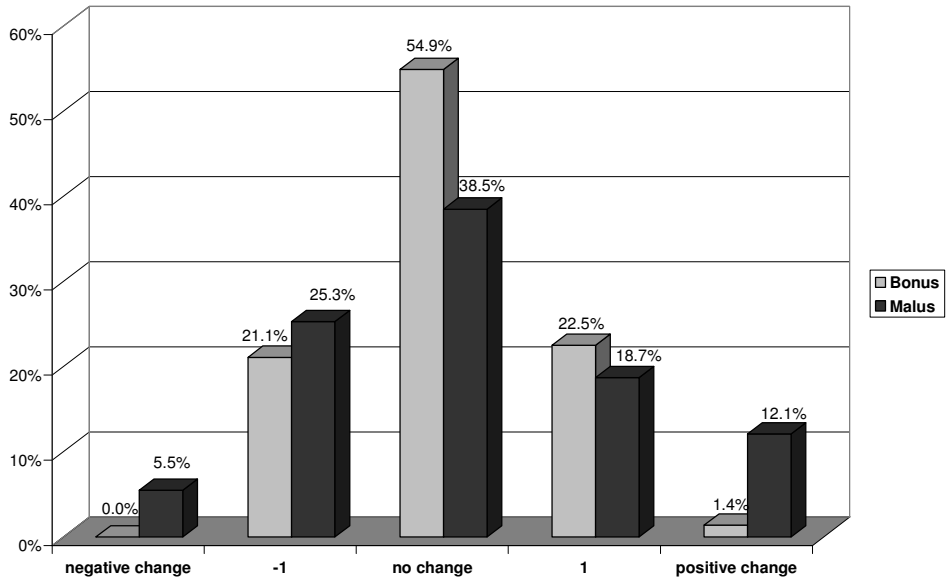



**Figure 2-4: Acceptability Change of the Current Danish Car Tax System for Different Payment Modes (Frequency in %)**

### Relationship between Acceptability and Behavioural Adaptation

In Deliverable 4.1 it was hypothesised that motivational factors might influence behavioural adaptation – that, even if people understand a differentiated charging scheme, they might not be willing to do so. More specifically it was hypothesised that a positive attitude towards the pricing schemes leads to more behavioural adaptation.

*Acceptability before the Experiment*

The results presented in Table 2-11 show that the current Danish car tax system, which is characterised by very high fixed taxes on car ownership, is appreciated by only 20 % of the participants. In contrast, the principle of road pricing was favoured by 72 % and 62 % supported a peak-hour charge for the morning and evening peak hours. A package solution, combing road pricing with a preferred revenue use was supported by only 44% of participants (although most previous studies - e.g. Schade & Schlag, 2003; Lyons et al., 2004 - had found more support for such packages than for road pricing as single measure).

**Table 2-11: Acceptability of Different Road User Charges (Frequency in %)**

| | Agree | Neither nor | Disagree |
|---|---|---|---|
| Current Danish car tax system | 20.2 | 25.2 | 54.5 |
| Road pricing | 72.3 | 12.9 | 14.8 |
| Peak hour charge | 61.3 | 16.3 | 22.5 |
| Cordon system | 54.7 | 19.5 | 25.8 |
| Package solution | 44.0 | 15.5 | 40.5 |

Similar figures have been obtained from a representative survey of Copenhagen citizens conducted in parallel to the AKTA experiment (AKTA, 2005a). The results show that the answers of the participants of the experiment are slightly more positive, but the pattern of response is the same in both groups (see Figure 2-5). Therefore, this result is not unique for the sample of the experiment. Instead, it seems that the current Danish car tax system, which is rejected by the respondents, provides a framing in which urban road pricing appears as an attractive alternative for saving costs for private car-use. This argument is further supported by the findings from Stead (2006). Using data from the 1999 Eurobarometer he found that in Denmark 51% of the survey respondents' identified urban road pricing as one of the three most effective policy options. In the other EU member states this figure did not exceeded 30%.

This high acceptability prior to the experiment, even though it is a valid result, causes statistical problems for the analysis of the acceptability in response to differentiated pricing and in relations to the behavioural adaptation. With a ceiling effect there is a reduced variability in the data which limit the possibility of finding statistically significant effects. Thus changes in public acceptability or relations with other variables are rather underestimated in the AKTA dataset due to the lack of variance.

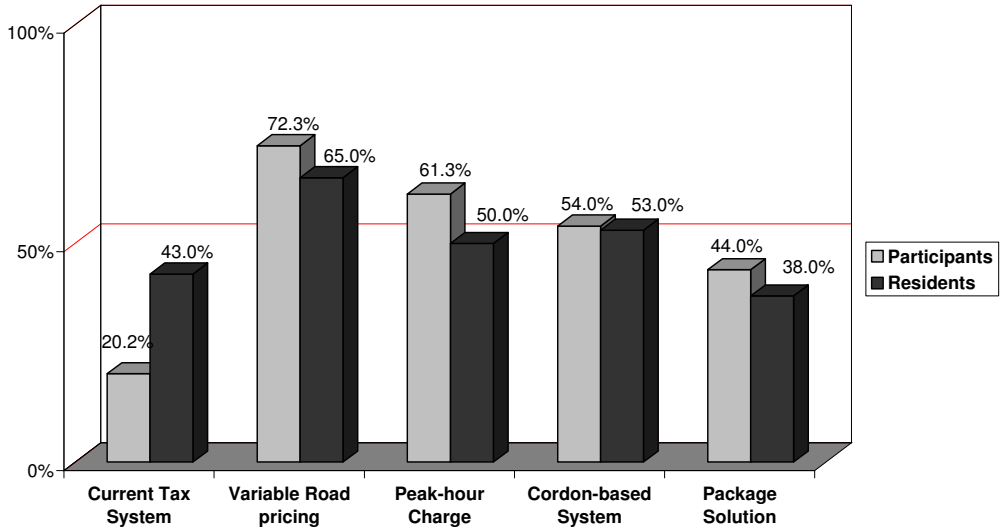



**Figure 2-5: Acceptability of Road User Charges of AKTA Participants and a Representative Citizen Sample (Frequency in %)**

*Acceptability and Behavioural Adaptation*

Table 2-12 presents the summary of non-parametric ANOVAs where the differences in the reduction of the GPS based indicators in relation to the acceptability of road user charges were analysed. Overall there are only a few significant differences in the reduction of GPS-based indicators in relation to the acceptability of road pricing before the experiment.

**Table 2-12: Differences in the Reduction of GPS-Based Trip Indicators in Relation to the Acceptability of Road Pricing before the Experiment (Summary of Non-Parametric Analysis of Variance)**

| | Current Danish car tax system | Road pricing | Peak hour charge | Cordon system | Package solution |
|---|---|---|---|---|---|
| | $X^2(2,244)$, p | $X^2(2,240)$, p | $X^2(2,243)$, p | $X^2(2,242)$, p | $X^2(2,239)$, p |
| Number of trips | 3.66, n.s. | 2.05, n.s. | 5.02, n.s. | 2.29, n.s. | 4.68, n.s. |
| Trip distance (km) | **6.10*** | 0.02, n.s. | 1.09, n.s. | 1.87, n.s. | 2.93, n.s. |
| Trip duration (min) | 4.82, n.s. | 0.60, n.s. | 2.48, n.s. | 1.03, n.s. | 5.98, n.s. |
| Trip costs (DKK) | 3.65, n.s. | 2.25, n.s. | **6.90*** | 0.14, n.s. | **9.10*** |
| Trip speed (km/h) | 4.01, n.s. | 1.43, n.s. | 3.28, n.s. | 0.90, n.s. | 0.45, n.s. |

*p < .05, **p < .01

Participants who were undecided concerning the current Danish car tax system increased their average trip distance per day in the pricing period, where as participants who were either supportive or against the current Danish car tax system reduced their average trip distance (M = + 0.31 km vs. M = - 2.40 km/ - 3.20 km). Furthermore, participants who supported peak hour charges saved more trip costs than participants who that did not support peak hour charges or were undecided (M = - 4.56 DKK vs. M = -1.08 DKK/ - 1.11 DKK). Similarly, participants who supported, or were undecided about, a package of road pricing and the preferred revenue use saved more trip costs than participant that did not support such a package (M = - 4.32/ - 4.37 DKK vs. M = -1.73 DKK).

A similar picture emerged for the stated adaptation strategies (see Table 2-13). There were only a few significant differences in the usage of these strategies in relation to the acceptability of road pricing. Only the acceptability of a package of road pricing and the preferred revenue use shows significant differences in relation to the acceptability before the experiment. Participants who were positive towards a package solution before the experiment claimed to have chained trips, changed departure time and switched to public transport whereas participants who were negative claimed not to have done this.

**Table 2-13: Stated Behavioural Adaptation Strategies in Relation to the Acceptability of Road Pricing before the Experiment**

| | Current Danish car tax system | Road pricing | Peak hour charge | Cordon system | Package solution |
|---|---|---|---|---|---|
| | $X^2$, p | $X^2$, p | $X^2$, p | $X^2$, p | $X^2$, p |
| Avoid expensive areas | 6.72, n.s. | 6.92, n.s. | 2.65, n.s. | 0.90, n.s. | 11.59, n.s. |
| Trip chaining | 1.14, n.s. | 3.56, n.s. | 8.79, n.s. | 1.53, n.s. | **17.84**** |
| Trip suppression | 7.56,n.s. | 3.59, n.s. | 8.16, n.s. | 4.11, n.s. | 7.87, n.s. |
| Change departure time | 7.57, n.s. | 7.27, n.s. | 7.50, n.s. | 3.73, n.s. | **17.81**** |
| Switch PT | 9.27, n.s. | 4.46, n.s. | 4.89, n.s. | 5.08, n.s. | **19.36**** |
| Postpone trips | 8.66, n.s. | 1.99, n.s. | 4.60, n.s. | 6.39, n.s. | 9.55, n.s. |
| Use other cars | 6.82, n.s. | 5.03, n.s. | 3.13, n.s. | 5.74, n.s. | 7.75, n.s. |
| Car pooling | 3.63, n.s. | 1.49, n.s. | 1.39, n.s. | 3.68, n.s. | 3.46, n.s. |
| | | | | | |
| **Route choice** | | | | | |
| Usual route | 3.63, n.s. | **8.39*** | 4.53, n.s. | 1.96, n.s. | 1.68, n.s. |
| Cheapest route | **10.04**** | **9.48**** | **6.52*** | 3.95, n.s. | **6.91*** |
| Shortest route | 1.73, n.s. | 2.95, n.s. | 0.23, n.s. | 1.17, n.s. | 2.11, n.s. |
| Fastest route | 1.52, n.s. | 1.96, n.s. | 0.72, n.s. | 3.51, n.s. | 2.93, n.s. |
| Super ordinate roads | 0.66, n.s. | 0.57, n.s. | 3.86, n.s. | **8.95**** | 5.10, n.s. |

*p<0.05, **p<0.01, n.s. = p > .05

There were however significant relationships between the acceptability before the experiment and route choice during the pricing condition. Participants who were positive towards road pricing chose the cheapest route during the experiment whereas participants that were negative chose the usual route. Similarly, participants who were positive towards peak hour charges and the package solution chose the cheapest route. Contrary to the expectations the same holds true for the current Danish car tax system. Furthermore, participants who were positive towards the cordon pricing scheme did not choose super ordinate routes whereas participants that were negative did. This could be interpreted as an indication that participants who were negative towards the cordon pricing scheme also did not change their routes in order to avoid the cordons.

### User Reactions in Relation to Income and Gender

The relationship between user reactions and income has been analysed using correlations. There are two very small statistically significant correlations between income and acceptability change for the overall sample; high income is associated with a positive acceptability change of the current Danish car tax system (Spearman's $\rho$ = .13, $p$ < .05) and with a negative acceptability change of the peak hour charge (Spearman's $\rho$ = -.12, $p$ < .05). There are however no significant relationships between income and acceptability change within the three different pricing schemes.

Concerning the behavioural adaptation there were no significant correlation between income and the GPS-based trip indicators and the stated adaptation strategies. This holds true for the overall sample as well as the three different pricing schemes. This means than in AKTA there is no moderating effect of income on behavioural adaptation. The only exception is a small statistically significant relationship between income and the stated switch to public transport in the low kilometre pricing scheme (Spearman's $\rho$ = -.33, $p$ < .05) whereby, the lower the income, the more participants have stated to switch to public transport.

A two way ANOVA was conducted to investigate the main effect of gender on public acceptability and behavioural adaptation as well as the interaction effect between the three different pricing schemes

and gender. Thus it was analysed whether gender affects user reactions as such and whether gender affects user reactions differently within the three different pricing schemes.
The results revealed only few main effects of gender on user reactions. There was a statistically significant gender difference in the acceptability change of the peak hour charge ($F$ (1, $N$ = 293) = 9.15, p < .01) and a tendency towards significance for the acceptability change of the package solution ($F$ (1, $N$ = 293) = 3.63, $p$ = .06). In both cases women's acceptability became more favourable compared to men in response to road pricing. No statistically significant interaction effects between gender and pricing scheme could be established. That means there was no differentiated impact of gender in the three different pricing schemes.

Concerning the impact of gender on behavioural adaptation only one statistically significant effect could be established, the one for the average trip speed. Women increased their average trip speed significantly more than men *(*$M$ = 1.56 km/h vs. $M$ = 0.33 km/h; $F$ (1, $N$ = 251) = 3.92, $p$ < .05) in response to urban road pricing. Again there was no differentiated impact of gender on behavioural adaptation in the three different pricing schemes.

### *Discussion*

The aim of this case study was to analyse the impact of differentiated pricing on behavioural adaptation and the role of psychological constraints in this process. Data from the AKTA road pricing experiment was used. AKTA was a field experiment where 500 car users volunteered for trying "virtual" road pricing systems between autumn 2001 and spring 2003 by the use of a GPS-technique. Three different pricing schemes were tested, a multiple zone/cordon pricing scheme and two kilometre-pricing schemes with different levels of charging. These three different pricing systems varied in their:

- time differentiation,
- spatial differentiation and
- payment mode.

Furthermore, it was analysed whether the acceptability of urban road pricing influences behavioural adaptation.

However, it needs to be stressed that AKTA was not initially designed to investigate the impact of price differentiation on user reactions and so the design of the pricing schemes reflects the conditions of the metropolitan area of Copenhagen rather than different aspects of price differentiation. This leads to some methodological inconsistencies discussed below which constrain the significance of the results.

The results show that the participants adapted their mobility behaviour to the pricing schemes of the AKTA experiment. The average number of trips, trip distance, trip duration as well as trip costs were reduced significantly. On the other hand the average trip speed did not change significantly. Participants mostly organised their car-use more efficiently by avoiding the expensive areas and trip chaining.

Concerning time differentiation and spatial differentiation it was hypothesised that the more differentiated the pricing schemes the more behavioural adaptation will occur. The results show only significant differences in behavioural adaptation between the pricing schemes for the average trip costs and trip speed. The contrast tests applied to analyse the differences between the pricing schemes concerning time and space were only significant for the time differentiation and here only for the comparison between the low vs. high kilometre pricing scheme but not for the comparison between the low vs. cordon pricing scheme. Furthermore, there were no significant differences in the stated behavioural adaptation strategies between the three different pricing schemes.

The AKTA road pricing experiment thus provides no convincing evidence that there is an impact of differentiated pricing over and above the effect of pricing as such. The reason could be that the three pricing schemes compared concerning time and spatial differentiation were not designed to reflect

these aspects. Rather they were adapted to the local situation of Copenhagen. Thus other aspects of the pricing schemes or the implementation of the field experiment could have counterbalanced the effect or interacted with the time and spatial differentiation.

The differentiated impact of the payment mode was analysed comparing participants in the high kilometre pricing scheme from the first and second round of the experiment with the participants from the third round. The payment mode of the first two rounds of the experiment was equivalent to a bonus system whereas in the third round it was equivalent to a malus system. That means, in the first two round participants received a reward (bonus) if they changed their behaviour. In the third round, they could avoid a punishment (payment) by changing behaviour. Based on prospect theory and loss aversion in particular it was predicted that people will adapt their travel behaviour more strongly in the malus system than in the bonus system, since they prefer avoiding losses more strongly than acquiring gains.

In line with the expectations there were significant differences in the behavioural adaptation between the two payment modes. Participants in the malus group saved significantly more charges than participants of the bonus group. On the other hand participants of the malus group increased their average trip speed in contrast to the participants of the bonus group who reduces their average trip speed. Furthermore, participants in the malus group have chosen the cheapest route more often whereas participants of the bonus group have chosen more often the usual route. In summary, participants in the malus group have adapted their mobility behaviour more strongly than participants of the bonus groups.

Concerning acceptability it was predicted that participants would favour the bonus mode over the malus mode (because of people's tendency to avoid losses more strongly than to acquire gains). Contrary to that expectation there were no significant differences in the acceptability of urban road pricing schemes depending on the payment modus. That means the bonus mode did not lead to a more favourable opinion about urban road pricing compared to the malus mode. The only difference was found for the assessment of the current Danish car tax system. Participants in the malus group changed their opinion about the current Danish car tax system more often as well as more strongly than the participants in the bonus group.

However, in focus group interviews conducted in parallel to the experiment, participants stated that earning money is not the same as paying money (Nielsen & Herslund, 2002). In line with the hypothesis, paying money made a stronger impression on participants than receiving money. The reason why this qualitative evaluation is not reflected in the acceptability data could be the exceptional high acceptability of road pricing before the experiment. The majority of respondents supported road pricing before the start of the field experiment and, with such a ceiling effect, there is reduced variability in the data and this limits the possibility of finding statistically significant effects.

Deliverable 4.1 identified acceptability as an important motivational factor that shapes people's reaction towards differentiated pricing, it was hypothesised that a positive attitude towards the pricing schemes leads to more behavioural adaptation. The assumption is that the previous attitudes, among other things, guide people's behaviour.

The results revealed a few significant differences in the reduction of GPS-based indicators in relation to the acceptability before the experiment. These differences were in the expected direction. The same hold true for the stated behavioural adaptation strategies. However, there is no consistent pattern of results to indicate a relationship between the acceptability of differentiated charging and the behavioural adaptation. The only consistent pattern was found for the relationship between route choice and acceptability - participants who were positive towards different types of road user charges chose the cheapest route whereas participants that were negative did not.

The reason why only a few significant relationships could be detected and no consistent pattern of results emerged could be again the exceptional high acceptability of road pricing before the experiment and the resulting ceiling effect (see also Gehlert et al, 2008).

The last research question dealt with the impact of personal characteristics on user reactions towards differentiated charging. The evidence so far is inconclusive. Therefore this aspect has only been explored. In general there were only a few significant relationships between income, gender, public acceptability and behavioural adaptation. One reason at least for income could be the restriction of the sample to one-car families. Due to the high taxes on car possession only a few people have more than one car (Progress, 2004). Thus the relation between income and car availability and subsequent car use is less pronounced than in other European countries. Furthermore there is evidence that the different socio-demographic factors such as residential location, access to public transport, income and gender are related to each other not only but also in the AKTA experiment (Gehlert & Nielsen, 2007). Thus further research should try to decompose the causal relations between the socio-demographics factors and their interdependencies to clarify how they influence user reactions towards differentiated charging.

In summary this case study did not reveal evidence of a direct impact of time differentiation or spatial differentiation on behavioural adaptation. It did however provide preliminary evidence for a moderating effect of psychological variables such as loss aversion and public acceptability. The main problem for the analysis was that the price differentiation was possibly confounded with other influences within the AKTA road pricing experiment.

### 2.1.2 Newcastle Survey on Attitudes and Responses to Road Charges

#### *Introduction*

This Section presents results from a questionnaire, implemented in Newcastle, which was designed specifically for the DIFFERENT project in order to explore the factors affecting public perception of the complexity and effectiveness of differentiated road charging schemes and their behavioural responses to them. It sought to explore a number of potential explanatory factors identified in the hypotheses, sub-hypotheses and research questions set out in Deliverable 4.1 (Hoffmann et al. 2006).

The questionnaire built on the results of an earlier questionnaire, implemented within the GRACE project and discussed in deliverable 4.1, which sought to explore people's ability and willingness to engage with complex road charging schemes and their likely responses to them, and was designed to complement a laboratory experiment, which was to be implemented in Leeds and Dresden, and which was intended to explore similar issues in a controlled environment (see section 2.2).

#### *Research Questions and Hypotheses*

This questionnaire was designed to address hypothesis 1, sub-hypotheses 2, 3, 6, 7, 8 and 9 and research question 2, which were, respectively:

| | |
|---|---|
| Hypothesis 1: | *There is a point, beyond which, the more differentiated a price structure, the less behavioural adaptation will occur.* |
| Sub-hypothesis 2: | *An individuals´ ability to understand the charging system and to adjust behaviour will be a positive function of their prior experience of similar price structures.* |
| Sub-hypothesis 3: | *An individuals´ motivation to adjust behaviour will be a positive function of their acceptance of the system (acceptance being a positive function of perceived fairness and perceived effectiveness).* |
| Sub-hypothesis 6: | *An individuals´ engagement with the charges and their motivation to adjust behaviour will depend on their type of personality.* |
| Sub-hypothesis 7: | *An individuals´ motivation to adjust behaviour will be a negative function of their disposable income.* |
| Sub-hypothesis 8: | *An individuals´ ability and motivation to adjust behaviour will be a positive function of their education.* |
| Sub-hypothesis 9: | *An individuals´ ability and motivation to adjust behaviour will depend on the type of trip: Commute trips tend to be less elastic than shopping or recreational trips.* |

Research Question 2*: How does age and gender influence the ability and motivation to deal with differentiated pricing systems and how does it affect transport behaviour?*

The questionnaire sought to address these hypotheses and questions by collecting information on individual characteristics and attitudes and on their responses to a series of schemes which differ in terms of their degree of complexity.

## *Method*

### The Questionnaire

The questionnaire, attached as Appendix 1, comprised two parts. The first part containing ten questions was administered on-street and sought to establish the eligibility of the potential respondent for the full interview (all respondents needed to drive and pay for journeys within the area where charges were envisaged and quotas were applied in respect of gender, income, trip frequency and trip purpose). Eligible respondents were offered a £5 'thank you' if they would agree to participate in the full interview. Those who agreed to participate were provided with briefing material - most notably descriptions of four road charging regimes chosen at random from a set of eight.

The eight charging regimes all related to the city in which the interviews were being conducted but differed in respect of the nature and degree of their inherent complexity. Appendix 2 contains an example of one of these schemes while Table 2-14 summarises their characteristics. The 8 scheme variants were chosen to reflect the different types and degrees of scheme complexity (number of zones; number of time periods; whether charges are per mile, per cordon crossing or as an area charge; whether there was any differentiation by road type) which might affect people's response to them. Although more complex schemes could have been devised, it was thought that unlikely that any authority would implement would implement anything more complex than our scheme 3.

The second part of the questionnaire was administered over the telephone and comprised sections which, together, took 15 – 20 minutes to complete. The first section sought respondents' opinions about congestion in their home city and about the likely purpose, effectiveness and fairness of road use charges within that city. The second section asked for details of their current usage of the roads on which charges might be applied and identified one journey which involved regular use of those roads. The third section asked the respondent to imagine that a road charging scheme had been introduced and, with reference to the identified journey, asked what maximum daily charge they would be prepared to pay before considering a change in mode, a reduction in frequency, a change in route or a change in departure time. The respondents were also asked if the sum would differ if the traffic conditions and/or public transport service were improved and whether, if the daily charge covered an unlimited number of journeys on that day, they would adjust the overall number of trips made and/or the distribution of trips between days.

**Table 2-14: Characteristics of the Schemes**

| Scheme | How many zones? | How many time periods? | Basis of charge | How many different charges appear in the text? |
|---|---|---|---|---|
| 1 | 1 | 1 | Use of any road in specified zone in specified period | 1 |
| 2 | 1 | 1 | Per-mile charge on all roads in specified zone in specified | 1 |
| 3 | 2* | 2 | Use of any road in central zone *plus* specified per mile charge on specified type of road in outer zone (all during either of two specified periods) | 4 |
| 4 | 1 | 1 | Charge for crossing into specified zone during specified period | 1 |
| 5 | 2 | 1 | Specified charges for crossing two specified cordons in specified period | 4 |
| 6 | 2 | 2 | Charge for crossing specified cordons during specified periods (multiple crossings allowed on any given day without extra charge) | 1 |
| 7 | 1 | 7 | Specified charges for crossing specified cordon in each of 7 specified time periods | 7 |
| 8 | 1 | 2 | Specified charges for crossing specified cordon in specified direction in specified time period | 2 |

* the outer of the two zones has 3 different types of road identified within it.

The fourth section comprised a set of questions which was repeated for each of the four charging scenarios which had been allocated to that respondent. For each one they were asked to estimate the likely monthly cost to themselves; to say how easy it would be to work out and the exact cost; to indicate whether it would cause them to change their travel patterns, reduce the number of car journeys and/or change the timing of those journeys; and to give their opinion on its likely impact on congestion in the city. The final section of the questionnaire sought information on the respondents' employment and educational background, their attitudes to motoring expenses, and their response to a series of questions (on their tolerance of ambiguity, need for cognition and attitude to uncertainty) which may provide some pointers to their personality type.[3]

### Implementation and Participants

The questionnaire was implemented in the city of Newcastle in late summer 2007 (16.08.07 – 3.09.07). The majority of respondents were recruited on city centre streets. 389 were recruited at stage 1 but around 100 of these could not be re-contacted by phone. 258 stage 2 interviews were completed. Of these: all drove at least 25 miles (or at least four journeys) per week in the charge area; 52% were male; 70% were commuters; 7% had annual household incomes below £14k, 11% were between £14k and £20k, 18% between £20k and £30k, 33% between £30k and £50k and 31% of at least £50k; 71% were employed, 33% had no qualifications beyond school, 40% had a degree and 46% had professional qualifications.

Inspection of the tabulated data revealed some interesting results but the most useful findings came from exploratory investigations involving the construction of regression models.

[3] Work by Bonsall et al. (2006) had suggested that attitudes to uncertainty and tolerance of ambiguity might be related to people's response to complex charge structures. Questions 59, 60 and 61 in the current questionnaire are adapted from questions designed to measure need to evaluate, need for cognition and tolerance of uncertainty, respectively. Recent work by Bonsall, Wickham and Lythgoe (2008) has established that these questions are related to the batteries from which they were adapted with question 60 having a particularly strong relationship with the need for cognition battery.

## *Results*

### Descriptive Statistics

Tabulation of the data reveals the following facts:

- Half (50%) the respondents think that the city suffers from congestion – but not seriously (30% think congestion is serious).
- Two thirds (67%) of respondents think that they are not much affected by congestion.
- About half (51%) of respondents think that the main purpose of road charging would be to reduce congestion – but 30% think it would be to raise revenue for non-transport purposes.
- About half (53%) of respondents think that the introduction of road charges would not make their journeys any quicker.
- About half (54%) of respondents think that the introduction of road charges would be bad for the city (of those expressing an opinion, 73% think this).
- About a third (31%) of respondents think that the introduction of road charges would be completely unfair (37% think it would be quite unfair and 31% think it would be quite fair).
- Just over half (52%) of respondents would apparently be prepared to pay up to £1 per day to continue to drive at their current frequency. This proportion did not increase significantly under the scenarios where improvements in public transport and car journey times were posited.
- About a quarter (26%) of respondents say that, if charges were introduced, they would consider making their regular journey less often, or by a different mode, however small the charge (50% would do so if the charge was up to £1 per day, 74% if it was up to £2.50 a day and 96% would do so if it was up to £5 per day).
- When asked to imagine the introduction of a daily charge which covered an unlimited number of journeys on that day, just over half (55%) of respondents think they would try to avoid driving on some days (a further 13% thought they *might* do), and a third (33%) thought they would make fewer car journeys overall (but 22% thought they would make more car journeys overall).
- A substantial proportion (39%) of respondents thinks that they could not estimate the length of their most frequent journey to within ½ a mile.
- On average, across all 8 hypothetical schemes, a third (32%) of respondents thought it would be difficult, very difficult or impossible to work out exactly what the charge would cost them.
- On average, across all 8 hypothetical schemes, almost half (47%) of respondents thought that they would not change their travel patterns if the scheme were introduced (this proportion was lower for the first-presented scheme and higher for the last-presented scheme).
- On average, across all 8 hypothetical schemes, more than half (54%) of respondents thought that the scheme would prove effective at reducing congestion in the city (this proportion was notably lower for the first-presented scheme and notably higher for the last-presented scheme).
- Almost half (46%) of respondents say that they do not normally think very much about the cost of each journey they make.
- When asked if they were the sort of person who likes to work out the pros and cons before making a decision, 33% said “yes certainly” and a further 41% said “yes” (to the extent that this question measures need to evaluate it would appear that 75% claim to have such a need).
- When asked if, they were the sort of person who liked to work on a problem only if there was a possibility of coming up with a clear cut answer, 57% said yes or certainly yes and 43% said no or certainly not (to the extent to which this question measures tolerance of ambiguity, it appears that almost half our sample are indeed tolerant of ambiguity).

The picture which emerges from the summary tabulations is thus of a population who consider that congestion is not really much of a problem, who are sceptical about the effectiveness of road charges

and tend to believe that they would be unfair and bad for the city. Although most respondents say they would consider changing their travel patterns if a substantial charge was introduced, many expected that, in the end, they would carry on as before. A significant minority of respondents say they would find it difficult to estimate the charges (a similar proportion thought they would have difficulty giving a precise estimate of their trip mileage). Although almost half say that they tend not to think about the costs of individual journeys and a similar proportion seem tolerant of ambiguity, a clear majority claim to like working out the pros and cons before making a decision and to experience satisfaction, rather than relief, on completion of a mental task. Finally, we note that respondents' opinions about the effectiveness of schemes, and about their likely behavioural response to them, were affected by the order in which the schemes were presented.

These global impressions are useful but much more insight can be gained by examining the interactions between different data items. The following paragraphs are based on the results of exploratory investigations of key issues using regression analysis to establish significant interactions (to justify inclusion in the model, a coefficient needed to be significant at 5%).

### Factors Affecting Calculation Difficulty

The first question to be explored using regression analysis was: *What factors contribute to the public perception that a given road charge would be difficult to calculate?*

For each of the charging schemes presented to them, respondents were asked (at Q35, Q41, Q47 and Q53) how easy they would find it to calculate the exact costs they would incur if that scheme was introduced (assuming that they did not adjust their behaviour). A series of models were tested in which the respondent's stated ease of calculation was the dependent variable. The initial models sought to explore whether the expressed degree of difficulty for each scheme was influenced by respondent's characteristics (age, gender, income, and educational background), their attitudes to decision making (need for cognition, tolerance of uncertainty etc), their opinion of the effectiveness of the scheme, or the order in which the schemes were presented to them. These models suggested that, for some schemes, there was a link with the respondent's income and opinion on scheme effectiveness, and those schemes were thought easier if presented later. Interestingly, no effect was found for the respondent's age or educational background even though these were found to affect the respondent's confidence in their own ability to estimate the mileage of their regular journey – with older and professionally-qualified people reporting higher confidence.

A dummy variable regression model indicated that exact calculation of charges was thought hardest for Scheme #3 and easiest for Schemes #8, #1, and #4. In order to determine what aspects of the schemes were influencing this assessment, key attributes of each scheme (the number of zones, the number of time periods, whether the charge was a function of mileage, and the number of separate charge levels appearing in the description) were codified and regression models were used to identify any systematic relationship between these attributes and the perceived ease of calculation. The models indicated that the perceived difficulty of the calculation was higher if the charge depended on the mileage driven and that it increased with the number of zones and the number of separate charge levels mentioned in the description.

A final model was defined to incorporate all the scheme attributes, presentational details and respondent characteristics which had shown a significant impact in at least one of preliminary the models. The model, which achieved an adjusted $R^2$ of 0.049, is presented below (as with all the models presented here, the coefficients are unstandardised and relate to a specific scale):

$$CD = 2.03 + (0.05 \times Numbers) + (0.24 \times Zones) - (0.37 \times rich?) + (0.29 \times permile?) \quad (1)$$

Where:

*CD*..... (calculation difficulty) quantified, as in Q35, on a scale from 1 (very easy) to 5 (impossible)

*Numbers….* number of separate charge levels mentioned in the scheme description (= 1, 1, 4, 1, 4, 1, 7, 2 for Schemes #1 to #8 respectively)

*Zones……..* number of zones in each charging scheme (= 1, 1, 2, 1, 2, 2, 1, 1 for schemes #1 to #8 respectively)

*Rich? .....* (dummy) set to 1 if annual household income is £20k or above, else zero

*permile?.....* (dummy) set to 1 if charging is by mileage (i.e. in schemes #2, and #3), else zero.

A further investigation allowed an additional variable, the respondents' assessment of the fairness of road charging (Q6) to enter the model as an additional explanatory variable. The resulting model had improved explanatory power of the model; (adjusted $R^2$ rose to 0.06), and was:

*CD = 1.58 + (0.05 x Numbers) + (0.23 x Zones) + (0.30 x permile?) - (0.36 x rich?) + (0.15 x unfair) (2)*

Where all parameters are defined as for model 1, except:

*unfair …….* respondent's opinion on the unfairness of road charges (Q 6) on a scale from 1 (absolutely fair) to 4 (completely unfair)

This result suggests that respondents who think road charging is, in principle, unfair report greater anticipated difficulty in making an accurate estimate of the charge. Of course, we do not know whether they really would find it more difficult to make an accurate estimate but we can say that their negative feelings about fairness are in some way associated with a reported perception that the charge would be difficult to calculate. The question of causality in this relationship, and its significance for our hypotheses, will be further addressed later in this paper.

### Factors Affecting Perceived Effectiveness

The next research question to be explored using regression analysis was: *What factors contribute to the public perception of the likely effectiveness of a road charging scheme?*

For each of the charging schemes presented to them, respondents were asked (at Q39, Q45, Q51 and Q57) how effective they thought that scheme would be at reducing congestion within the city. A series of models were constructed in which the respondent's reply to this question was the dependent variable. Initial models sought to discover whether perceived effectiveness was influenced by the respondent's characteristics, their opinions on congestion in the city (its seriousness, and whether it affects them), their opinion on the road charging (for what reason they think it is most likely to be introduced, whether it would affect them, whether it would be fair, and whether it would be good for the city), their assessment of the calculation difficulty, whether they might increase the number of journeys they make on a given day for which they had bought a multi-journey ticket, or by the order in which the schemes were presented. These models suggested that, although different relationships were found for different schemes, there was a tendency for perceived effectiveness to be correlated with perceived fairness, for the simplest schemes (#1 and #8) to be thought more effective if presented after other schemes, for one of the simplest schemes (#4) to be thought most effective by respondents who thought congestion to be a serious problem, and for the most complex scheme (#3) to be thought more effective by respondents who experienced little congestion, who thought road charges would be good for the city and who thought they might make more journeys on days for which they had bought multi-journey tickets.

A dummy variable regression model indicated that Scheme #4 was regarded as likely to be the most effective and scheme #2 the least effective. A model, which defined each scheme by its attributes (number of zones etc) and the order in which it was presented to the respondent, suggested that schemes based on mileage charges were thought to be less effective, that respondents who thought road charging was fair were more likely to think the schemes presented to them would be effective and that schemes were thought more effective if presented after at least one other scheme.

A final model was defined to incorporate all the scheme attributes, presentational details and respondent characteristics which had shown a significant impact in at least one of preliminary the models. The model, which achieved an adjusted $R^2$ of 0.077, is:

*PI = 1.58 + (0.28 x unfair) + (0.21 x permile?) + (0.15 x first?)* (3)

Where:

| | |
|---|---|
| *PI ……* | (perceived ineffectiveness) quantified, as in Q39, on a scale from 1 (very effective) to 4 (not at all effective) |
| *unfair……..* | respondent's opinion on the unfairness of road charges (Q 6) on a scale from 1 (absolutely fair) to 4 (completely unfair) |
| *permile?…..* | (dummy) set to 1 if charging is by mileage (i.e. in Schemes #2, and #3), else zero |
| *first? .....* | (dummy) set to 1 if the scheme was presented before any other, else zero |

This model is again plausible - the fact that the first-viewed schemes were thought less effective suggests a general expectation that schemes will be ineffective was revised after viewing more than one scheme. Although we cannot impute any causality, still less a direction of causality, to the relationship between perceived difficulty and perceived fairness, the fact that the fairness question was asked first, and that respondents were revising their opinion on effectiveness, suggests respondents had not given much thought to scheme effectiveness in advance of the interview, would suggest that the opinion about fairness is not dependent on the opinion about effectiveness (similarly, one would conclude that the opinion on fairness is not dependent on the perceived difficulty of estimating the charge).

### Factors Affecting Willingness to Pay the Charge

The questionnaire sought information (via questions Q22 - Q28) on respondents' preparedness to pay a charge rather than change their current travel arrangements. An initial series of models was run to see if their responses were affected by their journey purpose (in each case the potential explanatory variables were five 0/1 dummy variables, one of which will have been set to 1 for each respondent depending on which of 5 journey purposes - work, accompanying children to/from school, shopping, employer's business, or other – they had identified as their main purpose in question s5). Where a significant result was found, it is reported in models 4-7 below.

Model 4, which achieves an adjusted $R^2$ = 0.014, suggests that people are prepared to pay more for journeys to work, to school and on business. This is plausible.

*Max = 2.11 – (1.16 x shop?) - (0.70 x other?)* (4)

Where:

| | |
|---|---|
| *Max …….* | maximum sum prepared to pay before changing mode or travelling less often (Q22) |

The comparison of Models 4 and 5 (adjusted $R^2$ = 0.012) suggests that an improvement to public transport has least relevance to business trips – again this is thoroughly plausible.

*MaxPT50 = 2.41 – (1.21 x shop?) - (0.93 x business?) - (0.80 x other?)* (5)

Where:

| | |
|---|---|
| *MaxPT50…* | maximum sum prepared to pay before changing mode or travelling less often if public transport door-to-door journey times were reduced by 50% (Q27) |

The comparison of models 5 and 6 (Adjusted $R^2$ = 0.012) suggests that an incremental improvement in car journey times would be of most use to business trips and of least use to shopping trips.

*MaxPT50Road10 = 2.35 – (1.30 x shop?) - (0.80 x business?) - (0.73 x other?)* *(6)*

Where:

*MaxPT50Road10...* maximum sum prepared to pay before changing mode or travelling less often if public transport door-to-door journey times were reduced by 50% and car journey times improved by 10% (Q28)

Model 7 (Adjusted $R^2$ = 0.026) suggests that people on business trips have a higher value of time, and those on shopping trips have a lower value of time, than the average.

*Route10-75* = 0.45 + (0.30 x *shop?*) - (0.28 x *business?*) (7)

Where:

*Route10-75…….* =1 if would select an alternative route which took 10 minutes longer if by so doing they could reduce the charge payable to 75% of its full value (Q23)

Model 8 (Adjusted $R^2$ = 0.012) suggests that, of all trip types, it is school trips which are least flexible in terms of timing.

*Hourearly50 = 0.39 - (0.39 x school?)* *(8)*

Where:

*Hourearly50…….* = 1 if would be prepared to set off an hour earlier if by so doing they could reduce the charge payable to 50% of its full value (Q25)

The final investigation of willingness to pay sought to find out whether the difference in the amount that respondents would be prepared to pay with/without an improvement in car journey times reflected their personal characteristics or attitudes. This investigation was based on the difference between answers given to questions 28 and 27. Among personal characteristics (age, gender, income and qualifications) we found a weak model (adjusted $R^2$ = 0.009) suggesting that people with professional qualifications were less likely, but people on higher incomes were more likely, to quote a different maximum charge in the two situations. The attitudes whose influence we looked for were: attitude to motoring costs (Q58) and our proxies for need to evaluate (Q59), need for cognition (Q60), and tolerance of ambiguity (Q61). The resulting model was weak (adjusted $R^2$ 0.007), but suggested that people were more likely quote different amounts if they claimed to be the sort of person who liked to know their journey costs precisely and if they were tolerant of ambiguity – or, more precisely, they did not require simple clear cut answers.

### Factors Affecting Expected Behavioural Response

The next research question to be explored using regression analysis was: *What factors appear to influence respondents' expected behavioural response to road charges?* This investigation drew data from two sources; Q31/Q32 indicating respondents' reactions to a charge regime described in on sentence, and Q36/Q37/Q38 (*et seq.)* which referred to the more detailed charging schemes which were presented to the respondents.

An initial model sought to find any relationship between scheme characteristics and likelihood of changing behaviour (Q36, response c); no statistically significant relationship was found.

A series of models were constructed in an attempt to explain responses to the introduction of daily charges which allowed multiple journeys on that day for no extra charge (i.e. Q31 and Q32). Separate models were constructed to try and explain respondents' propensity to avoid driving on some days and to make more journeys overall (perhaps on the grounds that, having paid the charge they might as well get their money's worth). The potential explanatory variables, in both these cases, were the respondent's characteristics, their attitudes to decision making, their opinions on congestion in the city, and their opinions on the road charging.

The model for propensity to avoid driving on certain days, which achieved an adjusted $R^2$ of 0.041, is:

*PAD* = 1.91 + (0.16 x *likesCC*) – (0.12 x *thinkbad*) + (0.16 x *female?*) + (0.16 x *older?*) *(9)*

Where:

| | |
|---|---|
| *PAD*…… | (propensity to avoid driving on certain days) quantified as reverse of Q31 i.e. on a scale from 1 (probably wouldn't avoid) to 3 (would avoid) |
| *likesCC* …. | extent to which respondent likes clear cut answers (Q 61) on a reversed scale from 1 (certainly not) to 4 (yes certainly) |
| *thinkbad*….. | extent to which respondent thinks charges would be bad for the city (Q7) on a scale from 1 (good for the city) to 3 (bad for the city) |
| *female?*..... | (dummy) set to 1 if respondent is female, else zero |
| *older?*..... | (dummy) set to 1 if respondent is over 35, else zero |

The model (10) for propensity to make more journeys overall, which achieved an adjusted $R^2$ of 0.089, is:

*PMJ = 1.43 + (0.12 x workout)- (0.11 x expSC) + (0.07 x unfair) + (0.28 x rich?) - (0.25 x older?) - (0.15 x prof?) + (0.10 x thinkRC?)* *(10)*

Where:

| | |
|---|---|
| *PMJ* …… | (propensity to make more journeys overall) quantified, as in Q32, on a scale from 1 (fewer journeys) to 3 (more journeys) |
| *workout* …. | extent to which respondent likes to work out the pros and cons before reaching a decision, quantified, as in Q59, on a reversed scale from 1 (certainly not) to 4 (yes certainly) |
| *expSC* …….. | extent to which respondent has experienced serious congestion in the city, quantified as in Q2 on a scale from 1 (It does not affect me very much) to 3 (It has a very serious affect on me) |
| *unfair*..... | respondent's opinion on the unfairness of road charges (Q 6) on a scale from 1 (absolutely fair) to 4 (completely unfair) |
| *rich*?..... | (dummy) set to 1 if annual household income is £20k or above, else zero |
| *older?*..... | (dummy) set to 1 if respondent is over 35, else zero |
| *prof?*..... | (dummy) set to 1 if respondent is professionally qualified, else zero |
| *thinkRC?*..... | (dummy) set to 1 if respondent thinks that the main reason for introducing road charges would be to reduce congestion, else zero. |

Although there is nothing implausible about either of these models, some of the apparent links between behaviour and attitudes require interpretation (see discussion below).

Turning now to the responses which relate to the more detailed scheme descriptions. For each presented scheme, respondents were asked to indicate how their travel patterns might change if the scheme were introduced. There were three questions. The first (e.g. Q36) asked how likely they would be to change their travel patterns, the second (e.g. Q 37) asked how likely they were to make fewer car journeys and the third (e.g. Q38) asked how likely they were to change the time at which they travelled. Models were constructed to explore the extent to which the answers to these questions could be explained by the respondent's characteristics, their attitudes to decision making, their opinions on congestion in the city, their opinion on the road charging, and their expectation of the monthly charges they would incur if they continued to travel as now.

The model of likelihood of making a change in travel patterns, which achieved an adjusted $R^2$ of 0.05, is:

*LCTP = 1.19 + (0.12 x monthcost) + (0.14 x likesCC) - (0.09 x unfair) + (0.08 x workout) + (0.11 x prof?)* *(11)*

Where:

LCTP …….. (likelihood of changing travel patterns) is quantified, as in Q36, on a scale from 1 (I don't think I would change my travel patterns) to 3 (I would change my travel patterns)

*Monthcost...* respondent's estimate of the monthly cost of their regular journey – assuming they continue driving as now. As reported at Q34 on a scale from 1 (less than £20) to 5 (more than £80)

*likesCC…..* extent to which respondent likes clear cut answers (Q 61) on a reversed scale from 1 (certainly not) to 4 (yes certainly)

*unfair.....* respondent's opinion on the unfairness of road charges (Q 6) on a scale from 1 (absolutely fair) to 4 (completely unfair)

*workout.....* extent to which respondent likes to work out the pros and cons before reaching a decision, quantified, as in Q59, on a reversed scale from 1 (certainly not ) to 4 (yes certainly)

*prof?.....* (dummy) set to 1 if respondent is professionally qualified, else zero

The model of likelihood of making fewer car journeys, which achieved an adjusted $R^2$ of 0.052, is:

*LFCJ = - 0.44 + (0.33 x likesCC) + (0.24 x monthcost) - (0.24 x unfair) + (0.18 x workout) + (0.33 x prof?)* *(12)*

Where:

LFCJ…….. (likelihood of fewer car journeys) is quantified, as in Q37, on a scale from 1 (certainly the same) to 4 (definitely fewer)

Explanatory variables are as defined for model 11

The model for the likelihood of changing the timing of journeys, which achieved an adjusted $R^2$ of 0.035, is:

*LCJT = 0.50 + (0.91 x monthcost) + (0.25 x LikesCC) - (0.21 x unfair) - (0.34 x rich?) + (0.25 x prof?)* *(13)*

Where:

LCJT …….. (likelihood of changing journey times) is quantified, as in Q38, on a scale from 1 (no change) to 4 (would certainly change)

*rich*?.. (dummy) set to 1 if annual household income is £20k or above, else zero

Other explanatory variables are as defined for model 11

This set of models again contains interesting results which warrant further discussion.

### *Discussion*

The survey has identified some interesting features of drivers' response to road charges with different degrees of complexity. The overall picture which has emerged is of a population most of whom consider congestion to be a relatively minor problem, who are unconvinced of the need for road charges, sceptical as to their impact and inclined to consider them unfair and bad for the city. At an individual level, although most respondents say they would consider changing their travel patterns if a substantial charge was introduced, many expected that, in the end, they would carry on as before. This may reflect the fact that almost half the respondents say that they tend not to think about the costs of individual journeys and a significant minority thought they would have difficulty giving a precise estimate of their trip mileage.

A significant minority of respondents, particularly those on lower incomes, say they would find it difficult to estimate the charges accurately and substantial minorities indicated traits which we may interpret as tolerance of ambiguity, lack of need for cognition and lack of need to evaluate.

The regression models left most of the variance in the data unexplained so it cannot be claimed to have found anything approaching a full explanation for the observed phenomena. None of the regression models were able to explain more than 10% of the variance in the data but they did suggest that people's assessment of individual schemes reflects not only the attributes and presentation of the schemes, but also the respondent's own characteristics and opinions about road charging per se.

Considering **hypothesis 1** (*There is a point, beyond which, the more differentiated a price structure, the less behavioural adaptation will occur.),* no direct evidence was found to support this hypothesis (no statistically significant relationship between scheme characteristics and stated likelihood of changing behaviour). However, it appeared that people had difficulty in understanding charging systems with a large number of charge levels, numerous zones or a per-distance charge (in models 1 and 2). The attributes of a scheme which appear to most affect people's perception of its complexity (or more precisely, the ease with which they could make an accurate estimate of the charge) are, in decreasing order or significance, the number of separate charge levels included in the description, the number of zones, and whether or not the charges include a per-mile element. The number of time periods appears not to be an issue and the finding that spatial factors have more influence than temporal factors is consistent with conclusions from earlier qualitative work on this issue (Bonsall et al, 2006). It is interesting to note, in model 3, that people think that schemes which incorporate a mileage charge are likely to be less effective than those based simply on zones or cordons. Unfortunately we cannot know whether this is an "honest" opinion (based perhaps on a belief that since a mileage-based charge would be difficult to predict it could not be expected to have a clear impact on behavior, or perhaps on the logical deduction that it would encourage drivers to use short, direct, congested routes rather than specially constructed bypasses), or a strategic response (based perhaps on the belief that it would disadvantage them but that they needed to give some other reason for finding it unacceptable).

The fact that the perceived complexity of a scheme is related to the number of separate charge levels appearing in the scheme description should be no surprise but it does serve to highlight the importance of scheme presentation. Considering **sub-hypothesis 2** (*An individuals´ ability to understand the charging system and to adjust behaviour will be a positive function of their prior experience of similar price structures)* – we found no direct evidence to support this hypothesis (as above, there was no statistically significant relationship between scheme characteristics and stated likelihood of changing behaviour), but noted that, according to model 3, people's perception of the effectiveness of a scheme depended on whether they had already been asked to think about other schemes. The fact that the order in which schemes were presented has an influence on respondents' assessment of their effectiveness (model 3) suggests that people's initial opinions may change when they begin to think more carefully about the issues.

Referring to **sub-hypothesis 3** *(An individuals´ motivation to adjust behaviour will be a positive function of their acceptance of the system),* although there were no specific questions on the respondents' acceptance of different schemes, significant positive relationships between perceived fairness of road charging per se and stated likelihood of changing behaviour in response to the charges were found (models 11, 12 and 13). Furthermore, a particularly interesting set of results are those which indicate that, when presented with the charging scenarios, people who had thought road charging unfair in principle reported:

a. greater anticipated difficulty in making an accurate estimate of the charge,

b. lower expected effectiveness of the scheme,

c. lower likelihood of them changing their travel patterns,

d. lower likelihood of them changing the number of journeys and

e. lower likelihood of them changing the timing of their journeys.

The question of the direction of causality in these relationships has already been touched above where we concluded that the assessment of fairness was probably not dependent on the perception of calculation difficulty or of scheme effectiveness. The idea that people who perceive a scheme as unfair are less motivated to estimate the charge accurately would certainly fit hypotheses advanced in Deliverable 4.1.

The lower reported likelihood of changing their behaviour may be an indication that their perception of its unfairness is linked in some way to a perception that their travel patterns (and other people's?) are inflexible (they may subscribe to the view that it is unfair to penalise people who have no choice).This explanation might also explain why, according to model 9, people who think road charging would be bad for the city indicate a lower likelihood of avoiding driving on some days if daily charges were introduced. An alternative, more cynical, explanation of these findings would be that the respondents are biasing their answers for strategic intent (a possible chain of logic being: "I don't like the scheme, they want it to affect people's behaviour, I won't give them any reason to believe that it will change my behaviour"). The presence of this kind of bias might also explain why, according to model 10, people who think that the main reason for road charging would be to reduce congestion are more likely to indicate that daily road charges might actually cause them to make more journeys overall. Interestingly, model 10 suggests that respondents who like to work out all the pros and cons of a choice (Q59) are particularly likely to say that the introduction of a daily charge would cause them to increase their total number of car trips – perhaps such people are attracted by the apparent logic of making maximum use of the unlimited access which the postulated payment would allow!

Considering to **sub-hypothesis 6** (*An individuals´ engagement with the charges and their motivation to adjust behaviour will depend on their type of personality.)* – there were significant relationships between respondents' expected behavioural response to charges and their answers to questions 59 and 61 – our proxies for need to evaluate and tolerance of ambiguity (models 9, 10, 11, 12 and 13). We also found that the degree of discrimination shown between the charges that people were prepared to pay under different assumptions about improvements in network conditions was significantly influenced by their attitude to travel costs and their preference for simple, clear cut, answers. Model 11 seeks to explain respondents' reported likelihood of changing their travel patterns in response to introduction of the charging scenarios. Unsurprisingly, it is positively correlated with the level of charges which they expected to face. It was also positively correlated with their reported desire to work out all the pros and cons of a choice (Q59) and their preference for clear-cut answers (Q61). Similar results are found in respect of expected likelihood of making fewer car journeys (model 12) and of changing the timing of journeys (model 13). This may be taken as evidence of a tendency for behavioural adjustment to be most likely among those who like to seek a "rational" solution to changed circumstances. Respondents' reported attitudes to journey costs (Q58) had, as noted above, an influence on the amount that people were prepared to pay; the fact that it had no significant impact on behavioural response was therefore surprising (but may be due to a correlation between answers to questions 58 and 59).

Considering **sub-hypothesis 7** (*effect of income*) and **sub-hypothesis 8** (*effect of education*), it was interesting to note, from the comparison of the amounts that people would be willing to pay under different scenarios for improvement in public transport and car journey times, that people with professional qualifications were less likely, but people on higher incomes were more likely, to quote a different maximum charge in the two situations and that people were more likely quote different amounts if they claimed to be the sort of person who liked to know their journey costs precisely (Q58) and did not require simple, clear-cut answers (Q61).

It was found a significant negative relationship between income and expected likelihood of changing the timing of car journeys following the introduction of charges (model 13) but a significant positive relationship between income and expected likelihood of increasing the overall number of car journeys in response to the introduction of a daily charge allowing an unlimited number of trips on that day (model 10 - see below for further discussion). Moreover people on higher incomes were significantly more likely to show discrimination between the charges they would be prepared to pay under different assumptions about improvements in network conditions. Rather surprisingly we found no significant relationship between education or qualifications and stated difficulty of understanding the charging regimes (but it may be that the any effect of education was taken up in model 1 by the income variable). We did however find significant positive relationships between having a professional qualification and expecting to change travel patterns or change the timing of car journeys in response to the introduction of charges (models 12 and 13). Model 10 suggests a significant negative relationship between having a professional qualification and expecting to increase the overall number of car journeys in response to the introduction of a daily charge allowing an unlimited number of trips on that day (see below for further discussion).

Referring to **sub-hypothesis 9** (*An individuals´ ability and motivation to adjust behaviour will depend on the type of trip: Commute trips tend to be less elastic than shopping or recreational trips.*), it appeared (in models 4-8) that people's willingness to pay a charge rather than change their travel patterns, varies significantly depending on their journey purpose. It seems that people are prepared to pay more for journeys to work, to school and on business, that improvements to public transport has least relevance to business trips, that improvements in car journey times would be of most use to business trips, that people on business trips have higher values of time, and that school trips are least flexible in terms of timing.

Considering **research question 2** (*How does age and gender influence the ability and motivation to deal with differentiated pricing systems and how does it affect transport behaviour.*), there was no significant relationships between respondents' age or gender and their perceived difficulty of estimating charges or the nature of their response to the charge scenarios. We did however find that females and older people were more likely to say they would seek to avoid driving on certain days if a daily charge were introduced allowing multiple trips on that day. Model 9 suggests that older respondents appeared to be keenest to try to avoid travelling on some days if daily charges were introduced and model 10 suggests that they were less likely to expect to increase their overall trip numbers in response to such charges – both results suggesting a reluctance to drive more than necessary. Model 10 indicates that this reluctance to make additional journeys is also apparent among people who experience serious congestion. This is wholly logical since they are likely to expect such journeys to be more irksome. It will be recalled that model 10 is based on a question which sought evidence of a keenness to get ones money's worth from a daily charge. It seems that this tendency is most associated with people who are rich, young, and professionally unqualified!

### 2.1.3 The Edinburgh Demonstration Trial

#### *Introduction*

This case study analyses the moderating impact of users' attitudes and habits on their behavioural adaptations towards differentiated charging. Data from the Edinburgh demonstration trial is used. The growth of population in Edinburgh and the related increase of traffic volume led to an overload of the traffic system. In 1999 it was decided to develop a new integrated traffic concept, which manages these traffic problems and leads to a more efficient traffic system. The development included the

introduction of urban road user charges (Saunders, 2005). The charging scheme proposed by the City of Edinburgh Council aimed at reducing congestion and raising revenues to improve public transport. In association with this and within the PROGR€SS project, the Edinburgh demonstration trial was implemented in September 2002 and ran until February 2003.

The objective of the Edinburgh technology demonstration trial was to demonstrate the viability of the proposed congestion charging approach (Figure 2-6). The proposed full scheme consisted of two cordons and a £2 charge for inbound travel. The charge would have applied between Monday and Friday, during the day (7am–7pm) for both cordons. Drivers passing through either cordon would be charged a maximum of £2 per day. Furthermore, this trial aimed at investigating aspects of enforcement and behavioural adaptation towards a full scheme (PROGRESS, 2003).


**Figure 2-6: Proposal of Congestion Charging Scheme in Edinburgh**

Although this trial was not primarily designed to examine effects of charging scheme differentiation on users' behaviour, the data collected allows examining attitudes to road user charges.

### *Research Questions and Hypotheses*

This case study investigates the moderating impact of users' attitudes and habits on their behavioural adaptations towards differentiated charging. Current analyses address the following research questions and hypotheses:

**Research question 1: How does acceptability of congestion charging affect car users' stated likelihood to behavioural adaptation?**

*An individuals' motivation to adjust behaviour will be a positive function of their acceptability of the system* (sub-hypothesis 3).

As formulated in Del. 4.1 (Hoffmann et al., 2006) motivational factors might influence behavioural adjustments. Even if people are able to deal with road charging schemes they might not be willing to respond to them. Thus it is assumed that the more individuals accept congestion charges the more behavioural adaptation will occur.

To test this hypothesis, non-parametric correlation analyses between acceptability statements and indicators of behavioural adaptation are conducted. Once to test whether acceptability is able to explain variance in behavioural adaptation within either month separately and once according to cross-lagged-panel design to examine whether the acceptability statement is able to predict future

differences in behavioural adaptation. Furthermore, non-parametric tests of differences in indicators of behavioural adaptation are conducted between the group of participants that supported congestion charges in principle and the group that do not support congestion charges.

**Research question 2: How does personal involvement influence car users' stated likelihood to behavioural adaptation according congestion charges?**

*An individuals´ motivation to adjust behaviour will be a positive function of their personal involvement* (sub-hypothesis 4).

As also formulated in Del 4.1, it is not only important to perceive traffic related problems but also to feel affected by them. Involvement is a reflection of strong motivation in the form of high perceived personal relevance of a product or service in a particular context. This aspect of motivation can influence attention as well as exerting an effect on comprehension. When a stimulus is perceived as personally relevant, more attention is paid to it. Furthermore it was found that the degree of personal involvement is likely to influence the effort of decision making. Thus it is assumed that personal involvement affects also behavioural adaptation to congestion charging: the stronger people perceive congestion related problems in a road network and the more frequent people use the road network, the more behavioural adaptation will occur.

To test such an interaction effect, a two way analysis of variance would be necessary using the frequency of car usage and problem awareness as independent variables and behavioural adaptation as a dependent variable. But since the data is not normally distributed, parametric procedures cannot be applied. Instead the assumed interaction effect is examined by a descriptive view on the data. The main effects of frequency of car usage and problem awareness on behavioural adaptation are tested by non-parametric procedures separately.

*An individuals´ ability and motivation to adjust behaviour will depend on the type of trip: Commute trips tend to be less elastic than shopping or recreational trips (sub-hypothesis 9).*

As also stated in Del 4.1, one situational aspect is the type of the intended journey as trips range in their value. Emergency- and commuting trips are higher-value trips and therefore inflexible even when conditions change. Lower value trips such as for occasional shopping or recreation trips will only occur if prices are low (otherwise they forgo them or shift to a cheaper mode or destination) and high value trips will occur even if user costs are high (Litman, 2006; Stradling, 2002). Within the EUROTOLL project it was further differentiated between trips with or without schedule constraints, such as the individuals´ need to arrive at his / her place of work by a certain time (Francsics & Ingrey, 2000). When there is a schedule constraint, people's value of time is at a higher level for these trips than for journeys without these constraints.

To test that hypothesis, frequency distributions of alternative statements (yes / no) on which type of journey would be most likely to switch to an alternative mode of transport are compared. Statistical significance is tested by the Cochran-test (repeated measurements, alternative data).

## *Method*

### Procedure

During the demonstration trial, two sites were equipped with cameras and Automatic Number Plate Reading (ANPR) equipment: the sites formed part of the proposed inner cordon for the full scheme. Volunteers were asked to simulate the purchase of licences whenever travelling through one of the demonstration sites by car during the day. The purchase could take place through one of the participating retailers, or via a dedicated website or telephone line set up for the demonstration. To be realistic, the payment arrangements were similar to those likely to be used in practise including:

- The ability to pay the day before or during hours of operation of the charging (7am to 5pm),
- The ability to pay after the trip until midnight.

Further, participants received £10 for every month they participated in the demonstration trial. Additionally, they received £2 on each occasion that they used the charging points. In order to reflect the penalty that might be incurred in a real life scheme, any payment made between 5pm and midnight received a reduced payment of £1 instead of £2.

Accompanying the demonstration trial, participants were asked for their opinions and experiences on congestion charging by telephone interviews at three different time points:

- after the recruitment and before the trial became active (September 2002),
- October 2002 and
- December 2002.

For each stage of interviewing, a questionnaire was developed by Napier University and George Street Research and administered via telephone. The analysis presented in this case study is based on the data sets obtained in the October and December interviews.

### Participants

203 volunteers were recruited to participate in the technology demonstration via face-to-face recruitment by George Street Research. Due to the fact that all participants were volunteers, volunteer biases of the results are not entirely excludable. Voluntary participants might be more interested in issues concerning road pricing and / or approve road pricing measures more strongly than others, thus, biased pre-selections by mentioned matters are possible. Due to this pre-selection it might be further possible that acceptance values are higher and / or behavioural adaptations are stronger within the sample than within the population.

During the demonstration period, a total of 71 participants dropped out of the study because they were no longer able to take part, they wished no longer to take part or they were retired from the panel because they were inactive (they had not obtained any license at all during the trial period).

During the October interviews, views were successfully elicited from 192 out of the maximum sample of 203 volunteers. During the December interviews, views were successfully elicited from 121 out of the maximum sample of 132 volunteers.

56% of the initially recruited participants were between 35 and 54 years old. Further, 33% of participants stated that they travelled four or more days per week into Edinburgh. A substantial proportion (41%) of participants indicated that they drove one to three days per week into Edinburgh and about a quarter drove less than once a week into the city. The most frequently stated purpose of travelling into Edinburgh was commuting trips (33%), followed by business trips (25%). 22% of participants stated that they travelled mainly for shopping purposes and slightly less than one fifth drove into Edinburgh mainly for leisure purposes. About three in five (59%) volunteers were male and about two in five (41%) were female.

### Questionnaires

For each stage of interviewing, a questionnaire was developed. In the following, we concentrate on those variables which are of relevance to the current analyses. Among others, the October questionnaire sought information about:

- Frequency of car usage,
- Acceptability towards congestion charging,
- Congestion and traffic related problem awareness,
- Main purpose of trips into city centre,
- Likelihood of switching to other modes of transport separately for trips into city centre and trips to other parts out of city centre (as response to congestion charging) and

- Likelihood to cutting down on trips separately for trips into city centre and trips to other parts out of city centre (as response to congestion charging).

The questionnaire used in December was similar to the previous version but included questions on a new proposal for the full operating scheme and additional information about the aesthetic appearance of cameras.

## *Results*

### Impact of Acceptability on Behavioural Adaptation

#### *Mode Choice*

The following results consider the relationship between acceptability and the motivation to adjust behaviour. Overall, the results show that the likelihood to switch to an alternative transport mode decreases slightly from October to December. Most respondents stated that switching to other modes of transport as a result of congestion charges is quite unlikely (see Figure 2-7) and, in this respect, there was no statistical difference between data collected in October and December (Wilcoxon-Test, into city centre: $p = 0.055$, to other parts: $p = 0.190$).

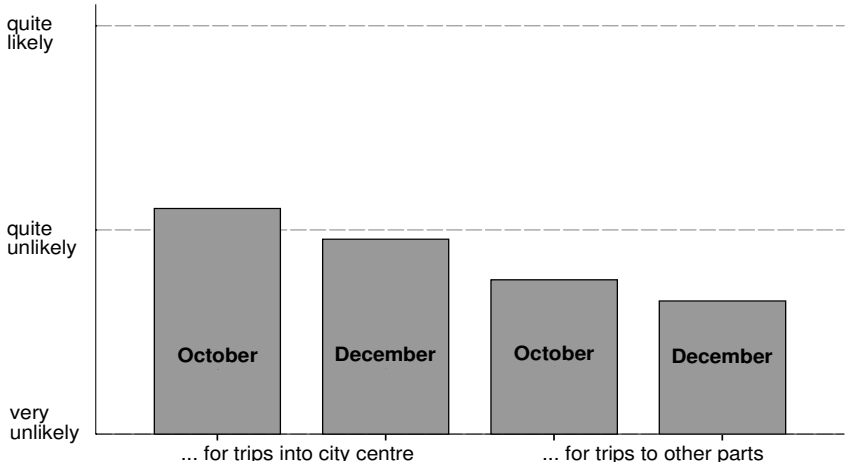



**Figure 2-7: Likelihood to Switch to Other Transport Modes as a Result of Congestion Charging**

Considering the relationship between acceptability and the intention to switch to an alternative transport mode, the findings partly support the assumptions: for the month October positive correlation coefficients have been identified between acceptability and the likelihood of switching to alternative transport modes for trips to Edinburgh centre ($r_s = 0.385$, $p < 0.001$) and for trips to other areas outwith Edinburgh centre ($r_s = 0.261$, $p = 0.004$).

Further, individuals who expressed support for congestion charges appeared more likely to switch to other transport modes as a result of these charges than those who did not support the charges (Table 2-15, Figure 2-8). The differences are statistically significant for trips into city centre as well as for trips to other parts outwith the city centre (Table 2-16).

**Table 2-15: Mean Values of Likelihood to Switch to Other Modes of Transport (On Four Step Scale from 1 Very Unlikely to 4 Very Likely)**

| I support congestion charges in principle… | Disagree / Disagree strongly | Agree / Agree strongly |
|---|---|---|
| **Likelihood to switch to other modes of transport as a result of congestion charges when travel …** | **Mean** | **Mean** |
| …into Edinburgh centre | 1.67 | 2.53 |
| …to other parts | 1.51 | 2.00 |

**Table 2-16: Significance Tests - Likelihood to Switch, Grouping Variable: Acceptability**

| | L'hood to switch to other modes of transport (into city centre) | L'hood to switch to other modes of transport (to other parts) |
|---|---|---|
| Mann-Whitney U | 828.0 | 1032.0 |
| Wilcoxon W | 1863.0 | 1935.0 |
| Z | -4.288 | -3.093 |
| Asymp. Sig. (2-tailed) | **.000** | **.002** |

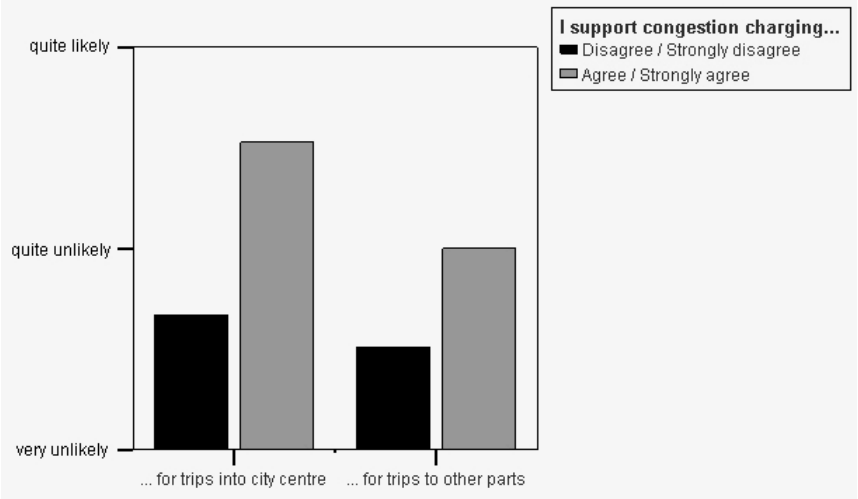



**Figure 2-8: Mean Values of Likelihood to Switch Depending on Acceptability _ October**

However, the December interviews provide inconsistent results. The correlation between acceptability and the likelihood of switching to an alternative mode of transport declines to a non-significant level both for trips to city centre and for trips to other parts outwith city centre.

Further, as illustrated in Figure 2-9, acceptability statements obtained during the October interviews do not contribute significantly to the prediction of likelihood of switching to other modes for trips into city centre as well as for trips to other parts in December. Figure 2-9 also contains indicators of intrapersonal consistency. Indicators suggest that statements about acceptability are more consistent across the time than stated likelihood of behavioural changes. That might corresponded with overall decreasing of behavioural changes' likelihood at the 2nd interview stage mentioned above. So, it might be plausible that the impact of situational factors on stated likelihood of behavioural changes became stronger over time and – corresponding with this – the impact of acceptability declined (for instance, car usage seems to be more attractive during winter months than in autumn).

Furthermore, no differences between supporters and non-supporters have been identified for the likelihood to change the mode of transport.

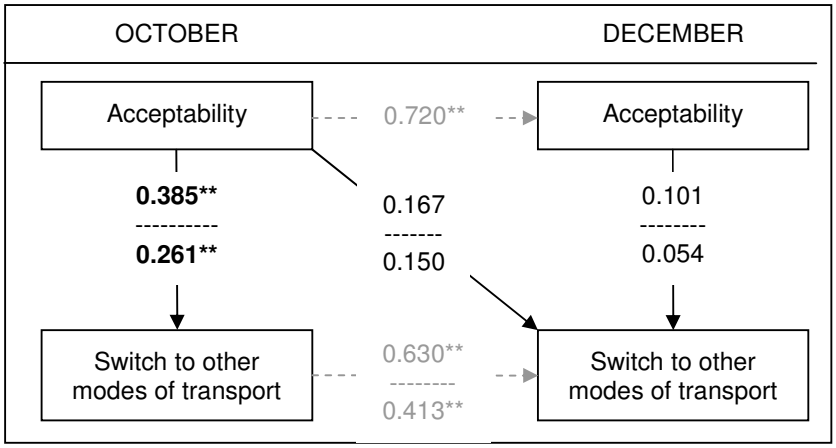



**Figure 2-9: Correlation Coefficients Acceptability ~ Mode Change (Above the Line: For Trips into City Centre, Under the Line: For Trips to Other Parts)**

*Cutting Down on Trips*

Overall, the results show that cutting down on trips seem rather unlikely to be a result of congestion charging (Figure 2-10). Similar to the findings reported above the likelihood of cutting down on trips decreases slightly from October to December. The differences across the time are not statistically significant (Wilcoxon-test, p = 0.426, p = 0.437).

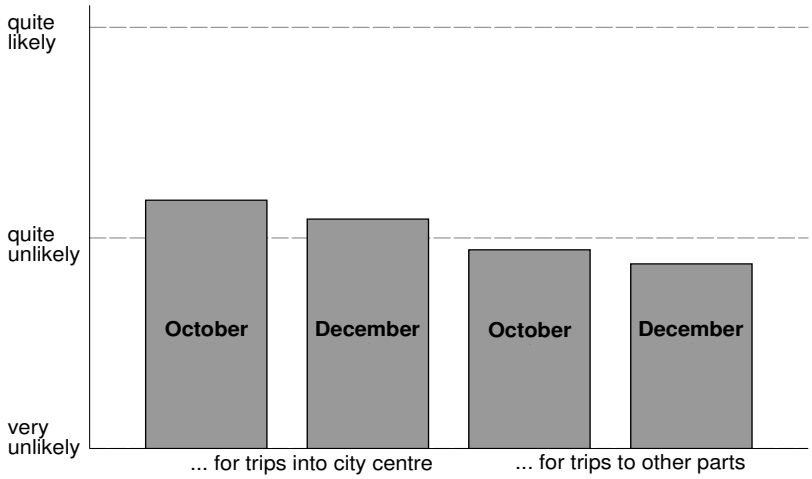



**Figure 2-10: Stated Likelihood of Cutting Down on Trips as Response to Congestion Charging**

Results of the correlation analysis show a weak positive coefficient $r_s = 0.186$ (p = 0.018, Figure 2-11) between acceptability values and the likelihood of cutting down on journeys to other parts outwith city centre. For trips into the city centre, acceptability and the likelihood of cutting down on journeys are unrelated. Furthermore, acceptability in October does not contribute significantly to the predicted likelihood of cutting trips in December.

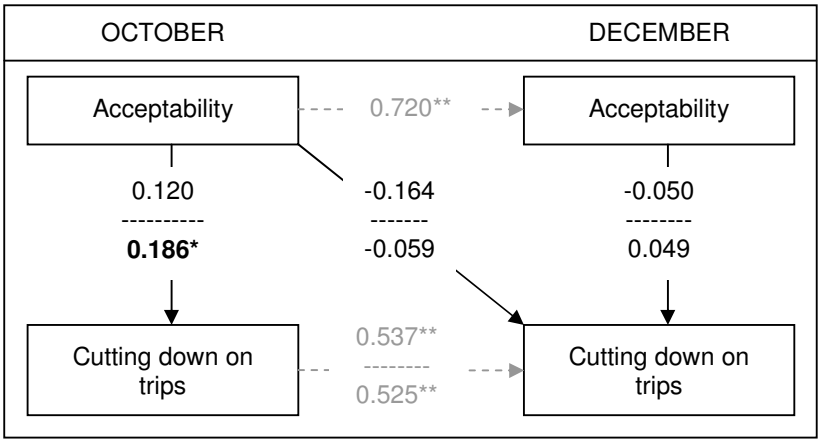



**Figure 2-11: Correlation Coefficients Acceptability ~ Cutting Down on Trips (Above the Lines: For Trips into City Centre, Under the Lines: For Trips to Other Parts)**

At least regarding trips to other parts outwith the city centre, respondents who support congestion charges stated that they are more likely to cut down on trips than respondents who do not support congestion charges (Table 2-17, Figure 2-12).

**Table 2-17: Mean Values Likelihood of Cutting Down on Journeys**

| I support congestion charging… | Disagree / Disagree strongly | Agree / Agree strongly |
|---|---|---|
| **Likelihood of cutting down on journeys…** | **Mean** | **Mean** |
| … into city centre | 2.02 | 2.24 |
| … to other parts | 1.72 | 2.09 |

**Table 2-18: Significance Tests - Likelihood of Cutting Down on Trips, Grouping Variable: Acceptability**

| | L'hood of cutting down on trips into city centre | L'hood of cutting down on trips to other parts |
|---|---|---|
| Mann-Whitney U | 1442.0 | 1099.5 |
| Wilcoxon W | 2523.0 | 2045.5 |
| Z | -1.122 | -2.359 |
| Asymp. Sig. | .262 | **.018** |

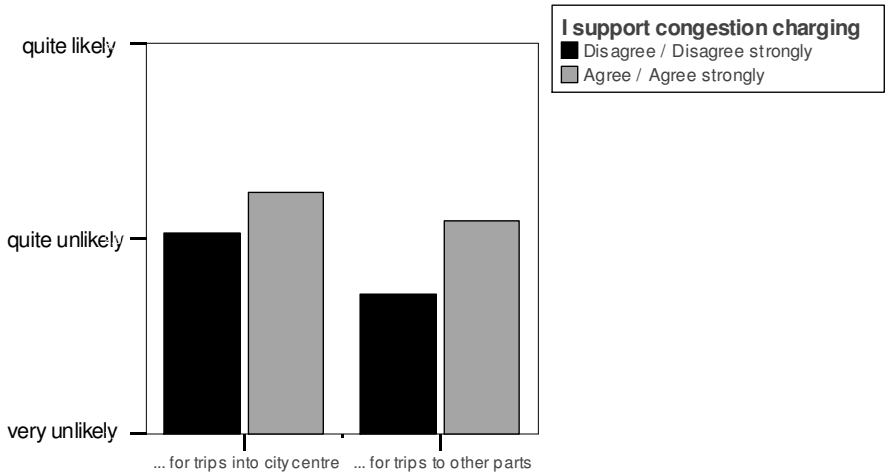



**Figure 2-12: Mean Values of Stated Likelihood Cutting Down on Trips Depending on Acceptability (October)**

### Impact of Personal Involvement on Behavioural Adaptation

It has been assumed that a strong personal involvement may be assumed for participants who perceived congestion related problems on Edinburgh's road network as more profound and who drove more often on road network than others. Considering this, strong personal involvement may be assumed for participants with high frequency car usage and strong perception of traffic congestion on the road network.

Deriving from these assumptions, the influences of two factors are examined. One factor considers respondents' frequency of driving into Edinburgh. The second factor, the problem awareness, was built up by median split of distribution of an index regarding problem awareness. This index was derived from the participants' statements to three items considering their agreement about congestion related problems. Cells have been composed if single cell occupation was smaller than 4. The likelihood to switch to another mode of transport and the likelihood to cut down on trips are considered as dependent variables. Due to the lack of Gaussian distribution of the data non-parametric procedures have been conducted (Kruskal-Wallis-Test, Mann-Whitney-Test). The assumed interaction effect of trip frequency and problem awareness is examined only descriptively.

### Likelihood of Switching to Other Modes of Transport

Regarding the likelihood of switching to other transport modes to travel into city centre (Figure 2-13), the results based on the October data show that respondents who rate congestion problems on Edinburgh's road network as more profound tend to be more likely to switch to other modes of transport. Furthermore, respondents who drive more often into the city centre tend to be less likely to switch to another transport mode. An interaction effect between frequency and problem awareness could not be identified. Considering the likelihood of switching to other modes of transport to travel to other parts of Edinburgh, no main effects and no interaction effect were found.

The analysis of the December data set reconfirms partly the results reported above. A main effect of travel frequency on the likelihood of switching to other transport modes for trips into the centre is identified. The more often respondents travel into the city centre by car the more unlikely they will switch to alternative transport modes. Further, respondents who perceive congestion problems more seriously tend to be more likely to switch than others (Table 2-20). Considering the likelihood of switching to other transport modes for trips to other parts, significant effects could not be identified (Table 2-19).

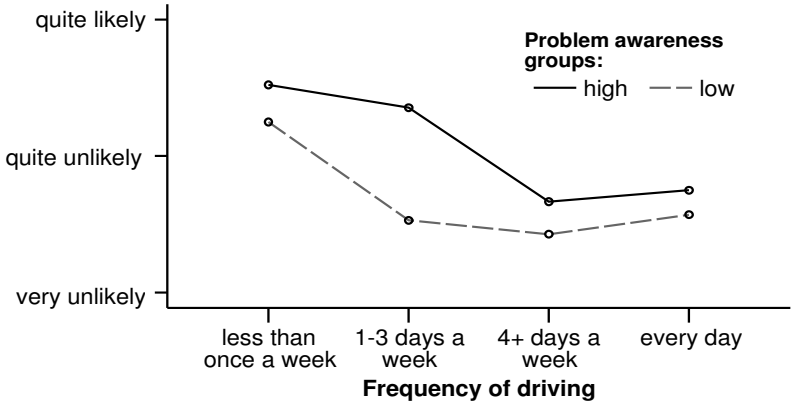



**Figure 2-13: Likelihood to Switch to Other Transport Modes for Trips into City Centre _ October**

**Table 2-19: Results from Kruskal-Wallis - Tests, Grouping Variable: Frequency of Driving**

| | Likelihood to switch to alternative mode of transport | | | |
|---|---|---|---|---|
| | October | | December | |
| | For trips into city centre | For trips to other parts outwith city centre | For trips into city centre | For trips to other parts outwith city centre |
| Chi-Square | 7.006 | 3.538 | 6.790 | 2.540 |
| df | 3 | 3 | 2 | 2 |
| Asymp. Sig. | **.072** | .316 | **.034** | .281 |

**Table 2-20: Results from Mann-Whitney - Tests, Grouping Variable: Congestion Related Problem Awareness**

| | Likelihood to switch to alternative mode of transport | | | |
|---|---|---|---|---|
| | October | | December | |
| | For trips into city centre | For trips to other parts outwith city centre | For trips into city centre | For trips to other parts outwith city centre |
| Mann-Whitney U | 959.0 | 1068.0 | 700.0 | 776.0 |
| Wilcoxon W | 1739.0 | 1929.0 | 1228.0 | 1304.0 |
| Z | -2.818 | -2.553 | -2.561 | -1.648 |
| Asymp. Sig. | **.005** | **.011** | **.010** | .099 |

### Likelihood of Cutting Down on Trips

Results of significance tests based on both data sets show partly the same pattern as the findings reported above: the likelihood of cutting down on trips decreases with an increasing frequency of driving (journeys into the city centre, Figure 2-14). According to tests based on the October data set, respondents who rate congestion problems on the road network as more profound tend to be more likely to cut down on journeys - into city centre as well as to other parts outwith city centre (Figure 2-15, Table 2-21). Considering problem awareness, tests based on the December data set failed to find any significant result.

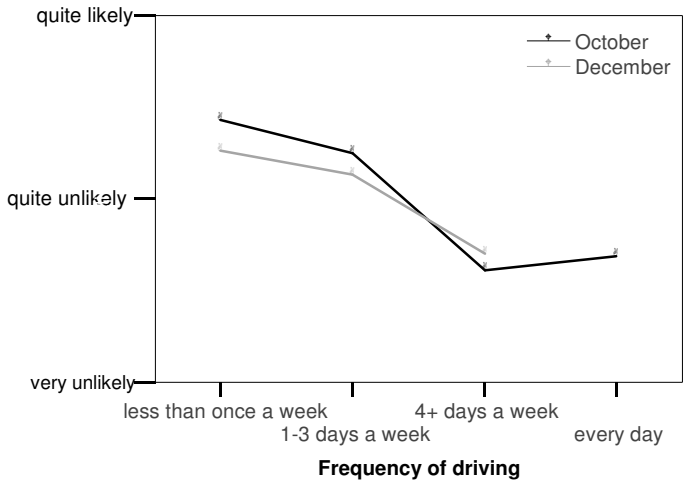



**Figure 2-14: Likelihood of Cutting Down on Trips into City Centre Depending on Frequency of Driving [4] (Mean values)**

**Table 2-21: Significance Tests of Differences in Likelihood of Cutting Down on Trips, Grouping Variable: Frequency of Driving**

| | Likelihood to cutting down on trips | | | |
|---|---|---|---|---|
| | October | | December | |
| | For trips into city centre | For trips to other parts outwith city centre | For trips into city centre | For trips to other parts outwith city centre |
| Chi-Square | 10.562 | 5.809 | 6.790 | 2.540 |
| df | 3 | 3 | 2 | 2 |
| Asymp. Sig. | **.014** | .121 | **.034** | .281 |

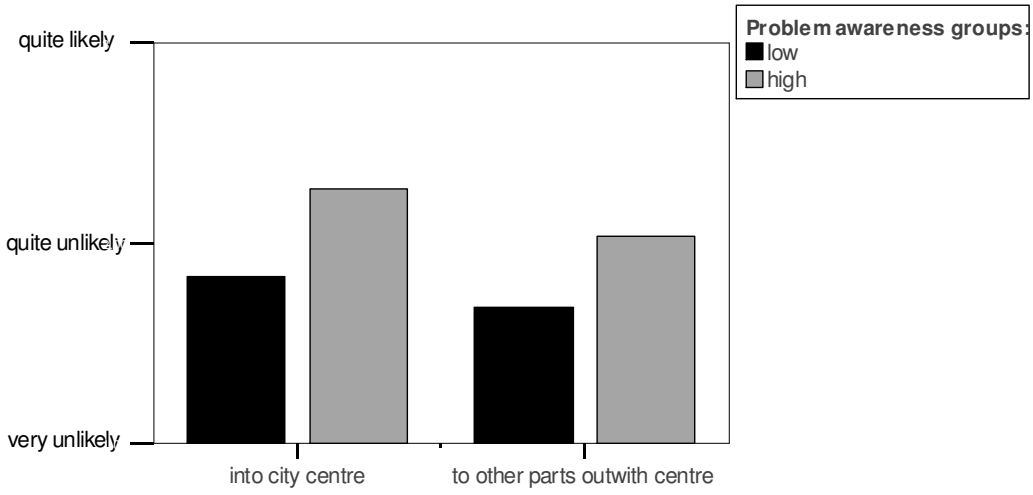



**Figure 2-15: Likelihood of Cutting Down on Trips Depending on Perception of Traffic Congestion Problems (October)**

[4] For December sample, frequency categories „4+ days a week“ and „every day“ has been composed because of cell occupation smaller than 4.

**Table 2-22: Significance Tests of Differences in Likelihood of Cutting Down on Trips, Grouping Variable: Congestion Related Problem Awareness**

| | Likelihood to cutting down on trips | | | |
|---|---|---|---|---|
| | October | | December | |
| | For trips into city centre | For trips to other parts outwith city centre | For trips into city centre | For trips to other parts outwith city centre |
| Mann-Whitney U | 1182.500 | 1068.500 | 969.000 | 774.500 |
| Wilcoxon W | 2043.500 | 1929.500 | 1564.000 | 1270.500 |
| Z | -2.163 | -2.063 | .930 | -1.632 |
| Asymp. Sig. | **.031** | **.039** | .352 | .103 |

It was hypothesised that an individuals´ motivation to adjust behaviour will be a positive function of their personal involvement. Further it has been assumed that high personal involvement is given by the strong perception of traffic congestion related problems and frequent car usage. Considering the results of descriptive examinations, this hypothesis has been falsified. However, it could be proved that the perception of traffic related problems in road network seems to have an effect on motivation of behavioural adjustment. The frequency of car usage as second precondition of personal involvement is inversely related to the motivation of behavioural adjustment. No obvious interaction effects could be identified.

### Impact of Journeys Purpose on Behavioural Adaptation

Respondents who reported high likelihood of switching were polled on which type of journey they would most likely switch to an alternative mode of transport. Participants could make statement of 'yes' or 'no' to all types of trips that apply. The results show significant differences between work related travels and shopping or leisure trips at least based on the October data (Figure 2-16). The differences in the December data are less considerable but point in the same direction. Due to the smaller sample size and weaker differences in December, the test of statistical significance failed (Table 2-23).

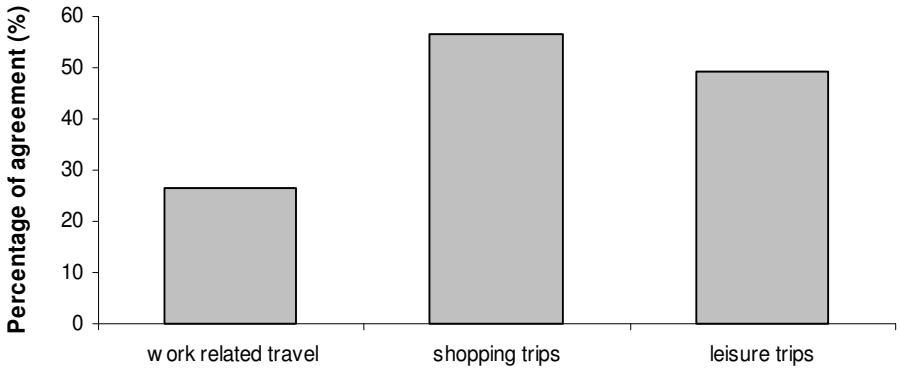



**Figure 2-16: Frequency Distribution of Probability to Switch Regarding Types of Trips**

**Table 2-23: Distribution of Positive Responses - Likelihood to Switch to Alternative Modes**

| | Work related travel | Shopping trips | Leisure trips | Cochran –test |
|---|---|---|---|---|
| October (n = 53) | 26.4% | 56.6% | 50.9% | **0.017** |
| December (n = 21) | 36.4% | 45.5% | 39.4% | 0.789 |

### *Discussion*

The present case study is based on data sets obtained during the Edinburgh demonstration trial. However, it needs to be acknowledged that this trial was not designed to examine effects of charging scheme differentiation on users' behaviour. The obtained data do however provide opportunities to test some underlying assumptions formulated in Deliverable 4.1 (Hoffmann et al, 2006).

At first, it was tested whether attitudes have an impact on users' stated likelihood of behavioural changes. According to a first overview, the likelihood of switching to other modes of transport seems to be greater than that of cutting down on trips. Furthermore, changing mode of transport and cutting down on trips are seen by respondents as rather unlikely responses to congestion charging. Early results suggest that the more people accept congestion charging the more they are willing to adapt their behaviour to the charges. This result was not apparent in the second survey – perhaps because situational constraints had become more prominent and were obscuring any impact of acceptability on behavioural adaptation, or perhaps because behavioural adaptation takes place in a broader range of action than obtained. For instance, it could be that persons would consider car pooling. It might also be possible that the reference point of stated likelihood (at least for cutting down on trips) in the later interviews is shifted by behavioural adaptation which had already taken place.

Moreover, results suggest differences between various types of behavioural adaptation in relation to the destination of trips. It is shown that acceptability is more strongly correlated to the stated likelihood of changing transport mode for trips into city centre than for trips to others parts outwith the city centre. Further, acceptability is related to the likelihood of cutting down on trips for trips to other parts but not for trips into city centre. The theory of planned behaviour (Ajzen, 1985) provides an explanation for these results: according to this theory, behaviour is determined by an individuals' intention whereas attitudes, social norms and perceive behavioural control influence the intentions. Control beliefs are described as individuals' perceptions of external (perceived situational opportunities to perform an action) and internal resources (perceived ability to perform an action). In addition to the indirect link via intentions control beliefs have also a direct impact on behaviour. That means if people do not perceive opportunities to respond in certain a way they will not behave due to lack of perceived behavioural control in spite of positive attitudes. Transferred to our analyses, it might be that the impact of acceptability on stated likelihoods is stronger where people perceive more behavioural control to respond in a certain way (for instance by perception of better public transport infrastructure for trips into city centre than for trips to other parts). Thus, it would be valuable to focus on the impact of individuals' control beliefs in future studies more closely to examine importance regarding effectiveness of congestion charging on behavioural responses.

Further analyses consider the impact of personal involvement on behavioural adaptation. It has been assumed that personal involvement is given if individuals perceive traffic related problems but also feel affected by them. Moreover, it has been hypothesised that the motivation to adjust behaviour will be a positive function of personal involvement. The findings do not support this interaction hypothesis. They do however partly confirm a main effect of problem awareness: the more problematic people perceive congestion to be the more likely they will adapt their behaviour. Thereby, the impact of problem perception seems to be depending on destination of trips and respectively on operationalisation of behavioural adaptation. The likelihood of switching to other modes of transport seems to be more affected by problem awareness than is the likelihood of cutting down on trips. The frequency of car usage has a main effect on behavioural adaptation: the more people travel by car the less likely they will change transport mode as response to congestion charges (at least for trips into city centre). There are two possible explanations: it may simply reflect the lower elasticity of commuting trips, or it may indicate that habits determine stated likelihood of modal shift. The likelihood of changing mode for trips was higher the more people used public transport at present.

Current results emphasise that – regardless of the complexity of charging schemes – congestion charges will be more effective in terms of behavioural adaptations the more individuals perceive alternatives to car driving and the more individuals accept congestion charging. Also problem awareness seems to be a key issue that needs to be addressed. Awareness measures are therefore strongly recommended to ensure the effectiveness of congestion charges, i.e. make people aware of

traffic related problems and to point out alternative opportunities to car usage. Otherwise, congestion charges can cause perceived helplessness to respond toward pricing schemes or they might lead to individuals' perception of threatening of their behavioural freedom, and associated with this, to an intense adverse motivational state which implies to restore behavioural freedom (theory of reactance, section 4.1.2, page 138). Failures of behavioural adaptation to charging system might be possible consequences.

### 2.1.4 Evidence from Analysis of GRACE / DfT Questionnaire Surveys

#### *Introduction*

This section provides a summary of results from questionnaires developed for the UK Department for Transport (DfT) (Bonsall, Thornton, Goldstein and Dix, 2008) and within the EU GRACE project (Bonsall, Shires, Link, Becker, Papaioannou, and Xanthopoulos, 2007a; Bonsall, Shires, Ngoduy, Link, Becker, Papaioannou and Xanthopoulos, 2007c). It concentrates on results which are relevant to the hypotheses and research questions posed in Deliverable 4.1 (Hoffmann et al., 2006).

The DfT questionnaire was developed in 2006 for the express purpose of exploring drivers' response to complex charging regimes and the longer term ambition of developing models of this response. It was piloted in Oxford in 2007 – an exercise which produced 201 completed questionnaires.

The GRACE questionnaire was based on that developed for DfT and was intended to help in the specification and calibration of models of drivers' response to complex charging regimes. The questionnaire was implemented, in variant forms, in Newcastle, Koln and Thessaloniki during 2007 with achieved samples of 189, 210 and 121 respectively.

#### *Research Questions and Hypotheses*

Current summary of findings and evidences from GRACE / DfT questionnaire surveys aim for providing explanatory contributions to following hypotheses formulated in section 1.2:

| | |
|---|---|
| Hypotheses 1: | *There is a point, beyond which, the more differentiated a price structure, the less behavioural adaptation will occur.* |
| Hypothesis 2: | *Modus of payment has an effect on behavioural adaptation according pricing schemes.* |
| Sub-hypothesis 2: | *An individuals' ability to understand the charging system will be a positive function of their prior experience with similar price structures.* |
| Sub-hypothesis 5: | *An individuals´ degree of engagement will be a positive function of their motivation to adjust behaviour.* |
| Sub-hypothesis 7: | *An individuals´ motivation to adjust behaviour will be a negative function of their disposable income.* |
| Sub-hypothesis 8: | *An individuals´ ability and motivation to adjust behaviour will be a positive function of their education.* |
| Sub-hypothesis 9: | *An individuals´ ability and motivation to adjust behaviour will depend on the type of trip: Commute trips tend to be less elastic than shopping or recreational trips.* |

Furthermore, following research question are addressed:

| | |
|---|---|
| Research questions 1: | *Does a highly differentiated charging system make people avoid such systems?* |
| Research question 2: | *How does age and gender influence the ability and motivation to deal with differentiated pricing systems and how does it affect transport behaviour.* |

## *Method*

### Questionnaire

The idea behind the questionnaires was that eligible respondents would be provided with a description of a complex charging scheme and then asked to indicate their understanding of, and likely response to, that scheme. The questionnaire had a two-stage format. Appendix 3 contains the script for the DfT questionnaire but is representative of all four variants.

The DfT and Newcastle versions of the questionnaire contained the following elements (with items 1-4 being in the first stage questionnaire and items 5-9 in the second):

1. Screening questions (identifying whether the interviewee was a car user, making regular journey through the charging zone and paying for that journey);
2. A description of the journey (origin, destination, frequency, purpose, approximate length etc);
3. Details of the arrangements they would make for their regular journey if their car was not available:
4. Personal characteristics and attitudes (gender, age {estimate}, effort expended in getting value for money in non-transport contexts, value of time)
5. Background socio-economic information – age {actual}, household characteristics including income and car ownership).
6. Perceived characteristics of current travel arrangements (estimates of current cost, distance, and duration, estimates of fixed costs of car use. Confidence in those estimates).
7. Perception of congestion charge (estimate of congestion charge they would have to pay to make the journey identified in the previous questionnaire (a) assuming no change in travel arrangements and (b) assuming various specified changes in travel arrangements {e.g. travelling at a different time, by a different route etc}. Confidence in those estimates).
8. Likelihood of each of a series of behavioural responses (no change, change route, change time, change mode, reduced frequency, share car, etc).
9. Exploration of effect of complexity (assessment of complexity of the charges, effect of less complex charges, willingness to pay to avoid complexity).

The content of the Köln and Thessaloniki variants of the questionnaire were very similar to the DfT and Newcastle originals but some variations were introduced to meet local concerns and constraints.

### Implementation

The questionnaires were designed to be implemented in two stages; the first stage took 15-20 minutes and allowed us to screen suitable respondents, to gain an insight into the type and characteristics of a regular journey they were making, to obtain data on some personal characteristics and attitudes (age, sex, attitude to complex prices), and to establish their willingness to take part in a further telephone interview. At the end of stage one, the information gathered was used to determine which of several alternative charging regimes should be allocated to each willing respondent – the aim being to ensure that they were allocated a scheme that was relevant to their particular journey pattern. The different schemes varied in terms of the area covered and the structure of the charges (e.g. number of time periods, whether per-kilometre or at a cordon) but all were deliberately complex (an example is attached as Appendix 4).

Stage two was conducted by telephone after giving the respondents time to study the charging scheme and consider their possible responses to it. The second questionnaire took about 20-25 minutes to complete and sought more detail about the respondent's regular journey and, most importantly, tested their understanding of the charging scheme and asked them to indicate their likely response to it.

### Participants

As mentioned above, pilot study in Oxford views were successfully elicited from 201respondents. Further, the questionnaires were implemented in Newcastle, Cologne and Thessalonica during 2007 with achieved samples of 189, 210 and 121 respectively.

Readers should note that, although we have a combined sample exceeding 700, we make no claim that it is fully representative of the surveyed populations - it is, for example, likely to be biased towards people who were prepared to complete a fairly demanding interview. It should also be noted that, although most results are based on the full sample of 721, since some questions were not asked in all four variant questionnaires, others are necessarily based on a smaller sample.

## *Results*

Results from the four questionnaires have been written up in some detail elsewhere (Bonsall et al, 2007a, 2007c and 2008) and it is not appropriate to seek to reproduce all those analyses again here. We will simply concentrate on those findings which are of relevance to the current enquiry.

### Evidence of Lack of Engagement with Prices

- A significant proportion of respondents (up to 30% in Newcastle) say that they rarely make much effort to work out the best deal in terms of utility supplier.
- A significant proportion (67% Newcastle, 56% Oxford, 44% Thessaloniki) say they rarely or never think about the cost of individual journeys.
- A significant proportion (35% Thessaloniki, 33% Newcastle and 31% Oxford) say that they never think about the cost when choosing between routes.
- A significant proportion (31% Köln) say they would not give much thought to reduce their transport costs if charging were introduced.

After they had been asked to estimate the charges for a specified scheme, respondents were asked whether, if it had been easier to predict the charges, they would have put more or less thought into the pros and cons of alternative travel arrangements. Although a slim majority (54%) said that it would have made no difference, a clear majority (89%) of those who said that it would make a difference said that they would have given more thought to alternative travel arrangements if the charges had been easier to predict.

### Evidence of the Existence of a Personal Threshold for Engagement with Prices

Respondents were asked how much they would have to be paying each month (in congestion charges) before they began to seriously think about changing their travel arrangements. This can be thought of as their personal threshold level. Although the results varied significantly between the four surveys (due, we think, to differences in trip characteristics and income and the possibility of different degrees of strategic bias) it is interesting to note that up to 69% (in Thessalonica) would not think seriously about their options unless charges exceeded €37 per month and up to 22% (in Newcastle) say they would still not consider alternatives even if the monthly charge exceeded €110.

A more detailed examination of thresholds suggested that they varied according to the respondent's journey purpose; journeys to and from work or school being more likely than other journeys to be associated with high thresholds.

One of our analyses of respondents' expected behavioural response to charges was based on a categorisation of respondents according to whether the estimate they gave for the charges they expected to face was above or below their personal threshold (defined above). Unsurprisingly, the proportion of people expecting to change their travel arrangements was much lower among those who estimated a charge below their threshold than among those who estimated a charge above their

threshold (52% compared to 86%)[5]. We also noted that those who had estimated a charge that was well above their threshold thought tended to say they were "very likely" (rather than just "likely") to adopt a specified alternative pattern of behaviour.

### Evidence on Other Reasons for Disengagement

Respondents were asked why they would not consider alternative travel arrangements when the expected charge was below their threshold. Table 2-24 indicates which reason, from a pre-specified list, they regarded as most important. The most commonly quoted reason was that they thought they had no choice about making the journey as they do now. The effort required to calculate the congestion charge and, among the Thessalonica sample at any rate, a lack of concern with "trivial" sums, clearly also has some bearing on the decision to disengage.

**Table 2-24: Most Important Reasons for Not Considering Alternative Travel Options**

| | Percent of sample giving this response | | |
|---|---|---|---|
| | Oxford (n=201) | Newcastle (n=110) | Thessalonica (n=120) |
| No choice about making Journey | 62% | 57% | 38% |
| Effort of working out the saving > saving itself | 26% | 10% | 32% |
| Cannot work things out precisely | 2% | 3% | 4% |
| Not bothered to think about trivial sums | 3% | 4% | 24% |
| Other | 7% | 26% | 2% |

There was considerable evidence to suggest that respondents had little confidence in their own ability to estimate distances and costs for their current journey (for example, in Oxford: 7% said they could not estimate the length of their regular journey more precisely than to within 5 miles (in the context of an average journey length of 12 and a half miles); 30% said they could not estimate their monthly expenditure on fuel more precisely than to within £25 (in the context of an average estimated expenditure of £76 per month); 24% said they could not estimate the daily cost of their regular journey more precisely than to within £5 (in the context of an average estimated daily cost of £5.43); 17% said they could not estimate the fixed costs of owning their vehicle more precisely than to within £500 per year (in the context of an average estimate of £1218 per year) and, in the same context, 36% of people said they could not estimate the fixed costs of owning their vehicle more precisely than to within £200 per month). Evidence on peoples' confidence in their own ability to estimate the charges which they might be faced with is summarised in section below.

### Evidence on Attitudes to Uncertainty

Respondents' attitude to an uncertain toll was probed via a stated preference exercise which asked them to choose between two tolled routes one of which had a fixed toll while the other had a toll which varied randomly between known extremes. The experiment involved varying the difference between the fixed toll and the mid-point of the distribution of variable tolls. About 25% of people were apparently indifferent to the uncertainty but, of those who responded to it, most people (around 70%) indicated a preference for the fixed toll - but around 30% deliberately chose the variable toll.

### Evidence of the Difficulty Experienced in Predicting the Likely Charges

Respondents were asked how easy they had found it to estimate the charges they would face if the hypothesised regime were in introduced. A majority said that they had found the task easy or quite easy (of course this result is not transferable – it relates only to the set of charging regimes presented to them). They were then asked what, if anything, had been difficult. Analysis of the replies confirmed that, unsurprisingly, the reasons differed depending on the characteristics of the schemes which

[5] Based on data from the GRACE surveys – Oxford result not yet analysed)

people had been asked to study. Nevertheless, it is interesting to note that up to 1/3 of respondents made specific reference to the complexity of the required calculations and that people appeared to have particular difficulty with schemes which included per-distance charges or charges which varied significantly over time and space (and thus required respondents to predict the time at which they would pass specified timing points).

Respondents were asked how sure they were about their estimate of the charge they would incur. The results are summarised in Table 2-25.

**Table 2-25: Ability to Estimate Current Journey Costs and Future Congestion Charge**

| Degree of Certainty * | Oxford | Newcastle | Cologne | Thessalonica |
|---|---|---|---|---|
| % To the nearest 0.10£, 0.5€, 0.5€ | 72 | 61 | 91 | 67 |
| % To the nearest 0.50£, 1.0€, 1.0€ | | 23 | 8 | 27 |
| % To the nearest 1.0 £, 2.0€, 3.0€ | 19 | 15 | 1 | 3 |
| % To the nearest 5.0£, 5.0€, 5.0€ | 3 | 1 | 1 | 1 |
| % Less certain than that | 5 | 1 | 1 | 1 |
| *Total Sample Size* | *201* | *189* | *210* | *120* |

* different certainty bands were applied in the three countries – they are indicated in the sequence UK, Germany, Greece

In all three samples, but particularly in Koln, the respondents were quite confident of their ability to estimate the daily charge (of course differences between the cities may simply reflect differences in the charge scenarios offered). Interestingly, all three samples, respondents are claiming greater confidence in their ability to estimate an as yet unknown congestion charge which they have not experienced than they did in their ability to estimate the costs of the current journey which they make on a regular basis. This finding is consistent with the well accepted view that motorists do not have an accurate perception of motoring costs – and the more recent finding (Bonsall et al., 2006) that they have a particular problem thinking about the costs of individual trips – rather than a weekly or monthly budget. Although the respondents are confident in their own ability to estimate the charge for their regular journey, it is not clear whether this confidence would hold for unfamiliar journeys.

Figure Using origin and destination postcodes supplied, and assuming they would use the quickest routes, we made our own estimate of the charges which respondents would incur. On this basis (which is not precise because we cannot be sure which route they normally use) we conclude that respondents tended to overestimate charges (typically their estimate was about 50% higher than ours) and that only slightly over 10% of respondents were able to estimate the price to within 10% of its true level. There is some doubt (see below) as to whether the respondents' recorded estimates accurately reflected their true expectation, but taken with the evidence in Table 2-25, these results suggest that people are over-estimating the precision with which they can estimate the charge. A similar analysis of respondents' estimates of the length of their regular journey suggested that, while they were not very confident about their estimates of journey length (e.g. in Oxford, only 49% thought they knew the distance to within half a mile), the actual estimates were not far out (with a typical overestimate of only about 15%).

### Evidence of Factors Affecting Behavioural Responses to Charges

Respondents were asked to indicate how they would expect to be travelling (for their regular journey) after introduction of the charges. Their responses were analysed and modelled in several different ways in a search for explanatory factors. What follows is a summary of the findings from this analysis and modelling.

- We have already noted that people's personal thresholds for serious consideration of alternative travel arrangements differ according to their journey purpose.
- A majority of those who disengaged from serious consideration of their options indicated that they would simply pay the charges and continue with their existing travel behaviour.

- Respondents who had claimed to find the charges "easy" (or "very easy") to understand were much more likely to express certainty about their expected behavioural response (whether it was to say they were very likely to continue with their current pattern or very likely to change it). This tendency is most marked for all responses except the likelihood of choosing an alternative mode.

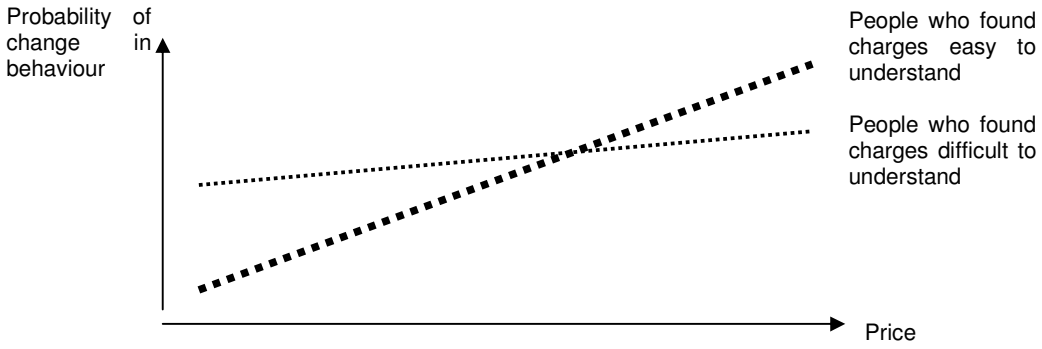
Logit models were constructed in an attempt to explain each of the potential behavioural responses (travel as now, change route, change time, reduce frequency, share driving, change mode, and stop travelling altogether). The explanatory power of a number of variables was examined and the full results can be found in Bonsall et al (2007a). The following findings are of relevance here (in each case the result is significant at 95%):

- The ratio of **expected toll** to perceived current out of pocket costs had a negative effect on the likelihood of continuing to travel as now and a positive effect on the likelihood of reducing the journey frequency. In both cases this effect was stronger for respondents who had found the charges easy to understand
- A dummy to indicate whether journey was mandatory (if the **journey purpose** was work, education or escorting children) had a positive effect on the likelihood of continuing to travel as now but a negative effect on the likelihoods of changing the timing of the journey or stopping travelling altogether.
- The **age** of driver in years had a positive effect on the likelihoods of continuing to travel as now, of reducing the journey frequency and of stopping travelling altogether but a negative effect on the likelihood of sharing the driving.
- A dummy to indicate whether the driver was **female** had a positive effect on the likelihoods of choosing a new route, sharing the driving or stopping travelling altogether but a negative effect on the likelihood of changing the time of travel.
- The annual **household income** had a positive effect on the likelihood of continuing to travel as now, but a negative effect on the likelihoods of reducing the journey frequency and of choosing an alternative mode.
- The perceived **cost of the most likely alternative mode;** had no significant impact on the likelihood of choosing an alternative mode.

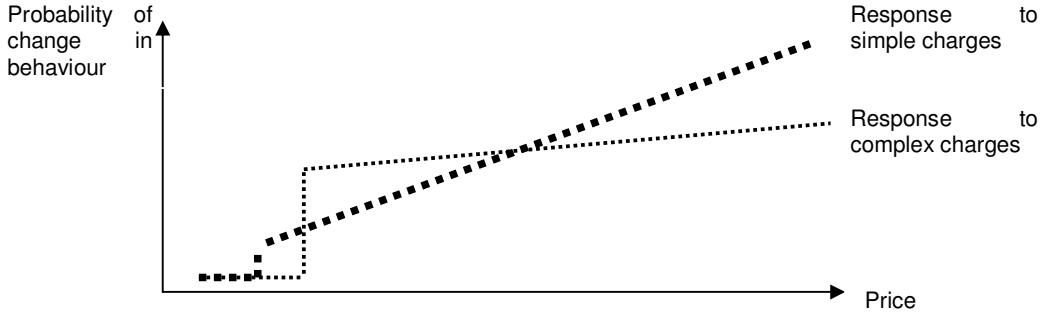
A separate strand of logit modelling revealed that the cost ratio had a greater impact on the behaviour (likelihood of continuing to travel of as now) of high income people than of low income people (sic), of men than of women and of older people than of younger people.

Figure 2-17a shows, in idealised form, the relationships between price and likelihood of response identified by our logit models for people reporting different degrees of difficulty estimating the charges. An important implication of the different slopes and intercepts is that, when prices are generally low, people who are not sure about the price will tend to change their behaviour more than they "should" while, when prices are high, they will tend to change their behaviour less than they "should". In other words, lack of understanding (and thus, presumably, complexity) is associated with over- response in low price domains and under-response in high price domains.

Figure 2-17b builds on the relationship exemplified in Figure 2-17a adding in the "threshold effect" noted earlier (whereby people make no response at all if they consider the charge too trivial to warrant any action). It thus summarises our evidence on the difference between responses to simple and complex charges.




*a) Relationship derived from logit models*




*b) Hypothesised responses to simple and complex charges (based on evidence from DfT and GRACE questionnaires)*

**Figure 2-17: Idealised Relationship between Price and Response**

Finally, it is worth noting that, in all these models, the objectively-estimated charge (based on origin and destination post codes) appeared to offer more explanation of behavioural response than did the respondent's own recorded estimate of that charge. This was entirely unexpected and suggests that the estimates recorded by the respondents may have been less accurate than the figures that they had in mind when deciding on a behavioural response (perhaps some respondents did not understand that we were asking them to record their estimate of their daily charge - rather than a per-journey charge, or perhaps their recorded estimates were quite roughly rounded). Whatever the reason, we must conclude that the inaccuracies calculated by comparing the respondent's recorded estimates with "objective estimates based on post codes may have exaggerated.

### *Discussion*

**Hypotheses 1** (*There is a point, beyond which, the more differentiated a price structure, the less behavioural adaptation will occur)* seems to be supported by our finding that people say they would have put more effort into the consideration of alternative travel arrangements if the charge had been easier to predict. It would be useful to know more about the process whereby an individual comes to the opinion that a given charge structure is too complex to warrant a serious effort to understand it, is it a causal relationship or simply a post-hoc rationalisation?

The relationships predicted by our logit models, and shown in Figure 2-17, suggest that the relationship between complexity and behavioural response may be as hypothesised in high price domains but is quite the opposite in low price domains.

The findings on the existence of something akin to a personal threshold price (below which it is not worth thinking about alternative travel arrangements) is a useful reminder that disengagement is not simply a function of complexity. We noted that, if a charge fell below the threshold people were very likely to continue to travel as before, whereas if it was above the threshold a change became more likely. The combination of high complexity and an (expected) low charge seems likely to produce no change in behaviour. The interesting question that remains is how people make their initial judgement on the likely level of the charge and whether the assessment is influenced by degree of complexity (our finding that the objectively-estimated charge offers more explanation of behavioural response than did the respondent's own estimate of that charge is clearly relevant here).

The finding that people rarely think about the cost of individual journeys and generally have little knowledge of the cost of journeys is clearly relevant to any discussion on the amount of effort that people are likely to make to adjust their behaviour following introduction of a new charge.

The finding that people thought that per-distance charges were particularly difficult to estimate suggests that the existence of such charges in a charging regime will cause it to be considered "complex". However, it was interesting to note that peoples' estimates distance may be more accurate than they realise – suggesting that the presumed "difficulty" of per-distance charges may be exaggerated and that the perception might be overcome with experience. This issue touches indirectly on **sub-hypothesis 2** (*that an individuals' ability to understand the charging system will be a positive function of their prior experience with similar price structures*).

The finding, referred to above, that people rarely think about the cost of individual journeys and generally have little knowledge of the cost of journeys, may be due to the lack of immediate feedback on the cost of such journeys. If so, this is not inconsistent with **hypothesis 2** (Modus of payment has an effect on behavioural adaptation according pricing schemes.).

**Sub-Hypothesis 5** (An individuals´ degree of engagement will be a positive function of their motivation to adjust behaviour) is supported by the fact that people said that "lack of choice" was the main reason for not considering alternative travel arrangements. Part of the reason for disengagement appears to be a belief (possibly wholly rational) that the effort required to conduct a full assessment of the costs of all the feasible responses is simply not worth while (that the effort required would outweigh the likely benefit). This belief is probably acting as a brake on the adjustment of behaviour to complex charges – and the more complex they are, the more effort that would be required to assess their implications, and so the greater the obstacle presented. Our finding that people tend to disengage from the process of carefully considering alternatives if they consider the charge is below a personal threshold is also relevant here.

**Sub-Hypothesis 7** (An individuals´ motivation to adjust behaviour will be a negative function of their disposable income) appears to be contradicted by the finding that people on higher incomes are more sensitive to the actual charge. However, the finding that income is negatively related to the likelihood of changing behaviour (and most particularly to changing the mode or time of travel) indicates that the picture is not straightforward.

**Hypothesis 8** (An individuals´ ability and motivation to adjust behaviour will be a positive function of their education) was not supported by the data – we found no statistically significant relationships between respondents' educational qualifications and their ability to calculate charges or the likelihood of them changing their behaviour in response to introduction of charges.

**Sub-Hypothesis 9** (An individuals´ ability and motivation to adjust behaviour will depend on the type of trip: Commute trips tend to be less elastic than shopping or recreational trips) is supported by the fact that people whose trips were mandatory were less likely to change their travel arrangements following introduction of a charge.

The finding that a majority of people who disengaged from serious consideration of their options indicated that they would simply pay the charges and continue with their existing travel behaviour is clearly relevant to **research questions 1** (Does a highly differentiated charging system make people avoid such systems?) and suggests that the predominant response is to ignore the charge rather than

to seek to avoid it. However, it is not clear whether they would be continuing because they have disengaged or are disengaging because they perceive they have no choice other than to continue. The latter explanation would be more consistent with the fact that most of our respondents indicated an aversion to uncertain charges (perhaps disengagement is a way of reducing cognitive dissonance - avoiding direct confrontation with the fact that their failure to change behaviour may not actually be the correct course of action).

The findings on the significant influence of gender on the type of behavioural response, and that the sensitivity to price seems to vary with age and gender, are clearly relevant to **research question 2** (*How does age and gender influence the ability and motivation to deal with differentiated pricing systems and how does it affect transport behaviour).* However, we have not yet found any evidence to indicate whether these differences are related to ability or motivation rather than to situational factors.

### 2.1.5 Conclusions from Case Studies Regarding Car User Responses

The case studies have provided a considerable amount of evidence that **behavioural responses are affected by the perceived complexity of the scheme**, and that the **degree of complexity perceived is influenced not only by the amount of differentiation but also by the nature of that differentiation**. For example:

- The DfT/GRACE questionnaire results suggested that, when prices are difficult to understand, under-response occurs in high price domains but over-response occurs in low price domains (with this latter effect being mitigated by the existence of personal thresholds which result in a maintenance of previous behaviours when the expected price is trivial).
- The Newcastle questionnaire results suggested that the number of separate charge levels and the number of different spatial zones is correlated with the perceived complexity of pricing schemes and, other things being equal, pricing schemes which includes a per-mile element are perceived as more complex.

The case studies have provided evidence to suggest that people's **preparedness to engage with pricing structures may be influenced by their perception of the effort required** and the likely potential saving. For example:

- The DfT/GRACE questionnaire results suggested that people are prepared to put more effort into consideration of alternative mobility behaviour if prices are easier to predict.
- The DfT/GRACE questionnaire results suggested that people are likely to maintain their pre-existing travel patterns if the expected charges fall below a certain level (their personal threshold) and/or if the cognitive effort to deal with them is high.

The case studies have provided evidence to suggest that, over and above the degree of differentiation, **the presentation of pricing schemes may influence users' opinions and responses**. For example:

- The AKTA study suggested that if a pricing scheme is presented as a loss system, individuals will adapt their mobility behaviour more strongly than if it is presented as an incentive system.
- The Newcastle questionnaire results suggest that people's opinions (precisely their perception of scheme effectiveness) about pricing schemes depend on whether other pricing schemes were presented before – suggesting that individuals might change their opinions about charging schemes as they become more familiar with them.

These results emphasise that among others the framing / presentation of pricing schemes is an important key issue on consideration of effects of prices on behaviour.

Considerable evidence was found on the **effect of motivational factors on users' responses** towards pricing. For example:

- the DfT/GRACE questionnaire suggested that the stated likelihood of future behavioural adaptation, is strongly conditioned by the respondent's opinion on their ability to respond (which is determined also by situational aspects);
- results from the Newcastle questionnaire, and from first round of Edinburgh questionnaires, suggested that people who found road charges acceptable were more likely to anticipate changing their behaviour if charges were introduced (of course this correlation cannot be used to impute a direction of causality);
- the Newcastle questionnaire results similarly show a correlation between the perceived fairness of road charging and anticipated ease in making an accurate estimate of charges.

As stated above, results from the case studies emphasise that **situational aspects have a strong impact on the amount of behavioural adaptation**. For example:

- The DfT/GRACE questionnaire results suggested less likelihood of change to commuting trips and that the most important reason for not considering alternative travel options was "no choice about making journey".
- The Edinburgh surveys suggested that users' response seems to be moderated by destinations of trips.

These results, together with those on motivational aspects imply that, if road charges are to evoke behavioural changes it is necessary that individuals should perceive that they have opportunities to respond. Road charging schemes will not cause the desired behavioural changes unless people perceive an ability to react accordingly. Indeed, the introduction of road charges without users perceiving any behavioural control might lead to contrary effects like reactance or resistance to road charges.

Considering the **effects of users' socio–demographic characteristics on attitudes and responses**, the picture which emerged from the case studies is miscellaneous. For example results from the DfT/GRACE and Newcastle questionnaires suggested:

- that women viewed road pricing more favourably than men did;
- that females and older people were more likely to state they would seek to avoid driving on certain days if a certain daily charge were introduced;
- that older people were less likely to expect to increase their overall number of trips in response to daily charges (these differences might reflect differences in perceived abilities to adjust their behaviour);
- that individuals' income is positive related to lower likelihood to change the timing of car journeys and to a higher expected likelihood to increasing the overall number of trips in response to daily charges allowing an unlimited number of trips;
- that professional qualification is linked to expecting to change travel patterns, to expecting to changes the timing of journeys and is negative correlated to expecting to increase the overall number of car journey in response to daily charges allowing a unlimited number of trips.

It should, however, be noted that results from the other case studies do not confirm these effect of socio-demographic aspects (except in showing a negative relationship between income and stated switch to public transport). One reason might be that, because different socio-demographic factors are related to each other, the effect of a certain factor is taken up by another factor. Further research should try to decompose the causal relations between socio-demographic factors and their interdependencies to examine how they influence user reactions.

## 2.2 LABORATORY EXPERIMENTS REGARDING USER RESPONSE TOWARDS CHARGES

A major psychological assumption is that, since people have limited mental capacities to process information, their ability to respond to price signals will be constrained especially in case of highly differentiated prices. In addition to these cognitive aspects, motivational factors also affect the response to differentiated pricing schemes. Thus even if transport user are able to understand highly differentiated pricing schemes it does not mean that they are willing to deal with these and to adjust their behaviour accordingly (Hoffmann et al., 2006). So the question arises, up to what degree of complexity are people able and willing to understand, and respond to, differentiated transport charging structures? It is hypothesised, that there is a point, beyond which, the more differentiated and complex a pricing structure is, the less precise and more delayed the price estimations (and behavioural decisions) will be. To analyse this, in contrast to most of the other case studies three experiments in a controlled environment were conducted. This approach makes it easier to draw causal conclusions and to separate the effect of different factors - for instance the price level and the degree of differentiation.

The main objective of the experiments was to explore the factors affecting people's perception of the complexity of differentiated road charging schemes, their willingness and ability to predict the charges that would apply to specified journeys, and their behavioural responses to those charges. The first two experiments were conducted in Dresden (June, 2007) and Leeds (January, 2008). To ensure comparability and consistency a common design framework between these experiments was agreed.[6] However, the Dresden and Leeds experiments are not identical and the analyses focus on different research questions. Based on these initial findings a third experiment, focusing on motivational aspects affecting user responses to differentiated pricing structures, was conducted in Dresden in October 2007. The results of all three experiments are presented below.

### 2.2.1 Experiment I (Dresden)

#### *Introduction*

The main objective of this study is to analyse the impact of price differentiation and interfering cognitive as well as motivational factors on immediate responses towards differentiated road pricing charges. Furthermore the relation between acceptability and several motivational factors is examined.

#### *Research Questions and Hypotheses*

Based on the hypotheses formulated in section 1.2, research questions and hypotheses were specified as follows:

**Research question 1: What impact has the degree of price differentiation on behavioural responses?**

Pricing schemes which have a low degree of differentiation require only low (cognitive) effort in order to understand them. However, each additional dimension of differentiation should increase the cognitive load in dealing with the price measures and will finally lead to delayed responses and an increase in error rates in calculating the charge. This leads to four hypotheses:

| | |
|---|---|
| Hypothesis 1: | The more differentiated a pricing structure, the higher the response latencies will be. |
| Hypothesis 2: | The more differentiated a pricing structure, the higher the error rates will be (less precise price estimation). |
| Hypothesis 3: | The more differentiated a pricing structure, the lower the certainty about correct price estimation will be. |

[6] After a separate presentation of the results of each experiment (section 2.2.1, 2.2.2 and 2.2.3) a comparison of all three experiments is given in section 2.2.4.

Hypothesis 4: The more differentiated a pricing structure, the higher the perceived difficulty will be.

**Research question 2: Does acceptability have a moderating effect on responses towards differentiated pricing schemes?**

Even if people are able to understand complex price signals it may be that they are not willing to do so. One possible reason for this is low acceptability whereby two directions of effect are conceivable. On the one hand it is possible that people who like the idea of road pricing should be more motivated to understand it and therefore should invest in a given time interval more (cognitive) effort. Thus they should need less time to calculate the prices and make fewer errors compared to persons who do not accept road pricing. On the other hand, it is conceivable that people with a rather positive attitude towards road pricing think it less necessary to make an accurate estimate. Thus they need less time to calculate the prices but make more errors. By contrast people with a negative attitude towards road pricing are more critical to pricing schemes, and thus, they should invest more effort to deliberate the pricing schemes and thus need more time in handling and make fewer errors.

**Research question 3: Which psychological factors contribute to the acceptability of differentiated pricing schemes?**

Within Schlag's (1998) heuristic model of acceptability (Schade, 2005) several factors were identified as contributors to the acceptability of transport pricing measures (1.1.2). This leads to one further hypothesis:

Hypothesis 5: Acceptability is a positive function of traffic-related problem perception, perceived fairness, perceived effectiveness, comprehension and disposable income.

**Research question 4: Which impact has differentiation on the evaluation of differentiated pricing schemes?**

It is assumed that people have a strong preference for simple tariffs (Bonsall & Shires, 2005). Thus, with increasing differentiation the willingness and ability to handle the pricing schemes should decrease. This produces a further hypothesis:

Hypothesis 6: The more differentiated a pricing structure, the lower the perceived effectiveness, acceptability and comprehension will be and the less behavioural adaptation will occur.

In additional analyses, sub-hypotheses 3, 4, 7 and 8 identified in section 1.2, which concentrate on behaviour adaptation, are examined.

Sub-hypothesis 3: An individuals´ motivation to adjust behaviour will be a positive function of their acceptance of the system.

Sub-hypothesis 4: An individuals´ motivation to adjust behaviour will be a positive function of their personal involvement.

Sub-hypothesis 7: An individuals´ motivation to adjust behaviour will be a negative function of their disposable income.

Sub-hypothesis 8: An individuals´ ability and motivation to adjust behaviour will be a positive function of their education.

Furthermore, to address research question 2 raised in Deliverable 4.1 an analysis is conducted to examine *whether age and gender influence the ability and motivation to deal with differentiated pricing schemes and whether they affect travel behaviour*.

## *Method*

### Experimental Setting

For the experiment two sets of five urban pricing schemes were developed for a hypothetical city. The schemes had different degrees of complexity in the spatial and temporal dimensions (respectively different numbers of cordons and different numbers of time bands). The two sets differ from each other merely in terms of the level of price (to test whether the responses towards differentiated prices are affected by the price level and avoid correlation between the level of price and the degree of differentiation).

Each of the five charging scenarios includes one or more distance-based charge operating in specified parts of the city during specified hours (see Appendix 5). The degree of differentiation is categorised as 'very low', 'low' (two cases), 'medium' or 'high'. For instance, the first scheme is quite simple with one charged inner city zone and one time zone. The most complex one has three different charged spatial zones and two time zones (Table 2-26). Because of equal number of dimensions the schemes 'low1' and 'low2' are identically categorised in level of complexity.

**Table 2-26: Charging Regimes for the Hypothetical Schemes Used in the Dresden Experiment**

| Degree of differentiation | Number of zones | Number of periods | True price Set 1 (€) | True price Set 2 (€) |
|---|---|---|---|---|
| Very low | 1 | 1 | 2,00 | 1,00 |
| Low1 | 2 | 1 | 3,50 | 3,50 |
| Low2 | 1 | 2 | 1,50 | 3,50 |
| Medium | 2 | 2 | 3,00 | 1,50 |
| High | 3 | 2 | 1,85 | 1,85 |

### Procedure and Implementation

The battery of questions consists of four sections.

The **first section** provided the participants instructions on how to interact with the computer program (e.g. moving a cursor to a position along a scale) and provided an opportunity to respond to a test question.

In the **second section** each of the five pricing schemes was presented to the participants in a random order to avoid sequence effects and they were asked to imagine that they were to make a specified journey in the hypothetical city under the specified pricing regime. The journey was always the same – a 20 km journey from A to B, travelling at constant 30 km per hour, starting 7.40 and ending 8.20. Figure 2-18 shows, for the schemes with "very low" and "high" levels of differentiation, how the regimes were presented.

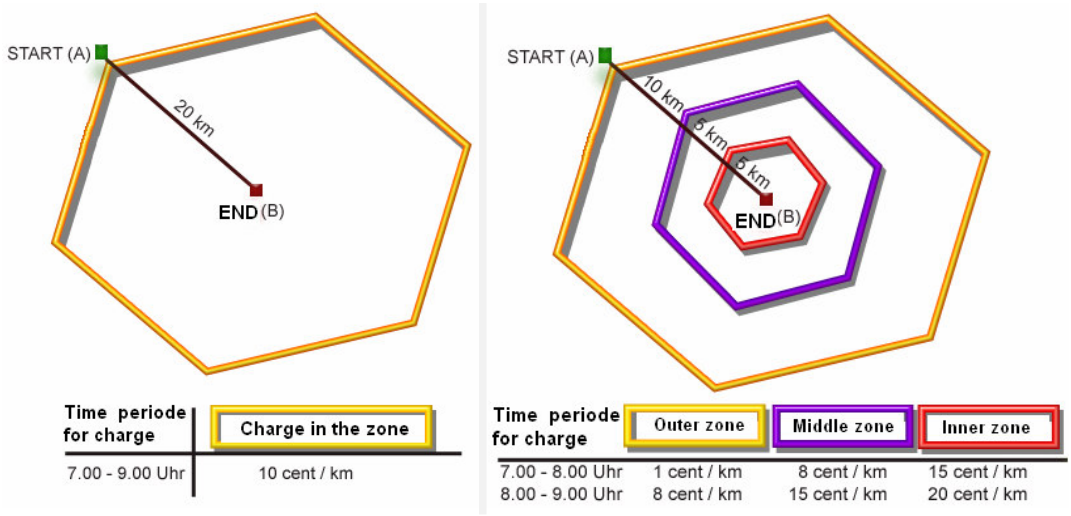



**Figure 2-18: Screen Dumps for Hypothetical Schemes with 'Very Low' and 'High' Differentiation (As Used in Dresden Experiment)**

While each scenario was displayed on screen, participants were asked to estimate the charge that would be incurred. The time that the respondent took to estimate the charge for the trip (latency time) was measured. The participant was asked to state how certain they were about the accuracy of their estimate (0 = 'uncertain' to 100 = 'certain') and to indicate the perceived difficulty of this cost calculation for the given scheme (0 = 'very easy' to 100 = 'very difficult'). The dependent variables are thus latency time (for cost calculation), error rate in price estimation, task certainty and perceived task difficulty. The degree of complexity provides the independent manipulable variable. Using this design, the impact of price differentiation on user response can be analysed (research question 1). Figure 2-19 illustrates the relationship between the independent (differentiated user charges) and the dependent variables (behavioural responses).

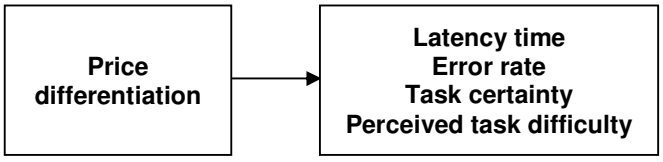



**Figure 2-19: Relation between Stimulus (Independent Variable) and Response (Dependent Variable)**

In **section three** participants were randomly assigned to just one of the five pricing schemes from set 1. The structure of these schemes is identical to the schemes used in part one (Table 2-26). Due to the fact that these schemes refer to Dresden (the area within which all respondents drive regularly) the sole difference is the graphic presentation. Figure 2-20 shows an example presentation of one of these charging schemes.

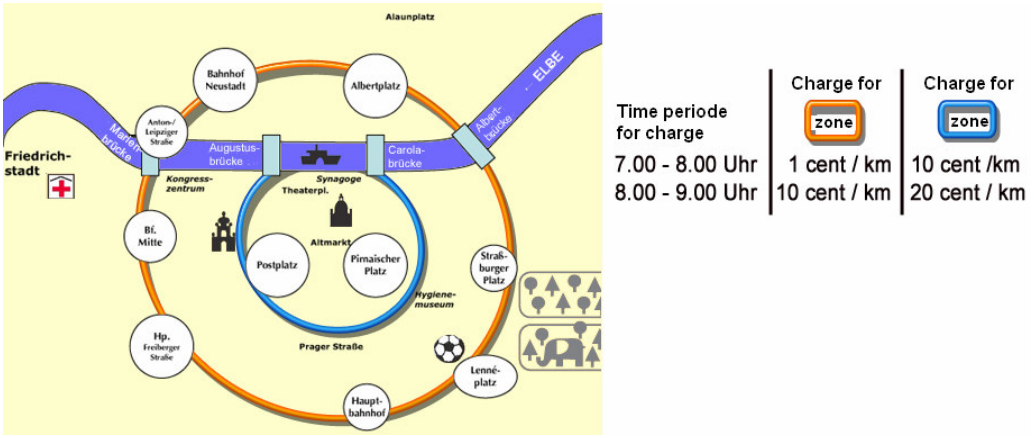



**Figure 2-20: Screen Dump for the 'Medium' Dresden Scheme**

First the participant had to state how problematic they perceive various traffic problems in Dresden (air pollution from motor vehicles, traffic congestion, infrastructure, inadequate public transport) to be. Next, while the allocated charging scheme was displayed on screen, participants were asked questions concerning acceptability, perceived effectiveness, fairness and comprehension. They were also asked to indicate how they might react, in terms of their travel behaviour, to the specified pricing scheme. Nearly all of these items were operationalised by a numerical scale (0 = low value to 100 = high value) or a four-graded rating scale.

Research questions 2, 3 and 4 concentrate on psychological factors that affect and explain behavioural responses on differentiated transport infrastructure use charges. This necessitates a focus on the interfering variables that connect independent and dependent variables (Figure 2-21).

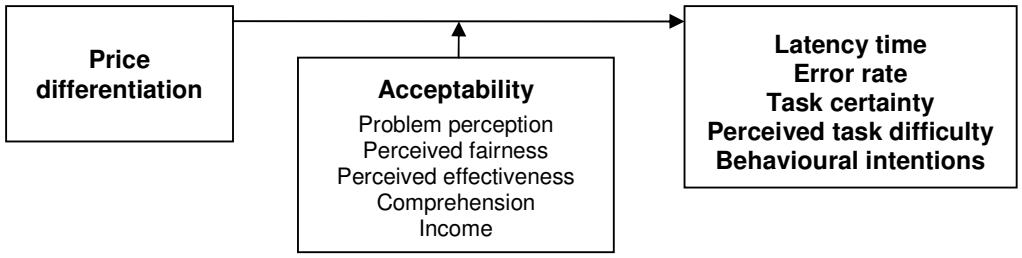



**Figure 2-21: Relation between Stimulus and Response with Regard to Interfering Variables**

In the **last section** of the experiment, socio-demographic data and travel habits were asked for.

Participants were recruited in late May 2007. They were mainly approached by an advertisement in a regional newspaper which mentioned a 5 € reward for participating in "a 20 minute questionnaire about measures of transportation policy". The experiment was conducted in June 2007 at the Dresden University of Technology, Germany.

### Sample

The sample consists of 106 persons (62 female and 44 male). The profile of participants is very homogeneous in terms of age (62.3 % under 26 years), level of education (93.4 % with Abitur), income (54.7 % less than 500 € per month) and current employment (81.1 % in education/student) and is thus non-representative.

Unfortunately, the majority of the participants would not be affected by the presented schemes because only 18.9 % of them use the car for ways to/from work and 22.6 % for leisure activities, 36.8

% never move in the city centre by car and approximately half of them never move motorised during peak hours (7.00 till 9.00 and 16.00 till 18.00).

A detailed sample description can be found in Appendix 6.

## *Results*

### Impact of Price Differentiation on Response towards Differentiated Pricing Schemes

First it is assumed that price differentiation affects user response and that there is a point, beyond which, the more differentiated a price structure, the less behavioural adaptation will occur. So the first research question deals with the impact of price differentiation on user response. To analyse this, a one-factorial variance-analytical design with five steps (low to high differentiation) was conducted. Investigation of the impact of price differentiation on time to calculate the travel expenses shows that response time increases with degree of differentiation. Thereby the variance analysis indicates a statistically significant effect of price differentiation on latency time ($p < 0.001$). The tests of contrasts identify that the highly differentiated scheme differs from all other schemes significantly. As can be seen in Figure 2-22, latency time increases with degree of differentiation (the x-axis uses descriptive labels for hypothetical schemes which reflect their degree of differentiation). For instance the respondents take more than twice as long to process the most complex pricing scheme than to process the simplest one. With regard to the two different sets (Table 2-26), it appears that latency time of respondents to whom set 1 has been presented is lower ($p = 0.009$).
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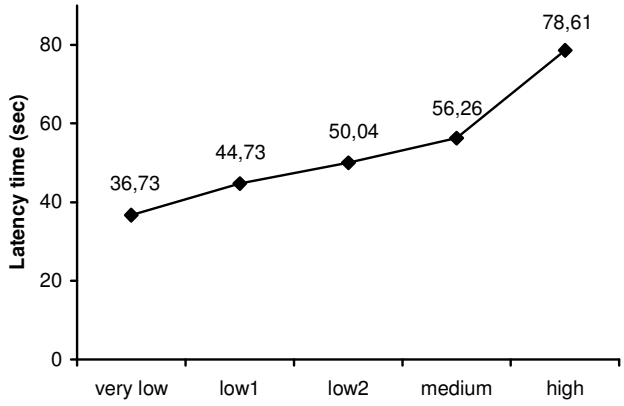



**Figure 2-22: Mean Values of Latency Time at Different Levels of Differentiation**

Regarding the relationship between degree of differentiation and the participants' tendency to make errors, the findings support the assumptions. Because of the dichotomous scale level of error rate (number of times that their estimate of the charge is incorrect) the Cochran-Q-Test was used. The analysis shows that the number of errors increases with rising differentiation ($p < 0.001$). Whilst the error rates of the lowly differentiated schemes are between seven and thirteen percent, it rose to approximately 38 % for the highly differentiated pricing scheme (Figure 2-23). The error rate did not differ significantly between the two sets of schemes.

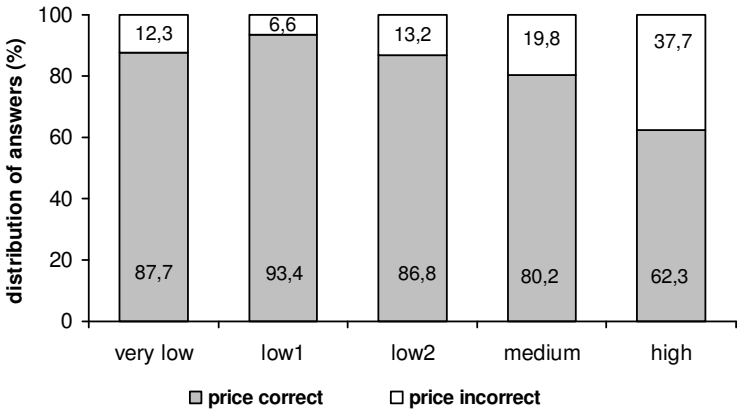



**Figure 2-23: Errors Made in Price Estimation at Different Levels of Differentiation**

Additional analysis showed that participants tended to underestimate the charges but there was no significant difference ($p = 0.213$) in the extent of underestimation, or overestimation, at the different level of differentiation.

These objective results are supported by the subjective evaluations of the price estimations. Statistically significant effects were found for the effect of price differentiation on task certainty ($p < 0.001$) and on perceived difficulty of price estimation ($p < 0.001$). The tests of contrasts suggest that both the very lowly and the highly differentiated scheme differ from the other schemes significantly. So, with increasing degree of differentiation participants feel more uncertain about their estimates of the charges. Moreover they evaluate the complex pricing schemes as being considerably more difficult than the simpler ones. Again, regarding the two sets, the analysis shows no statistical significant effect on task certainty ($p = 0.269$) or perceived task difficulty ($p = 0.576$).

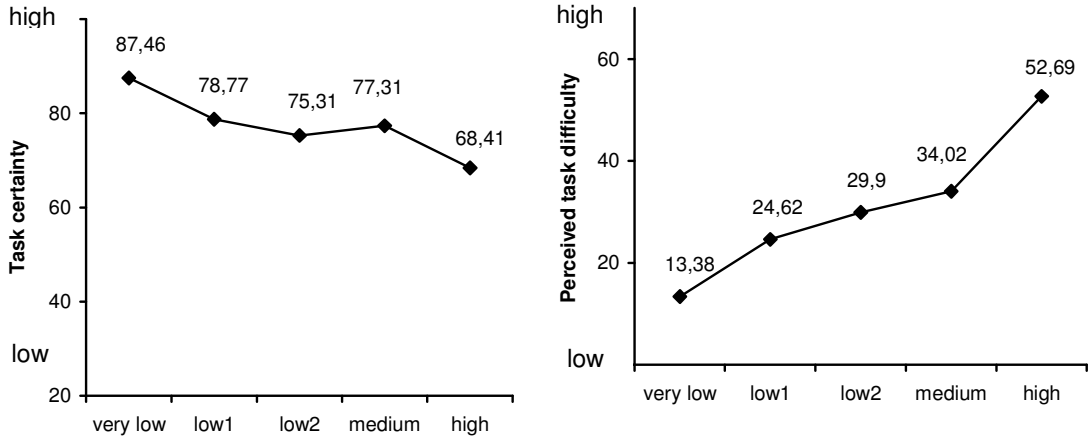



**Figure 2-24: Mean Values of Task Certainty and Perceived Task Difficulty at Different Levels of Differentiation**

### Impact of Acceptability on Response towards Differentiated Pricing Schemes

Research question 2 requires testing whether individuals' motivation affects their response to differentiated pricing schemes. To investigate the impact of acceptability on latency time, error rate, perceived task difficulty and task certainty, variance analysis with repeated measures was applied with the acceptability of the pricing schemes (asked in section three) added as a between-subject factor. Two groups of respondents were defined on the basis of the acceptability rating (mean value M = 50.23 and standard derivation SD = 34.36) which they gave to the Dresden scheme which was

presented to them in part 3 of the experiment[7]. The "high acceptance" group comprised those who gave high acceptability scores (> 85) and the "low acceptance" group comprised those who gave very low acceptability scores (< 16). Table 2-29 defines these two groups.

**Table 2-27: High and Low Acceptance Groups**

| | N | in % | M (SD) |
|---|---|---|---|
| Low acceptance | 24 | 22.64 | 2.63 (4.44) |
| High acceptance | 21 | 19.81 | 95.81 (4.43) |

In terms of latency time the results show that significant differences exist between between people with low and high acceptance values (p = 0.008); people in the high acceptance group took considerably less time to calculate the travel expenses than people in the low acceptance group (between 10 and 23 seconds). Latency time increases with the level of differentiation in both groups (Figure 2-25).

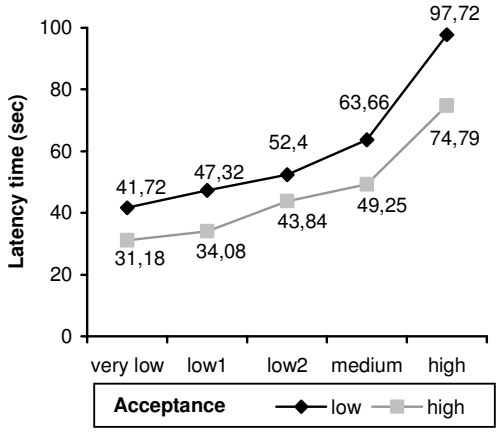



**Figure 2-25: Mean Values of Latency Time at Different Levels of Differentiation (High and Low Acceptance Groups)**

Tests of the relationship between acceptance (of the Dresden scheme) and the error rate in price estimation (for the hypothetical schemes) showed there to be no correlation. However, people in the high acceptance group made fewer errors than those in the low acceptance group (Table 2-28).

**Table 2-28: Error Rate (%) at Different Levels of Differentiation (High and Low Acceptance Groups)**

| | Very low | Low1 | Low2 | Medium | High |
|---|---|---|---|---|---|
| Low acceptance | 16.67 | 4.17 | 25.00 | 20.83 | 45.83 |
| High acceptance | 9.52 | 4.76 | 19.05 | 14.29 | 38.10 |

Figure 2-26 shows that people in the high acceptance group are more certain in their answers than persons in the low acceptability group and that, particularly in respect of the lowly differentiated schemes, the high acceptability group's evaluation of task difficulty is lower than that of the low acceptability group. However, there is little difference between the two groups' perceptions of the difficulty of the highly differentiated scheme and variance analysis shows that the effect of acceptability on perceived difficulty (p = 0.100) and on responsorial certainty (p = 0.117) is marginally non-significant.

[7] The assumption here is that the acceptability rating which the individual gave to the Dresden scheme is indicative of their general acceptance of the road pricing concept.

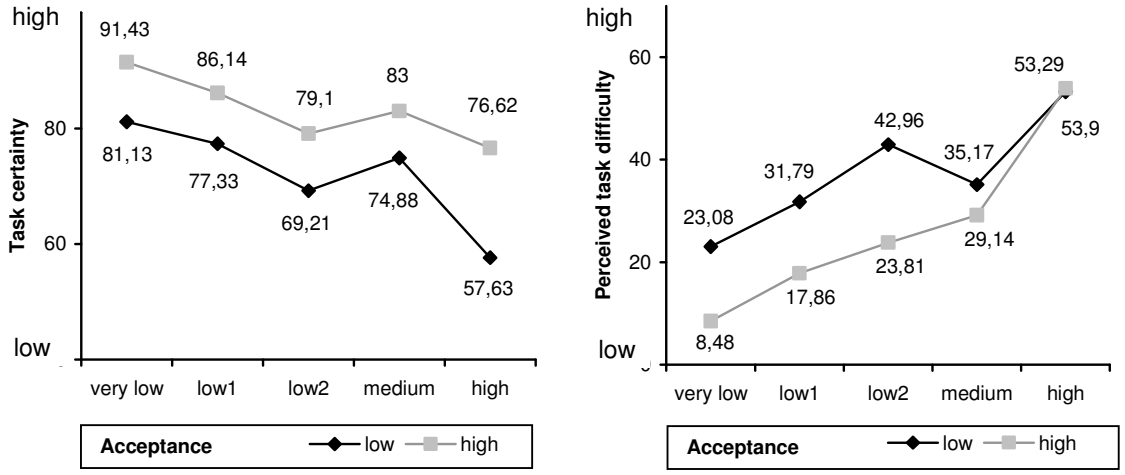



**Figure 2-26: Mean Values of Task Certainty and Perceived Task Difficulty at Different Degrees of Differentiation (Data from High and Low Acceptance Groups)**

### Factors Contributing to the Acceptability of Differentiated Pricing Schemes

Following the heuristic model of acceptability by Schlag (1998; Schade, 2005) the third research question deals with the relationship between acceptability and problem perception, perceived effectiveness and fairness, comprehension and income.

A series of models has been computed to examine the degree to which the acceptability values quoted by individuals for a given scheme are explained by their other assessments of that scheme (perceived effectiveness, perceived fairness, comprehension and problem perception), the characteristic of the scheme (degree of differentiation) and personal factors (income).

Correlations between acceptability and the explanatory variables are presented in Table 2-29.

**Table 2-29: Correlation between Acceptability and Several Predictor Variables**

| Predictor variables | R | p |
|---|---|---|
| Perceived fairness | **.609** | > .01 |
| Perceived effectiveness | **.417** | > .01 |
| Comprehension | **.414** | > .01 |
| Traffic related problem perception | **-.214** | .027 |
| Environment related problem perception | .080 | .416 |
| Income | -.127 | .193 |

Spearman's correlation coefficient shows a non-significant positive correlation between the perception of air polution from motor cars as a problem and the acceptability score allocated to the Dresden scheme ($r_s$ = 0.080; p = 0.416). However, the correlation between acceptability and traffic related problem perception has a contrary and significant effect ($r_s$ = - 0.214; p = 0.027). Thus, higher acceptance is associated with lower perception of traffic-related problems. Pearson's correlation coefficient was used to explore the relationship between acceptability and perceived effectiveness and fairness. This identifies a significant positive correlation both for effectiveness ($r_p$ = 0.417; p < 0.001) and for fairness ($r_p$ = 0.609; p < 0.001) - the more effective and fair a presented pricing strategy appears, the more acceptable this strategy appears to individuals. Regarding comprehension, Spearman's correlation coefficient shows a significant positive correlation between acceptability and comprehension ($r_s$ = 0.414; p < 0.001) - higher comprehension being associated with higher acceptability of the specified measure. Furthermore there is a negative but non-significant correlation of acceptability and income ($r_s$ = - 0.127; p = 0.193).

Explanatory variables were included in the regression equation stepwise by criteria of a significant increasing of explained variance in dependent variable. The final regression model of acceptability achieves adjusted $R^2$ = 0.455 and shows perceived fairness, perceived effectiveness and comprehension as the most important predictors. Changes in explained variances by including degree of differentiation, problem perception and disposable income are not significant. Table 2-30 contains the regression coefficients of the computed models.

**Table 2-30: Regression Coefficients: Predicition of Acceptability of Dresden Schemes**

| Model | | Non-standardised coefficients | Standardised coefficients | T | Significance |
|---|---|---|---|---|---|
| | | B | Beta | B | |
| 1 | (constant term) | 82.025 | | 16,712 | ,000 |
| | Fairness | .798 | .609 | 7.820 | .000 |
| 2 | (constant term) | 96.264 | | 14.658 | .000 |
| | Fairness | .686 | .523 | 6.571 | .000 |
| | Comprehension | .296 | .248 | 3.115 | .002 |
| 3 | (constant term) | 79.701 | | 8.815 | .000 |
| | Fairness | .599 | .456 | 5.590 | .000 |
| | Comprehension | .272 | .228 | 2.928 | .004 |
| | Effectiveness | .255 | .203 | 2.590 | .011 |

### Impact of Price Differentiation on Evaluation of Differentiated Pricing Schemes

It is assumed that differentiation has an effect on responses towards differentiated pricing schemes. The following results consider the effect of price differentiation on acceptability, comprehension and perceived effectiveness of the pricing schemes as well as on intended behaviour (research question 4). Due to the fact that the respondents were assigned to just one pricing scheme in a random order, the samples are independent. Variance analyses were used to analyse differences between mean values of acceptability, comprehension and perceived effectiveness (interval data). These analyses show no significant influence of price differentiation on acceptability (p = 0.849), comprehension (p = 0.483) or perceived effectiveness (p = 0.653). It merely appears that the pricing scheme with one cordon and two time zones is assessed as the most acceptable and, together with the very lowly differentiated scheme, as the most comprehensible. However, scheme 'low2' is perceived as the least effective one (Figure 2-27). It is interesting to note that the characteristics of the acceptability and the comprehension curve are almost similar, whereas the effectiveness curve runs almost in the opposite direction.

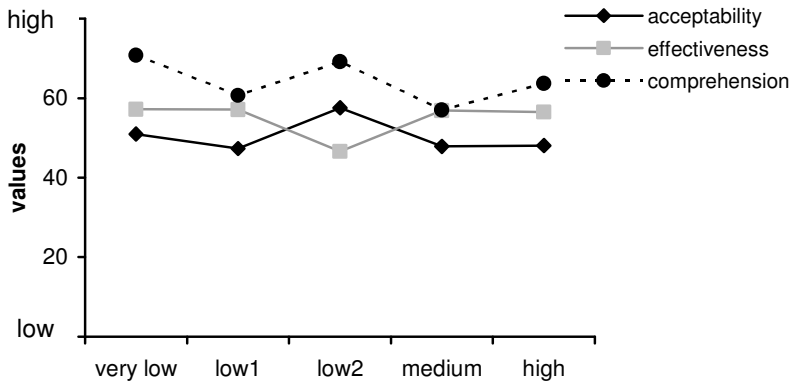



**Figure 2-27: Mean Values of Acceptability, Effectiveness and Comprehension for the Dresden Schemes**

Because the application requirements of variance analysis are violated, the effect of price differentiation on behavioural adaptation was analysed using the Kruskal-Wallis test. This also shows non-significant results, suggesting that the degree of price differentiation has no effect on stated behaviour intentions. Table 2-31 summarises the stated behavioural responses (although these may be of little value given that only a minority of respondents had indicated that they would be affected by the scheme). Nonetheless it is interesting to note that participants overwhelmingly indicated an intention to use alternative modes, routes or times in order to avoid paying the tolls.

**Table 2-31: Stated Behavioural Intentions in Respect of Dresden Scheme**

| | Maintain driving behaviour | | Switch to other transport mode | | Avoidance of tolled roads and times | |
|---|---|---|---|---|---|---|
| | N | in % | N | in % | N | in % |
| Absolutely disagree | 13 | 12.26 | 12 | 11.32 | 10 | 9.43 |
| Rather disagree | 40 | 37.74 | 12 | 11.32 | 9 | 8.49 |
| Rather agree | 35 | 33.02 | 31 | 29.25 | 36 | 33.96 |
| Absolutely agree | 18 | 16.98 | 51 | 48.11 | 51 | 48.11 |
| Total | 106 | 100.00 | 106 | 100.00 | 106 | 100.00 |

### Additional Analyses

In the following paragraphs the four sub-hypotheses (3, 4, 7 and 8) identified in Deliverable 4.1 are examined. At first it is analysed whether a*n individuals´ motivation to adjust behaviour is a positive function of their acceptance* (**sub-hypothesis 3**). There exist no measure of participants' motivation to adjust their behaviour but they were asked whether they would expect to change their behaviour as a result of introduction of the charges. Spearman's correlation coefficient shows that there is a slightly significant positive correlation between acceptability and 'to maintain mobility behaviour' ($r_s$ = 0.226; p = 0.020) and 'to switch to other transport mode' ($r_s$ = 0.197; p = 0.043). The correlation between acceptability and the intention to 'avoid of tolled roads and times' ($r_s$ = - 0.057; p = 0.562) is not significant.

It is assumed that *an individuals´ motivation to adjust behaviour is a positive function of their personal involvement* (**sub-hypothesis 4**). In this study a high personal involvement is assumed when the respondents regularly move by car either in the city centre of Dresden (spatially affected) or during peak hours (temporally affected) in the centre of Dresden (Appendix 6). Spearman's correlation coefficient was used to test whether a relationship exists between the participant's spatial or temporal involvement and their intended behaviour. A significant negative correlation was found between spatial involvement and the intentions to 'maintain mobility behaviour' ($r_s$ = - 0.237; p = 0.015) and to 'switch to another transport mode' ($r_s$ = - 0.282; p = 0.003) – suggesting that the more people are (spatially) affected by the measure the less they would maintain their current mobility behaviour and switch to other modes of transport. The correlation with the intention to 'avoid charged times and roads' is also negative but not significant ($r_s$ = - 0.073; p = 0.454). Moreover the correlation coefficient shows a negative correlation between temporal involvement and the intention to switch to another transport mode ($r_s$ = - 0.292; p = 0.002).

To analyse the *correlation between the several behavioural intentions and the disposable income* (**sub-hypothesis 7**) Spearman's correlation coefficient was again applied. A significant negative correlation ($r_s$ = - 0.427; p < 0.001) was found between income and the intention to switch to another transport mode - people with higher income being less willing to change their current mobility behaviour. In terms of other intentions no significant results appear.

Regarding the *relation between peoples´ educational background and the intended behaviour* (**sub-hypothesis 8**) the correlation coefficient showed no significant results although there was a tendency for people with a higher level of education to be more likely express an opinion about what they would do. They are less willing to switch to another mode of transport. In contrast they are rather willing to

maintain their current mobility behaviour but also to avoid tolled roads and times. However, this may be confounded by income.

Finally according to **research question 2** raised in Deliverable 4.1, the *influence of gender and age on response towards differentiated pricing schemes* is analysed. In terms of *gender,* principally the t-test for two independent samples (interval data) and the Mann-Whitney-test (nominal data) were used. It appears that men are more certain in calculating the travel expenses. T-tests show that the difference between men and women is significant in the schemes 'very low' (p = 0,024) and 'low2' (p = 0,027). In schemes 'low1' (p = 0.084) and 'high' (p = 0.193) significance marginally failed. Moreover men perceive the schemes less difficult compared to women. Here the differences in the schemes 'very low' (p = 0.024) and 'low2' (p = 0.038) are statistically significant and significance of 'low2' failed marginally (p = 0.068). Concerning the intended behaviour, the Mann-Whitney-test indicates a significant effect of gender on the intention to avoid the charge (p = 0,036). It becomes obvious that women are more inclined to avoid tolled roads and times. Regarding the impact of *age,* Spearman's correlation coefficient shows a significant positive correlation between age and latency for the 'low1' ($r_s$ = 0.264; p = 0.006), 'medium' ($r_s$ = 0.219; p = 0.024) and 'high' (p = 0.022) schemes. In each case the tendency is for older people to take more time to calculate the charge. In terms of intended behaviour a significant negative correlation to switching to other transport modes appears ($r_s$ = - 0.384; p < 0.001). So if road pricing would be implemented younger people rather tend to choose another mode of transport.

### *Discussion*

The main objective of this study was to analyse impact of price differentiation, and of interfering cognitive and motivational factors, on immediate responses to differentiated road pricing charges. First it was assumed that price differentiation has an effect on behavioural responses to differentiated prices. For this, latency time, error rate in calculating the charges, task certainty and perceived task difficulty of the given schemes were analysed. Consistent with the hypothesis the results show a significant increase of latency time with increasing complexity. Respondents take more than twice as long to calculate the correct price for the most complex pricing scheme compared to the simplest one. Whereas the differences in latency times between the less complex systems are rather low (between 6 and 8 sec.) the increase in latency time from the medium complex scheme (two cordons, two time zones) to the high complex (three cordons, two time zones) is more than 20 seconds. This finding indicates, as supposed, that with increasing complexity time and effort for calculating /estimating the correct price (i.e. cognitive load) may increase exponentially. Here, the critical step arises by moving from a 2*2 scheme to a 3*2 system.

The second objective measure is the error rate. Interestingly, the relationship between differentiation and error rate is almost identical to the relation between response time and complexity (see Figure 2-28). Thus the error rates for the more simple schemes are rather low and there are no substantial differences between the schemes. However, moving from a medium to a complex system the error rate increases drastically. Thus, the idea of an "exponential" increase in cognitive load as indicated by the response time is supported by a similar pattern in the error rates. Besides cognitive factors, the use of heuristics can explain the increasing error rate. It is assumed that the use of heuristics will be a positive function of the differentiation of the price structure (sub-hypothesis 1). Although there was no direct evidence on the use of heuristics, the existence of an increasing error rate with higher differentiation is consistent with their use because, especially in complex decision-making processes, simplification leads to more mistakes.

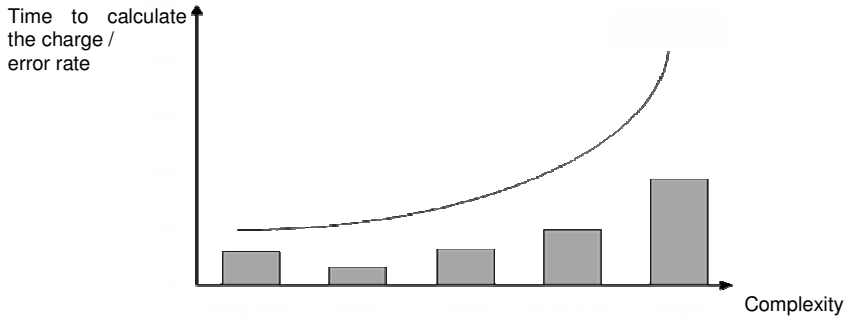



**Figure 2-28: Idealised Relation between Response Time, Error Rate and Differentiation/Complexity**

The objective results are supported by the participants' subjective evaluations of the price calculations. Task uncertainty as well as perceived task difficulty increase with increasing differentiation. In the case of perceived task difficulty, an exponential pattern from medium to complex can again be seen.

The differences in immediate response towards the pricing schemes (especially latency time) of participants assigned to the different sets of schemes can not be explained at that time. Further studies of responses to differentiated pricing should pay particular regard to the relationship between complexity and level of price.

Concerning cognitive factors, the results demonstrate that the majority of participants are able to cope with differentiation in road charges. Problems arise if the degree of differentiation increases and if different dimensions were to interact. It is not possible to determine a specific threshold of complexity. However, the problems in handling a 3*2 system argue for this. Interestingly the participants in this experiment apparently have fewer problems with spatial differentiation (low1) than with temporal differentiation (low2). This may be due to the fact that, in Dresden, people are more used to zone-based-prices (e.g. from public transport) than to temporally different prices (Sutter et al., 2006).

With regard to motivational factors, the results confirm that acceptability is related to latency time. Persons with a higher acceptance of road pricing took less time to calculate the prices. Although the anticipated effect on task certainty, perceived task difficulty and error rate was not significant, it appears that persons with a rather affirmative attitude towards road pricing were more certain in their answers, perceived the pricing schemes as less complicated and made fewer mistakes in calculating the charge. One explanation of the observed link between acceptability and latency time is that acceptance might have an effect on the amount of attention given to the charges. People who like the idea of road pricing should be more motivated to understand it and therefore should invest in a given time interval more effort. Thus they need less time to calculate the prices (and make fewer errors). However, it is unclear whether higher acceptance leads to faster answers or whether less effort generates higher acceptance (the causal direction is unclear). The relationship between acceptability and response to differentiated prices is analysed in more detail in the second experiment conducted in Dresden (section 2.2.3).

According to the heuristic model of acceptability by Schlag, one hypothesis has dealt with the relationship between acceptability and several psychological factors. The analysis has confirmed the separation between the perceptions of traffic-related and environment-related problems (Schade, 2005); whereas a positive but not significant effect of environment-related problem perception on acceptability of the pricing schemes has been detected, a rather contrary slight effect of traffic problems on acceptability was found. The anticipated positive correlation between acceptability and perceived effectiveness was confirmed – showing that the acceptability of a pricing strategy increases the more effective it is evaluated to be. The anticipated positive relationship between acceptability and perceived fairness was also confirmed. However, it should be considered that, since perceived effectiveness and fairness are both affected by outcome expectation, the isolated effect on acceptability would probably be lower (Schade, 2005). The anticipated positive correlation between comprehension and acceptance was confirmed. Strictly speaking, the existence of a correlation does

not provide evidence of causality. For further information concerning the relation between acceptability and the response towards differentiated charges see Experiment II (section 2.2.3). In terms of correlation between income and acceptability, it was assumed, that because of a higher willingness to pay, people with higher incomes would find road pricing more acceptable (in fact the correlation was negative - but not significant). This result may be explained by the fact that the low-income groups were less affected by the measures (Kruskal-Wallis, $p < 0,001$) and so, for them, the pricing measures have less financial impact but may bring environmental benefits. A regression model of acceptability showed that perceived fairness, perceived effectiveness and understandability were the most important predictors (adjusted $R^2 = 0.455$).

According to psychological findings it was anticipated that the degree of price differentiation would have a negative effect on effectiveness, acceptability, comprehension and behavioral adaptation. The results from the experiment did not confirm this. However, the rather neutral estimation of the pricing schemes should be interpreted with care because a high proportion of the participants had rather limited knowledge of the described pricing measures and most would not be affected by them It may be assumed that people who are not directly affected by pricing measures evaluate them more positively than those who are more directly affected (Jaensirisak, 2002). The schemes were not evaluated as particularly effective. Perhaps the participants' lukewarm acceptance of the pricing schemes presented to them can be explained by a strong preference for simple tariffs and predictable prices (Bonsall & Shires, 2005) – and, given their lack of knowledge of journey distances, a particular dislike of distance-based charges. The simplest schemes ('very low' and 'low2'), each of which had only one cordon, were regarded as easy to understand and, as the level of differentiation increased, there was an increase in response time and in error rates.

Behavioural intentions appeared un-related to the degree of differentiation. Investigation of the relationship between acceptability and behavioural intentions was not possible because there was only one estimate of acceptability from each participant and we had insufficient data to establish that any effect was related to that one acceptability score rather than to any other characteristic of that individual. It was, however, clear that the pricing scheme with one cordon and two time zones was perceived as more acceptable, more comprehensible and less effective, than the other schemes. Also, tellingly, it was the one for which the intention to 'maintain mobility behaviour' was most common. It may be that people found this scheme most acceptable because they saw it as the least threat to their previous behaviour and habits (Gärling et al, 2002).

Regarding all results, the non-representativeness of the sample should be noted. Particular problems are the fact that most would be unaffected by the proposed pricing schemes (Jaensirisak, 2002) and the predominance of one age group. A more heterogeneous sample would reveal more interesting evidence for factors which influence the response towards differentiated pricing and so, for further researches, a mixed sample is recommended.

### 2.2.2 Experiment II (Leeds)

#### *Introduction*

The experiment was designed specifically for the DIFFERENT project in order to explore the factors affecting public perception of the complexity, effectiveness and fairness of differentiated road charging schemes, their willingness and ability to predict the charges that would apply to specified journeys and their behavioural responses to those charges.

#### *Research Questions and Hypotheses*

It was hoped that the experiment would assist in consideration of some of the hypotheses, sub hypotheses and research questions identified within section 1.2. Namely:

H1 *There is a point, beyond which, the more differentiated a price structure, the less behavioural adaptation will occur.*

SH1 *The occurrence of errors in estimating prices and adjusting behaviour will be a positive function of the differentiation of the price structure.*

SH2 *An individuals´ ability to understand the charging system and to adjust behaviour will be a positive function of their prior experience of similar price structures.*

SH3 *An individuals´ motivation to adjust behaviour will be a positive function of their acceptance of the system (with acceptance being a positive function of social norms, perceived fairness, and perceived effectiveness).*

SH6 *An individuals´ engagement with the charges and their motivation to adjust behaviour will depend on their type of personality.*

SH7 *An individuals´ motivation to adjust behaviour will be a negative function of their disposable income.*

SH8 *An individuals´ ability and motivation to adjust behaviour will be a positive function of their education*

RQ1 *Does a highly differentiated charging system make people avoid such systems?*

RQ2 *How does age and gender influence the ability and motivation to deal with differentiated pricing systems and how does it affect transport behaviour.*

The experiment was designed to explore a range of potential explanatory factors including the attributes of the schemes (e.g. number of zones and the characteristics and attitudes of the individual travellers. A particular feature of the experiment was that, in addition to obtaining the participants' own estimates of how easy or difficult it was to understand a given charge structure or calculate the charge applicable to a given journey, objective measurements were taken of the response latencies (i.e. the time that participants took to answer the relevant questions).

## *Method*

### Experimental Setting

The experiment was programmed for CASI (Computer Assisted Self-Interviewing). Although it could have been administered remotely on participants' own computers the decision was taken to collect all data in a controlled laboratory environment in order to ensure that the computers were all of the same speed and were displaying the briefing material in an identical way, that participants were not interrupted during the task and that each participant had the same amount of preparation time[8].

The content of the experiment built on the results of an earlier questionnaire, implemented within the GRACE project, which sought to explore people's ability and willingness to engage with complex road charging schemes and their likely responses to them (section 2.1.4). It was also designed to complement a questionnaire being implemented in Newcastle which was exploring similar issues in the context of a wider range of scheme variants (section 2.1.2).

### Procedure and Implementation

The experiment comprised four sections.

The **first section** provided participants with instructions on how to interact with the computer (typing in an answer or moving a cursor to a position along a scale) and an opportunity to respond to a test question.

The **second section** sought participants' response to five charging scenarios for a hypothetical journey (the journey was always the same; a 20 mile journey from A to B starting at 0740 and

[8] A further reason for choosing to conduct the experiment in laboratory conditions was to retain the option of monitoring participants' pulse and galvanic skin response while they were undertaking the experiment – an operation which would only have been feasible in laboratory conditions. In the event that option was not taken forward.

travelling at a constant 30miles per hour. And they were helpfully informed that it would therefore take 40 minutes and that they would arrive at B at 0820). Each of the five charging scenarios included one or more distance-based charges operating in specified parts of the city during specified hours and was specified such that the participant had sufficient information to calculate the price that they would have to pay to make that journey under the specified pricing regime. Figure 2-29 shows two examples of the way that the regimes were presented. Each respondent was presented with five scenarios in random order.

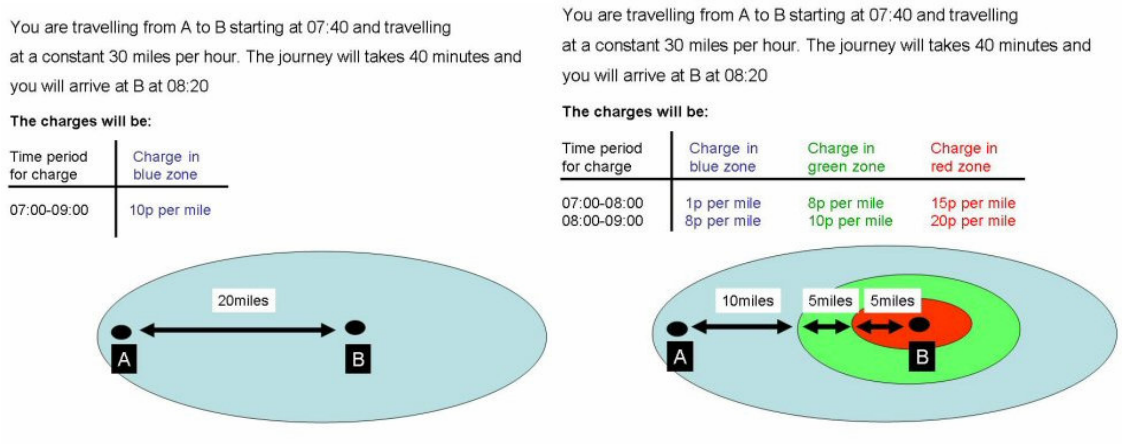



**Figure 2-29: Screen Dumps for Schemes 1 and 5 from the Leeds Experiment**

Table 2-32 summarises the characteristics of the schemes used in the experiment.

**Table 2-32: The Hypothetical Charging Regimes Used in the Leeds Experiment**

| Scheme number | Degree of differentiation | Number of zones | Number of periods | True price Set 1 (£) | True price Set 2 (£) |
|---|---|---|---|---|---|
| 1 | Very low | 1 | 1 | 2.00 | 1.00 |
| 2 | Low1 | 2 | 1 | 3.50 | 3.50 |
| 3 | Low2 | 1 | 2 | 1.50 | 3.00 |
| 4 | Medium | 2 | 2 | 3.00 | 1.50 |
| 5 | High | 3 | 2 | 1.85 | 1.85 |

A more detailed structure of the pricing schemes, which are identical to those used in Dresden except in respect of the units of distance, speed and currency, is given in Appendix 7. Note that, as in Dresden, each scheme has been allocated a "degree of differentiation" based on the number of zones and time periods it contains, and that two sets of schemes, differing only in respect of the charge levels, were used to test for the effect of the price level.

While each scenario was displayed on screen, the participant was asked to answer three questions relating to it:

H1 How much do you think the congestion charge for the specified journey would be (in pounds and pence)? ...

H2 How certain are you of that estimate? (with responses invited on the scale; 1= to within <5%, 2 to within 5%, 3= to within 10%, 4= to within 25%, 5= to within 50%, 6= to within 100%, 7 not to within 100% - note that the software specified actual values based on the response to H1 as well as %s – e.g. if the answer to H1 had been "£*2.00*" then option 2 would have appeared as "*to within 10 pence (i.e. to within 5% of your estimate)*" )

H3 How complicated do you think this congestion charging scheme is to understand? (on a scale from 0="easy" to 100= "difficult")

The section is identical to the Dresden experiment. However, latency times may differ slightly because of the use of different computer systems.

The **third section** tested participants' response to schemes which, it was suggested, might be introduced in their home area. It differs from the Dresden experiment in that participants were asked to respond to five (not just one) hypothesised charging schemes for their home area. Also, because participants were recruited only if they drove regularly within the Leeds area, a higher degree of personal involvement with the schemes could be assumed. Figure 2-30 shows an example of one of the charging regimes used at this stage of the experiment.

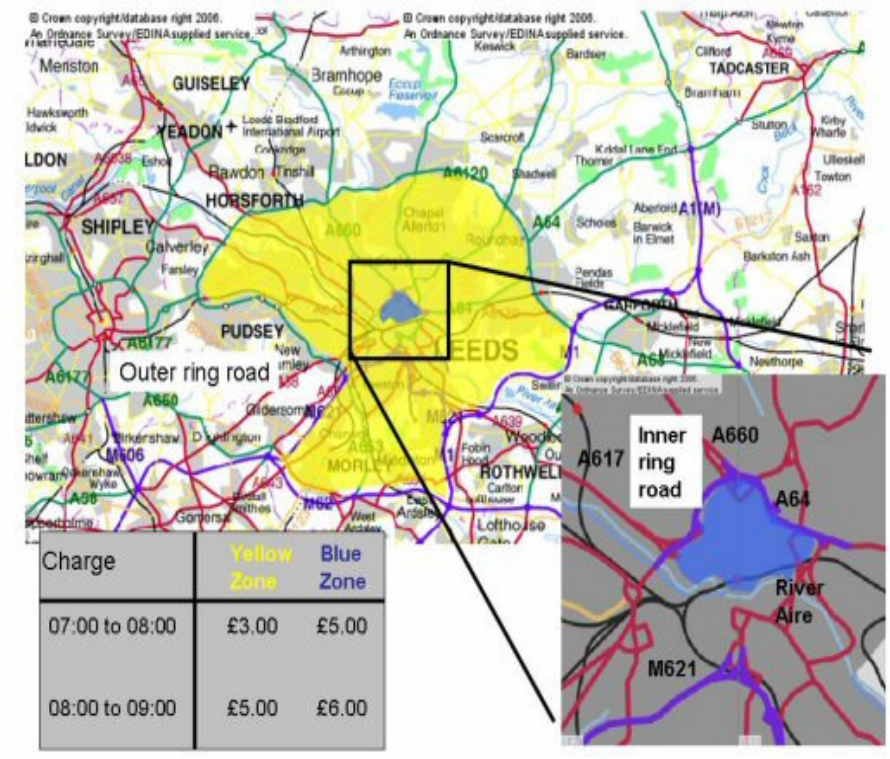



**Figure 2-30: Screen Dump for Leeds Scheme 4**

Table 2-33 summarises the characteristics of the five Leeds schemes.

**Table 2-33: Description of the Leeds Charging Regimes**

| Charge scheme | Degree of differentiation | Description (all roads are free unless specified to the contrary) | summary | | | |
|---|---|---|---|---|---|---|
| | | | Number of road types | Number of zones | Number of time periods | Typical price* (£) |
| 1 | Very low | £5 charge to use any roads in inner or outer zone between 0700 and 0900 | n.s. | 1 | 1 | 5 |
| 2 | Low1 | £4 charge to use any roads in outer zone plus £6 charge to use any roads in inner zone (between 0700 and 0900 in each case) | n.s. | 2 | 1 | 10 |
| 3 | Low2 | charges to use any roads in inner or outer zone; £4 between 0700 and 0800, or £6 between 0800 and 0900 | n.s. | 1 | 2 | 6 |
| 4 | Medium | charges to use any roads in outer zone; £3 between 0700 and 0800, or £5 between 0800 and 0900.<br>charges to use any roads in inner zone; £5 between 0700 and 0800, or £6 between 0800 and 0900c | n.s. | 2 | 2 | 9 |
| 5 | High | arterial roads in inner or outer zone: £4<br>major arterial roads in inner or outer zone: £6 | 2 | 1 | n.s. | 10 |

* The "typical price" assumes a start about 5 miles outside the outer zone and which reaches the outer at about 0745 and finishes in the inner zone at about 0830 having used both arterial and major arterial roads.
"n.s." indicates that this dimension was not specified in the scheme description.

Ten questions were asked while each of charging schemes was displayed on screen:

L1 How much do you think this congestion charge would cost you per month? (assume that you carry on making all the journeys that you make in a typical month)…….pounds and pence
L2 How certain are you of that estimate? (the options being: *to within ..... 1 <5%, 2 5%, 3 10%, 4 25%, 5 50%, 6 100%, or 7 >100%.* Note that the software specified actual values based on the response to L1 as well as %s – e.g. if the answer to L1 had been "*£40.00*" then option 2 would have appeared as "*to within £2.00 (i.e. to within 5% of your estimate)*" )
L3 How effective do you think this charge would be in reducing congestion? (on a scale from *0 Ineffective to 100 Effective*)
L4 On balance, if you carried on driving and had to pay the charges, do you think that you personally would be better off (because of driving conditions) or worse off (because of having to pay the charge)? (on a scale from *0 Better off to 100 Worse off*)
L5 How sure are you that you would be this much better off or worse off? (on a scale from *0 Just a guess to 100 Completely sure*)
L6 If this congestion charge were to be introduced, would you need time to decide what to do? (the options being: *1 No, I would simply carry on driving as now, 2 No, I definitely reduce the amount of driving I do in the charge zone, and 3 Yes, I would want to think carefully about the costs and benefits of all the alternatives- then decide what to do*)
L7 Do you think that, when you have had time to think more carefully, you would be more likely to ...(the options being: *1 Carry on driving as now, 2 Reduce the amount of driving I do in the charge zone, and 3 Really don't know what you would do*)
L8 Different People would be affected by the scheme in different ways. Overall, do you think that a charge is fair or unfair? (on a scale from *0 Fair to 100 Unfair*)
L9 Would you approve or disapprove of this congestion charging scheme? (on a scale from *0 Disapprove to 100 Approve*)
L10 How complicated do you think this congestion charging scheme was to understand? (on a scale from *0 Easy to 100 Difficult*)

The **fourth section** contained nine questions which sought background information on the participant and their attitudes:

E1 What do you think would be the Council's main reason for introducing road charges like the ones we have described? (the options being: *1 To raise revenue for investing in public transport, 2 To raise revenue for investing in roads, 3 To raise revenue for non-transport purposes, 4 To reduce the amount of traffic on the roads, and 5 Don't know*)
E2 In general, when you complete a task that has required a lot of mental effort, do you feel satisfied - or relieved that it is over? (the options being: *1 Mainly satisfied, 2 Mainly relieved, and 3 Half and half*)
E3 In general, would you say that you are the sort of person who likes to work out all the pros and cons before making a decision? (the options being: *1 Yes certainly, 2 Yes, 3 No, and 4 Certainly not*)
E4 In general, would you say that you are the sort of person who likes to work on a problem only if there is a possibility of coming up with a clear-cut and unambiguous answer? (the options being: *1 Yes certainly, 2 Yes, 3 No, and 4 Certainly not*)
E5 What is your gender? (1=*Male, 2 = female*)
E6 What was your age on your last birthday? (…. Years)
E7 Which of the following best describes you employment status? (the options being: *1 Employed, 2 Self-employed, 3 Retired/ unemployed, 4 Student, and 5 Home maker*)
E8 Which of the following best describes your educational background? (The options being: *1 No qualifications, 2 School level qualifications, 3 Degree, 4 Professional qualifications and 5 Degree and professional qualifications*)
E9 And finally, which best describes your household income? (the options being: *1 Up to £13,499, 2 £13,500 - £29,999, 3 £30,000 - £49,999, 4 £50,499 - £74,999, and 5 £75,000 or more*)

Note that questions E2, E3 and E4 are adapted from batteries which seek to measure, respectively, (lack of) need for cognition, (lack of) need to evaluate and tolerance of ambiguity.

The experiment was conducted in the first two weeks of January 2008 in the Decision Research Laboratory of the Leeds University Business School. Participants were recruited in early January 2008. Three methods of recruitment were used; (i) via emails to staff at Leeds University and to the UOLDS[9] panel, (ii) via posters at strategic locations around the university campus and (iii) via direct contact with people at locations within the university. The email/poster/approach mentioned a £5 reward for participating in "a 15 minute questionnaire on a computer" or "a survey about motoring costs" but it was stressed that all participants should be drivers in the Leeds area. 123 people were recruited.

### Sample

The profile of participants is shown Table 2-34 in and indicates a fairly good representation of drivers within the Leeds area – although with a slight bias towards students, people with degrees, females and people on higher incomes.

[9] The UOLDS (University of Leeds Driving Simulator) panel is a specialist driver database comprising people who have participated in driver behaviour studies in the recent past or drivers who have registered their interest in doing so in forthcoming studies. The panellist have been recruited from a combination of the social, personal and research networks of university staff and students and therefore are predominantly from the university community though not exclusively so.

**Table 2-34: Profile of Participants in Leeds Experiment**

| | Attribute | Category | n | % |
|---|---|---|---|---|
| E 5 | Gender | male | 59 | 48.0 |
| | | female | 64 | 52.0 |
| E 6 | Age | 17-25 | 10 | 10.0 |
| | | 26-35 | 50 | 40.6 |
| | | 36-45 | 37 | 30.0 |
| | | 46-55 | 15 | 12.2 |
| | | 56-69 | 11 | 8.9 |
| E 7 | Employment status | Employed, | 94 | 76.4 |
| | | Self-employed | 7 | 5.7 |
| | | Retired/ unemployed | 6 | 4.9 |
| | | Student | 14 | 11.4 |
| | | Home maker | 2 | 1.6 |
| E 8 | Educational background | No qualifications, | 3 | 2.4 |
| | | School level qualifications | 16 | 13.0 |
| | | Degree | 57 | 46.3 |
| | | Professional qualifications | 13 | 10.6 |
| | | Degree and professional qualifications | 34 | 27.6 |
| E 9 | Household Income | Up to £13,499 | 6 | 4.9 |
| | | £13,500 - £29,999 | 49 | 39.8 |
| | | £30,000 - £49,999 | 39 | 31.7 |
| | | £50,499 - £74,999 | 24 | 19.5 |
| | | £75,000 or more | 5 | 4.1 |

### *Results*

The hypothetical schemes were almost identical to those used in the Dresden experiment and so the results should be comparable. Some of the analyses which had been conducted on the Dresden data (section 2.2.1) were repeated on the Leeds data.[10] This was followed by more detailed analysis of the Leeds data using regression models.

#### Impact of Price Differentiation on Response towards Differentiated Pricing Schemes

Figure 2-31 compares latencies (time taken to calculate the charges) with degrees of differentiation. The x-axis uses descriptive labels for hypothetical schemes (1 – 5) which reflect their degree of differentiation.

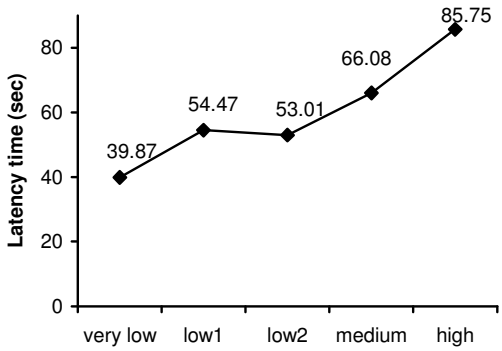



**Figure 2-31: Mean Values of Latency Time at Different Levels of Differentiation**

[10] A comparison of the data of Dresden and Leeds is given in section 2.2.4.

The time taken to calculate the charge clearly increases with the degree of differentiation; respondents require more than twice as long to calculate the charge for the most complex pricing scheme than for the simplest one (analysis of variance shows this to be a significant effect at $p < 0.001$). A post hoc pairwise comparison suggests that the most and least differentiated schemes differ from the other schemes to a significant extent. Regarding the two different sets of prices (Table 2-32) it appears that respondents who received set one took slightly less time to calculate the charges – although the difference is not statistically significant ($p = 0.179$).

The participants' error rate (the number of times that their estimate of the charge is incorrect) was analysed as a function of scheme complexity. Figure 2-32 shows that, as differentiation increases, the error rate goes up at an increasing rate. For the simplest scheme the error rate was about 15% and for the most highly differentiated it was about 50%. The Cochran-Q-Test shows that the positive relationship between error rate and differentiation is significant ($p < 0.001$). No significant difference was found between the error rates for the two sets of schemes.

An investigation of the calculated charges showed that, except in the case of the 'low1' scheme, participants tended to overestimate the charges. However, the effect is not statistically significant ($p = 0.276$).

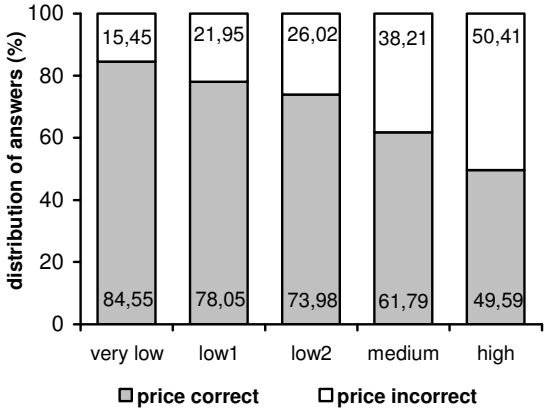



**Figure 2-32: Errors Made in Price Estimation at Different Levels of Differentiation**

The results of questions H2 and H3 (the confidence which participants expressed in their estimate and their assessment of the "difficulty" they had experienced in understanding the scheme) were analysed as a function of degree of differentiation. The results are shown graphically in Figure 2-33.

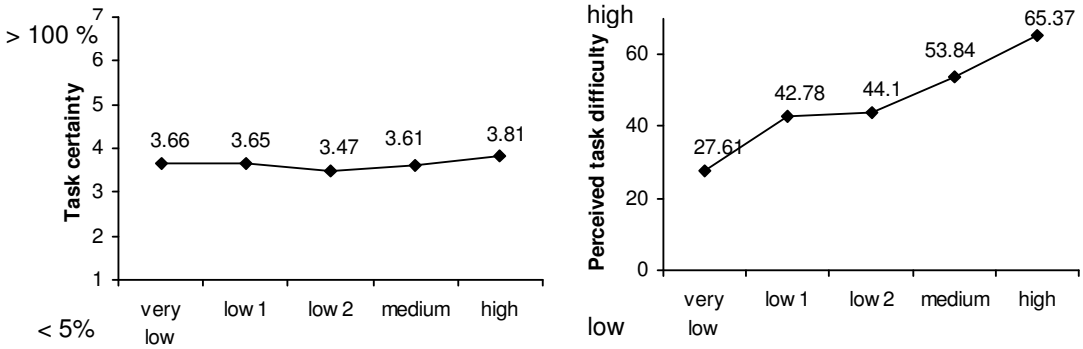



**Figure 2-33: Mean Values of Task Certainty and Perceived Task Difficulty at Different Levels of Differentiation**

The Friedman test revealed that the relationship between confidence and degree of differentiation (on an ordinal scale) is not statistically significant ($p = 0.259$). However, the positive relationship between degree of differentiation and perceived difficulty shown in Figure 2-33 (figure to the right) was confirmed by analysis of variance with repeated measures which showed this relationship to be statistically significant at $p < 0.001$. The post hoc pair-wise comparison indicates that the schemes with very low, medium and high differentiation differ from the others to a significant degree. Further analysis revealed a non-significant difference between levels of confidence expressed in the two different sets of schemes but indicated that participants who had received set one reported perceiving the schemes significantly easier to understand than did those who received set two ($p = 0.010$).

### Impact of Acceptability on Response towards Differentiated Pricing Schemes

The relationship between an individual's motivation and their responses to differentiated pricing schemes was analysed by looking for relationships between the assessed acceptability of the local schemes (question L9) and the latency, error rate, confidence and perceived task difficulty associated with each of the hypothetical schemes (using latency for question H1 and answers to questions H2 and H3 respectively).[11] The analysis was based on a comparison of results from participants whose acceptance ratings were in the top quartile of the distribution with those from paricipants whose ratings were in the bottom quartiles of that distribution. These were called the "high acceptance group" and the "low acceptance group" respectively (cases where the assessed acceptability of the scheme was between the 25$^{th}$ and 75$^{th}$ percentiles were excluded). We have between 31 and 38 observations for each of the hypothetical schemes for each of the two acceptance groups thus defined.[12]

Figure 2-34 indicates that, except in the case of the 'low2' scheme, the high acceptance group took less time to calculate the charge than the low acceptance group. This relationship is particularly evident for schemes towards the top of our complexity range (i.e. 'medium' or 'high') – although it is only for the 'medium complexity' schemes that a statistically significant difference is found ($p = 0.025$).

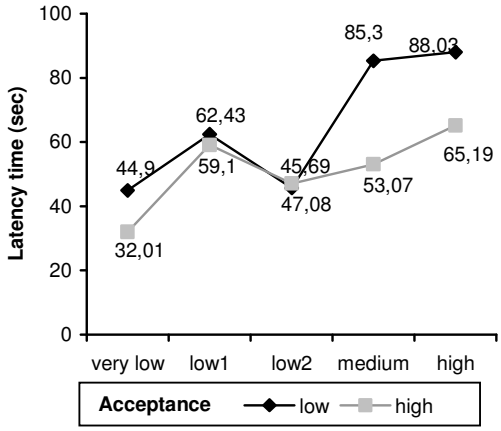



**Figure 2-34: Mean Values of Latency Time at Different Levels of Differentiation (High and Low Acceptance Groups)**

Figure 2-35 shows how the error rate differs for the two acceptance groups. It seems that the high acceptance group had a greater likelihood of making an error in the charge estimate. This relationship was investigated using chi-square tests and significant correlation was found within schemes 'low1' (p

[11] The use of acceptance ratings from the local schemes to examine latencies, confidence and understanding of the hypothetical schemes is here justified by the assumption that the rating is a characteristic of respondents rather than of schemes. Subsequent analyses will explore the relationships between the acceptability rating given to specific schemes and the latencies and other assessments made of those schemes.

[12] In the Dresden experiment each participant assessed only one local scheme and so gave only one acceptability rating whereas, in the Leeds experiment, each participant assessed five local schemes and so gave five acceptability ratings. The Leeds participants' assessments of the hypothetical schemes were entered into the pool five times – once with each of their acceptability ratings.

= 0.008) and 'high' (p = 0.043); the correlations for schemes 'low2' and 'medium' are marginally non-significant - with p = 0.068 and p = 0.093 respectively.

No significant difference was found between the acceptance groups in respect of their assessment of task certainty or perceived difficulty but there was a slight tendency (not statistically significant) for the high acceptance group to report higher levels of confidence in their estimates.

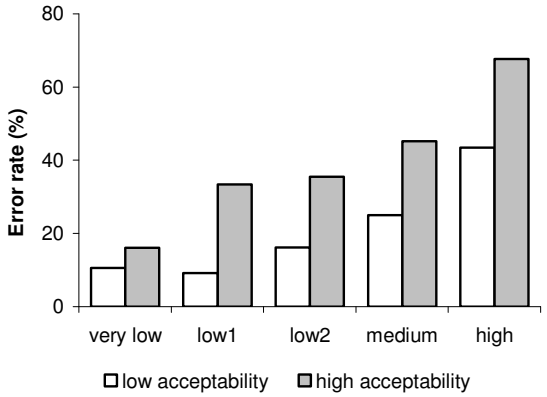



**Figure 2-35: Error Rates at Different Levels of Differentiation (High and Low Acceptance Groups)**

### Impact of Price Differentiation on Evaluation of Differentiated Pricing Schemes

Finally the following results consider the effect of price differentiation on acceptability, comprehension and perceived effectiveness of the pricing schemes. Figure 2-36 shows an analysis of the Leeds participants' assessment each of the local schemes. The x-axis uses descriptive labels for hypothetical schemes (1 – 5) which reflect their degree of differentiation. The data on assessed acceptability is taken from question L9, that for ease of understanding or comprehension is taken from question L7, and that for perceived effectiveness is taken from question L3.

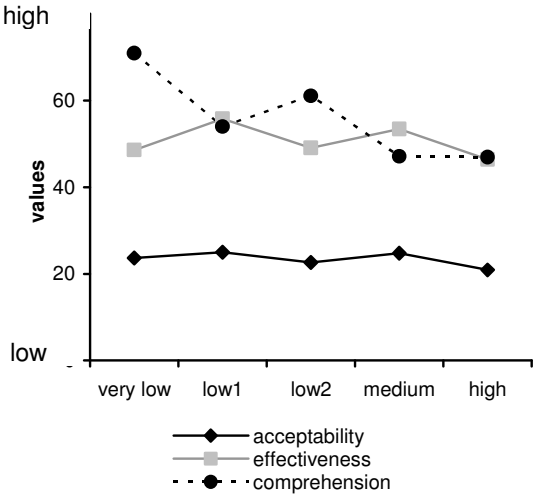



**Figure 2-36: Mean Values of Acceptability, Effectiveness and Comprehension for the Leeds Schemes**

There appears to be a clear relationship between the degree of differentiation and the level of comprehension - with comprehension falling as differentiation increases – but no clear relationship for

assessed acceptability or effectiveness. Analysis of variance with repeated measures (five steps) was used to analyse the extent of differences between mean values of acceptability, comprehension and perceived effectiveness for different levels of charge differentiation, and showed that different degrees of differentiation were associated with significantly different levels of perceived effectiveness ($p < 0.001$) and comprehension ($p < 0.001$). The levels of assessed acceptability did not vary significantly ($p = 0.155$).

### Regression Models

In the following a more detailed analysis of the Leeds data is presented which was based on the estimation of regression models designed to identify relationships within the data and thereby help throw light on issues of interest.

Table 2-35 lists the models which were tested and shows, in bold, the variables which offered significant explanation (at 5%)[13] of the dependent variable. In the commentary which follows, unless there is a specific statement to the contrary, as mention only those relationships which offered significant explanation at the at 1% level.

[13] This was achieved by starting from a model including all variables and then progressively eliminating variables which, firstly had t value s lees than 1.0, and then those that had t values of less than 1.5, and finally those that were not significant at 5%.

**Table 2-35: Models Tested**

| | Dependent Variable | $AdjR^2$ | Potential explanatory variables (bold if retained in the model, light shaded if achieved significance at 5%, dark shaded if achieved significance at 1%, , underscored if negative effect) | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | H1 | .005 | **AC** | order | RED | | | | | | | | | | | | | | | | | | |
| 2 | \|H1-AC\| | .326 | nzones | ntimes | nnos | order | H2 | H3 | NFC | NTE | TA | FEM | OLD | EMP | DEG | £££ | **error** | | | | | | |
| 3 | \|H1-AC\| | .052 | nzones | ntimes | nnos | order | **H2** | H3 | NFC | **NTE** | TA | **FEM** | **OLD** | EMP | DEG | **£££** | | | | | | | |
| 4 | H2 | .092 | nzones | ntimes | nnos | order | H3 | **NFC** | NTE | **TA** | **FEM** | **OLD** | EMP | DEG | **£££** | | | | | | | | |
| 5 | H3 | .267 | **nzones** | **ntimes** | nnos | order | H2 | NFC | **NTE** | **TA** | **FEM** | **OLD** | EMP | DEG | £££ | | | | | | | | |
| 6 | L2 | .101 | nzones | ntimes | nnos | Sch5 | order | **NFC** | **NTE** | **TA** | FEM | **OLD** | **EMP** | **DEG** | **£££** | **error** | | | | | | | |
| 7 | L2 | .073 | nzones | ntimes | nnos | Sch5 | order | **NFC** | **NTE** | **TA** | FEM | **OLD** | **EMP** | **DEG** | £££ | | | | | | | | |
| 8 | L3 | .149 | **nzones** | ntimes | nnos | Sch5 | order | **L1** | **L4** | L8 | **L9** | **L10** | **RED** | NFC | **NTE** | TA | FEM | OLD | **EMP** | DEG | £££ | | |
| 9 | L4 | .404 | nzones | ntimes | nnos | Sch5 | order | **L1** | **L8** | **L9** | **L10** | **RED** | NFC | **NTE** | TA | FEM | **OLD** | **EMP** | **DEG** | £££ | | | |
| 10 | L5 | .129 | nzones | ntimes | nnos | Sch5 | order | **L1** | RED | **NFC** | **NTE** | **TA** | FEM | OLD | EMP | **DEG** | £££ | | | | | | |
| 11 | L6 =1 | .254 | nzones | ntimes | nnos | Sch5 | order | **L1** | L2 | **L3** | L4 | L5 | **RED** | NFC | **NTE** | TA | **FEM** | **OLD** | **EMP** | **DEG** | **£££** | | |
| 12 | L6=2 | .150 | nzones | ntimes | nnos | Sch5 | order | L1 | **L2** | **L3** | L4 | **L5** | RED | NFC | NTE | **TA** | FEM | **OLD** | **EMP** | **DEG** | **£££** | | |
| 13 | L6=3 | .140 | nzones | ntimes | nnos | Sch5 | order | **L1** | L2 | L3 | L4 | **L5** | **RED** | NFC | **NTE** | **TA** | **FEM** | **OLD** | EMP | **DEG** | £££ | | |
| 14 | L7=1 | .147 | nzones | ntimes | nnos | Sch5 | order | **L1** | **L2** | L3 | L4 | L5 | RED | NFC | **NTE** | TA | **FEM** | OLD | EMP | DEG | **£££** | | |
| 15 | L7=2 | .125 | nzones | ntimes | nnos | Sch5 | order | L1 | L2 | **L3** | L4 | **L5** | RED | **NFC** | NTE | TA | **FEM** | **OLD** | EMP | DEG | £££ | | |
| 16 | L7=3 | .153 | nzones | ntimes | nnos | Sch5 | order | **L1** | **L2** | **L3** | **L4** | L5 | RED | **NFC** | **NTE** | TA | FEM | OLD | **EMP** | DEG | **£££** | | |
| 17 | L8 | .600 | nzones | ntimes | nnos | Sch5 | order | L1 | **L2** | *L3* | **L4** | **L5** | L6 | **L9** | L10 | RED | **NFC** | TA | FEM | OLD | **EMP** | DEG | £££ |
| 18 | L9 | .596 | nzones | ntimes | nnos | Sch5 | order | L1 | **L2** | ***L3*** | **L4** | L5 | L6 | **L8** | L10 | **RED** | **NFC** | TA | **FEM** | **OLD** | **EMP** | DEG | £££ |
| 19 | L10 | .209 | **nzones** | **ntimes** | nnos | **Sch5** | order | **L1** | L2 | ***L3*** | **L4** | **L5** | L6 | L8 | L9 | RED | **NFC** | TA | **FEM** | OLD | EMP | DEG | £££ |
| 20 | RED | .045 | NFC | NTE | TA | **FEM** | **OLD** | EMP | DEG | **£££** | | | | | | | | | | | | | |
| 21 | NFC | .087 | RED | NTE | **TA** | **FEM** | **OLD** | **EMP** | DEG | **£££** | | | | | | | | | | | | | |
| 22 | NTE | .234 | NFC | **TA** | FEM | **OLD** | **EMP** | **DEG** | £££ | | | | | | | | | | | | | | |
| 23 | TA | .223 | **NFC** | **NTE** | **FEM** | OLD | **EMP** | **DEG** | **£££** | | | | | | | | | | | | | | |

Note:
AC = actual charge ; error = mean value of |(AC – H1)| recorded for this individual – excluding current observation; order = order of presentation; nzones, ntimes and nnos = number of zones, time periods and charge levels mentioned in the scheme description; RED = assumed purpose is to reduce congestion – E1=4); NFC = lack of need for cognition (E2 with values 2 and 3 exchanged); NTE lack of need to evaluate (E3); TA = tolerance of ambiguity (E4); FEM= female (dummy); old (age); EMP= employed (E7= 1 or 2); DEG = has degree (E8= 3 or 4); £££ = household income; H1, H2, H3, L1, L2, L3, L4, L5, L6, L7, L8, L9, L10 = responses to specified questions.

*Models Relating to the Entirely Hypothetical Schemes*

Model1 indicates that the estimated charge is related, but not closely (!) to the true charge. Model 2 indicates that the main explanation of the deviation of estimated charge from actual charge is the mean deviation of estimated charge from actual charge for all schemes (i.e. the tendency of some participants to make larger errors than do other participants). Model 3 indicates that, if people's inherent deviation from the actual charge is not allowed to enter the model, the degree of explanation is much reduced but deviation of estimated charge from the actual charge error is seen to be higher for people who are older, less affluent and, interestingly, for those who express high confidence in the accuracy of their estimate.

Model 4 indicates that people are less confident about their estimates if they are older, less affluent, or with low need for cognition.

Model 5 indicates that people are more likely to consider schemes complicated if the schemes have a large number of zones or time periods or if they, themselves, are female or young, or if they have high tolerance of ambiguity or low need to evaluate.

*Models Relating to the Leeds Scenarios*

Model 6 indicates that a significant explanation of people's lack of confidence in their estimate of a Leeds charge is that they were making larger errors in their estimates of the hypothetical charges, but that, even allowing for this, people express less confidence if they are older, have low need for cognition, low need to evaluate, low tolerance of ambiguity or (disappointingly!) if they have a degree. Model 7, taken with model 6, indicates that when the influence of high tendency to make errors is removed, the influence having a degree and of not tolerating ambiguity become larger but all other effects become less pronounced.

Model 8 indicates that people are more likely to consider a scheme effective in reducing congestion if it has a high number of zones or road types, if they expect the charge to be high, if they found the scheme easy to understand, if they think the authorities' reason for introducing charges would be to reduce congestion, if they are in employment (presumably because they travel in peak hours), if they think they themselves would be better off, or if they approve of the scheme (though it cannot be said whether this last relationship is cause or effect).

Model 9 indicates that people expect to be worse off following introduction of a scheme if they expect the charge to be high, if they think the scheme is unfair or difficult to understand, if they assume the authorities' main purpose is to reduce congestion, if they themselves are young or employed (presumably because they travel during peak hours), or if they do not approve of it (again, the direction of causality in this relationship cannot be deduced).

Model 10 indicates that people are more likely to be confident in their assessment (of whether they would be better or worse off) if the charge is high, if they have low need for cognition or high need to evaluate (the appearance of both of these last two items may seem contradictory but may be explained by the existence of two sub-populations – one comprised of people who are not troubled by their inability to come to a conclusion and the other who would like to reach a conclusion but recognize that they do not have access to all the necessary information).

Models 11 and 12 relate to people's expected behavioural response. Model 11 indicates that people expect to be more likely to maintain their driving patterns after introduction of the charge if they expect the charge to be low, if they think the scheme's purpose is to reduce congestion but that it is unlikely to be effective in achieving this (a relationship which is probably an effect rather than a cause), if they are male, employed, of above average age or income, have a degree or a low need to evaluate. Model 12 indicates that people expect to reduce the amount of driving they do in the charge zone if they were unsure about their estimate of the charge, it they think it likely to be effective, are sure how worse off they will be, are not employed, are on a low income, are of above average age, or have low tolerance of ambiguity.

Model 13 indicates that people would want to think more carefully about the costs and benefits before deciding on how to respond to the charges if they expect the charge to be high or think the purpose of

the scheme will be to reduce congestion but are unsure whether they would be better off or worse off, if they are young and female without a degree, if they have high need to evaluate or high tolerance of ambiguity. Models 14, 15 and 16 relate to people's expectations of their more considered response (they are based on data from participants who, at question 6, indicated that they would want more time to consider their options). Model 14 indicates that people are more likely to expect, on reflection, to maintain their existing driving patterns if they confidently expect the charge to be low or if they are female. Model 15 indicates that people are most likely to expect, on reflection, to reduce the amount of driving they do in the charge zone if they expect the charge to be effective in reducing congestion, if they are young, or if they have high need for cognition. Model 16 indicates that people are likely, even after thinking about it, to be unsure what they would do if they are not confident in their estimate of the charge, if they do not expect the scheme to be effective in reducing congestion, if they are employed, have high need for cognition or low need to evaluate (Although the relationship is not significant at 1%, it is interesting to note that people were people were more inclined to be unsure of their best course of action when they expected the charge to be high – the combination of an unknown, but high, charge would thus seem to make it particularly difficult to decide what to do).

Models 17 and 18 relate to people's perception of the fairness of the scheme and whether they would approve of it. Model 17 indicates that people are likely to consider the scheme unfair, if they confidently expect to be worse off, if they disapprove of the scheme or are not in employment. Model 18 indicates that people are more likely to approve of the scheme if they expect it to be effective in reducing congestion, if they think it fair, or if they have high need for cognition (Although the relationships are not significant at 1% it is interesting to note that approval was more likely to come from people who expected they would be better off following its introduction, from people who were not in employment, and from those who assumed its purpose would be to reduce congestion).

Model 19 indicates that people are likely to consider a scheme difficult to understand the more zones, road types and time periods it has (with Scheme 5, with its multiple road types, being considered particularly difficult), if they are female, if they expect to be better off as a result of it (but are not sure about this), or if they do not expect the scheme to be effective in reducing congestion.

#### *Models Relating to Personal Characteristics and General Attitudes*

Model 20 indicates the assumption that a road charging scheme would be introduced in order to reduce congestion is most characteristic of older people on higher incomes.

Models 21, 22 and 23 explore the interrelationships between need for cognition, need to evaluate and tolerance of ambiguity (as proxied by questions E2, E3 and E4). Model 21 indicates that need for cognition is lower among females, older people, people on low incomes, people who are not in employment, and people with low tolerance of ambiguity. Model 22 indicates that need to evaluate is lowest among older people, people without employment, people without degrees and people with high tolerance of ambiguity. Model 23 indicates that tolerance of ambiguity is highest among females, people with degrees, people without employment, people with high need for cognition and people with low need to evaluate.

Models 24 and 25 sought to explore the effect of the estimated charge (L1) on people's assessment of whether they would be better off (L4) and on how sure they were about this (L5). The results, for different populations, are shown in Table 2-36. It appears that, judged by the relative values of the adjusted r-square, price has more influence on anticipation of being better or worse off (and on peoples' certainty about this) among people with high need for cognition than among those with low need for cognition. Also, although to a lesser extent, the price has more influence among people with low need to evaluate and low tolerance of ambiguity than among those with high need to evaluate or high tolerance of ambiguity.

**Table 2-36: Models of Effect of Estimated Charge among Different Populations**

| Model | Dependent variable | Set of observations | Number of observations | Adj. R2 | Independent variable |
|---|---|---|---|---|---|
| 24a | L4 | NFC=high | 305 | 0.25 | L1 |
| 24b | | NFC=low | 110 | 0.08 | L1 |
| 24c | | NTE= high | 540 | 0.18 | L1 |
| 24d | | NTE= low | 80 | 0.25 | L1 |
| 24e | | TA= low | 230 | 0.21 | L1 |
| 24f | | TA= high | 390 | 0.19 | L1 |
| | | | | | |
| 25a | L5 | NFC=high | 305 | 0.13 | L1 |
| 25b | | NFC=low | 110 | not sig. | L1 |
| 25c | | NTE= high | 540 | 0.07 | L1 |
| 25d | | NTE= low | 80 | 0.13 | L1 |
| 25e | | TA= low | 230 | 0.11 | L1 |
| 25f | | TA= high | 390 | 0.06 | L1 |

*Results Relating to Latencies*

A number of models were run to discover whether the time that participants took to respond to questions was related to any aspect of the question, the scheme being considered or of the participants' characteristics. This investigation was not directly related to the hypotheses in Deliverable 4.1 but it was thought that it might yield useful and relevant information. It must, of course, be recognized that the fact that someone takes longer to answer a question does not mean that they found it more difficult – it may simply be that they gave it more thought.

Unsurprisingly, the questions which required participants to estimate a charge took the longest to complete. Question E1 (which asked participants to say what they thought the authority's motive for introducing charges might be) also took a significant amount of time. The questions which took the next longest were L3 and L4 (which asked participants to say how effective they thought the schemes would be at reducing congestion, and whether, on balance they would expect to be better or worse off), followed by Questions E2 and E4 (which explored participants' need for cognition and tolerance of ambiguity).

For the Leeds schemes, the time taken to estimate the charge increased with the number of zones and the number of time periods (and was particularly increased for Scheme 5 – which featured differentiation of charges according to road type). However, the time taken to judge the likely effectiveness of a scheme was longest for Scheme 4.

The order in which schemes were presented had an impact on the time taken to estimate the charge for the hypothetical schemes and to decide on the likely response to Leeds schemes (in both cases less time was required the later the scheme appeared in the sequence – which is consistent with there being a learning effect (or a fatigue effect – with less effort being put in to thinking about the schemes presented towards the end of the sequence).

Older people took longer to complete the experiment - and most particularly to answer questions L3, L4, E1, E2 and E3 (which, respectively, sought the participant's assessments of the effectiveness of the schemes at reducing congestion, of whether they would be better or worse off, of the likely purpose of the scheme, of their own need for cognition and of their own need to evaluate) and, to a lesser extent, took longer to provide an estimate of the charges in the hypothetical schemes and to assess whether the scheme was fair.

People in full time employment took less time to complete the experiment and, most particularly, took less time to decide whether and how they would change their behaviour and to answer the question on need to evaluate.

Females took longer to complete the experiment and, most particularly, took longer to estimate the charges for the hypothetical schemes. However, they answered the questions on the assumed purpose of the scheme, their need to evaluate and their tolerance of ambiguity more quickly than did males.

People with high need to evaluate took longer to complete the questionnaire (suggesting that time taken is a function of effort rather than of difficulty) and, most particularly took longer to come to a decision on the likely purpose of the scheme, to report their confidence in that assessment, to assess their need for cognition and their tolerance of ambiguity. People low tolerance of ambiguity took longer to decide whether they would approve or disapprove of the scheme but took less time to decide on the likely purpose of the charges and to assess their own need to evaluate.

Interestingly, no significant relationship was found between the error which people made in estimating the hypothetical charges and the time they had taken to provide that estimate. But a positive relationship was found between the amount of time that had been taken to make the estimate and (i) the confidence that people expressed in its accuracy and (ii) the assessed degree of difficulty experienced in understanding that scheme. For the Leeds schemes a positive relationship was found between the amount of time that had been taken to estimate the charge and the confidence that was expressed in the assessment of how much better or worse off the participant would be if that scheme was implemented.

### *Discussion*

The objective of this study was to explore the factors affecting public perception of the complexity, effectiveness and fairness of differentiated road charging schemes, their willingness and ability to predict the charges that would apply to specified journeys and their behavioural responses to those charges. This section deals first with the results which were derived using analyses similar to those applied to the Dresden data and then brings in the evidence from the additional analyses conducted on the Leeds data.

Analysis of latencies indicated that significantly more time was taken to estimate charges for the more complex schemes; participants took more than twice as long to calculate the correct price for the most complex pricing scheme compared to the simplest one. Although someone may take longer to answer a question simply because they found it more interesting, our results suggest that the (cognitive) effort required to calculate or estimate the correct price increases with scheme complexity. The idea, that the increase in cognitive load might be an accelerating function of complexity is consistent with the latencies we observed and is certainly supported by the increasing trend in error rates (see also Figure 2-28). The error rate increases with the degree of differentiation and shows much larger increments between ‘medium’ and ‘high’ differentiations than it did between “very low’ and ‘low’.

The objective results are supported by the fact that the participants’ perception of difficulty involved in understanding the charges increases with increasing differentiation. Although the level of differentiation has no influence on participants’ confidence in their estimates, these results demonstrate that problems in handling the pricing schemes will arise if the degree of differentiation increases.

A relationship was found between the assessed degree of acceptability of local schemes and the time taken to estimate the hypothetical tolls; people who reported lower levels of acceptance took more time to estimate the charges. Even though this relationship was statistically significant only for schemes with a ‘medium’ level of differentiation, it is very interesting. An explanation of the higher latency and lower error rate among the low acceptance group is that the high acceptance group, having accepted the concept of charging, thought it less necessary to make an accurate estimate. Another possibility is that the lower error rate among the low acceptance group is due to the fact that more highly educated people (made fewer errors) are more likely to drive within the charge area and so are more likely to be affected by road charging and so are more likely to be in the low acceptance group.

It was expected that excessive differentiation would have a negative effect on perceived effectiveness, acceptance and comprehension. Although no impact on acceptability and no clear impact on

effectiveness were found, a significant impact on comprehension appeared – with the simplest schemes being regarded as much easier to understand. The low comprehension ascribed to schemes 3 and 5 ("low 2" and "high") suggest that the aspects of differentiation which appeared to cause the most problems were those relating to spatial factors – the number of zones and, even more seriously, the number of differently priced road types.

Respondents assessed all five local schemes as rather unacceptable. This is consistent with the generally negative attitudes towards road pricing in general (Schade, 2005) and, given that all the schemes had a degree of differentiation, may reflect people's distrust of complex tariffs and unpredictable prices (Bonsall & Shires, 2005). Moreover, since the participants were all motorists driving in the Leeds area, they will have felt a high personal involvement with the proposed local schemes and, as Jaensirisak (2002) has noted, this might have caused them to evaluate the proposals as less acceptable.

Turning now to the additional analyses conducted on the data from the Leeds experiment. Consideration of the findings of the regression analysis should be prefaced with the remark that, of the 23 models, 6 failed to explain more than 10% of the variance in the data and only 9 explained more than 20%. These nine are:

- Model 17 (explaining people's tendency to consider a scheme unfair)
- Model 18 (explaining people's tendency to approve of a scheme)
- Model 9 (explaining people's judgement as to how much better off they would be if the scheme were introduced)
- Model 2 (explaining the degree of error in people's estimation of the charge in a hypothetical scheme)
- Model 5 (explaining people's assessment of how complicated a hypothetical scheme was to understand)
- Model 11 (explaining the likelihood of no change in behaviour following introduction of the charge)
- Model 22 (explaining people's response to E3 - the "need to evaluate" question)
- Model 23 (explaining people's response to E4 - the "tolerance of ambiguity" question)
- Model 19 (explaining people's assessment of how complicated a Leeds scheme was to understand).

The overall picture presented by these models is that scheme characteristics affect people's perception of how complicated a scheme is to understand and of how effective it is likely to be but do not affect their response to it, that people's assessment of fairness, and their approval of a scheme seems to be closely related to their assessment of its impact on themselves, and that identifiable personal characteristics and personality traits affect many of the assessments and anticipated behavioural responses.

Turning now to the hypotheses, sub-hypotheses and research questions identified in Deliverable 4.1, it seems that the experiment has provided useful evidence on many of them.

With respect to **H1** (*There is a point, beyond which, the more differentiated a price structure, the less behavioural adaptation will occur).* Although it was found no strong evidence of any direct effect (e.g. no clear effect in models 11 or 14), in model 12 it is found that people were likely to reduce the amount of driving in the charge zone if they were unsure about the size of the charge. A similar effect, all be it less pronounced, was apparent in model 15 where the likelihood of reducing the amount of driving in the charge area was positively related to the participants' lack of certainty as to whether they would be better or worse off). Both these findings should be interpreted in the light of the finding (in models 5 and 19) that the number of zones and time periods contributed to the perception of a scheme's complexity. These findings suggest that, for the levels of complexity tested in the experiment, the dominant effect seems to be that additional complexity leads to greater uncertainty and in turn to a precautionary reduction in driving.

Model 13 suggests that scheme characteristics had no influence on participants' anticipated need for time to think carefully how best to respond to the introduction of a scheme. Rather, the results suggest that identifiable personal characteristics and character traits (notably, age, gender, education, need to evaluate and tolerance of ambiguity) offer a better explanation of people's expressed need for more time to consider their response. The fact that, on average, people took more time to estimate charges for the most complicated schemes suggests that none of the schemes tested were so complex that they resulted in widespread abandonment of any attempt to estimate the charge – but it does not mean that such behaviour was not occurring within subgroups of the population.

With respect to **SH1** (*The occurrence of errors in estimating prices and adjusting behaviour will be a positive function of the differentiation of the price structure).* Models 5 and 19 clearly indicate that the number of zones and time periods contributes to participants' perception of the degree of difficulty they had in understanding a scheme (and that Leeds scheme 5, with its differentiation by road type, was particularly difficult to understand). Although models 2 and 3 do not show any relationship between scheme characteristics and the extent of error (the deviation of the estimated charge from the actual charge), Figure 2-32 clearly shows that the likelihood of error increases with increased complexity.

With respect to **SH2** (*An individuals´ ability to understand the charging system and to adjust behaviour will be a positive function of their prior experience of similar price structures).* The only evidence on this sub-hypothesis is the observation that the length of time that people took to estimate charges and assess behavioural responses fell with exposure to successive schemes – a finding which is consistent with the presence of a learning effect.

With respect to **SH3** (*An individuals´ motivation to adjust behaviour will be a positive function of their acceptance of the system - with acceptance being a positive function of social norms, perceived fairness, and perceived effectiveness).* There exist no measure of participants' motivation to adjust their behaviour but they were asked whether they would expect to change their behaviour as a result of introduction of the charges. Models 11, 12, 14 and 15 suggested that a participant's perception of the fairness of a scheme was unrelated to their anticipated behavioural response to it. However, models 11, 12 and 15 indicated that their anticipated behavioural response was strongly related to their perception of a scheme's effectiveness (note, however, that this relationship does not prove that anticipated behavioural responses are conditioned by expected effectiveness – it may be that the expectation of effectiveness is based on the assumption that their own response is likely to be mirrored in that of other people – i.e. that their perception of effectiveness is a result of their own anticipated response).

With respect to **SH6** (*An individuals´ engagement with the charges and their motivation to adjust behaviour will depend on their type of personality*). Several instances were found where identifiable character traits (need for cognition, need to evaluate, and tolerance of ambiguity) helped to explain participants' responses, but the best evidence on this hypothesis came from models 24 and 25 which explored whether the influence of the anticipated charge (L1) on other responses differed among people with different needs for cognition, needs to evaluate and tolerances of ambiguity. These models showed that, for questions L4, and L5 (people's assessment of whether they would be better off and their confidence in that assessment) the anticipated price had most influence on people with high need for cognition (and, but to a lesser extent, on those with low need to evaluate and low tolerance of ambiguity). Model 13 showed that the desire to think more carefully about the costs was higher among people with high need to evaluate. These results are all highly plausible and suggest that the three character trait questions do help to identify groups of people with different levels of engagement with the charges. The findings on the different latencies associated with people who gave different answers to the character trait questions (e.g. the finding that people with high need to evaluate took longer to complete the experiment) tends to confirm the efficacy of these questions.

With respect to **SH7** *(An individuals´ motivation to adjust behaviour will be a negative function of their disposable income).* There was no direct evidence on motivations but it was found support for this hypothesis in the finding (from model 11) that the likelihood of anticipating no change in current travel patterns is positively related to household income, and in the finding (from Model 12) that the likelihood of anticipating a reduction in driving in the charge area is negatively related to household income.

With respect to **SH8** *(An individuals´ ability and motivation to adjust behaviour will be a positive function of their education).* Model 12 would seem to support this hypothesis because it suggests that people with degrees were more likely to expect to reduce their driving in the charge area. However, there is some inconsistency here because model12 (where the effect of having a degree has a more significant impact than it did in Model 11) suggests that people with degrees were more likely to anticipate maintaining their existing patterns of behaviour. This seeming contradiction is explained by the fact that graduates were more than averagely likely to select a positive position (rather than the "don't know") at L6. Also it was noted from models 9 and 10 that graduates were more than averagely likely to expect to be better off as a result of a charge scheme (and to be quite sure about this). Strangely, model 6 suggests that graduates were less inclined to express confidence in their estimate of the charges for the hypothetical schemes. Model 22 suggests that they have higher need to evaluate and model 23 suggests that they have greater tolerance of ambiguity.

With respect to **RQ1** *(Does a highly differentiated charging system make people avoid such systems?)* As noted in the discussion of H1 above, models 5 and 19 have shown that increased differentiation causes people to find schemes more difficult to understand while models 12 and 15 indicated that people were likely to reduce the amount of driving in the charge zone if they were unsure about the size of the charge or uncertain as to whether they would be better or worse off. This finding clearly has important consequences for the design of charging schemes.

With respect to **RQ2** *(How does age and gender influence the ability and motivation to deal with differentiated pricing systems and how does it affect transport behaviour?).* The participant's age and gender appeared to influence many of their responses. Age had strong effect (significant at 1%) in models 3, 4, 5, 6, 9, 11, 12, 13, 15, 21 and 22 and a weaker effect (but still significant at 5%) in models 7, 18, and 20. The emerging picture is that older people had less need for cognition and less need to evaluate, were less confident of their ability to estimate the charge (and their estimates were indeed further from the actual charge), more likely to maintain their current patterns (without needing to think very deeply about it), and less inclined to expect to be worse off, to assume the purpose of the scheme would be to reduce congestion or to approve of its introduction. Gender had a strong effect (significant at 1%) in models 5, 11, 13, 14, 19, 20, 21 and 23 and a weaker effect (but still significant at 5%) in models 3, 4, 15, and 18. The emerging picture is that females were more inclined to say that they found the schemes difficult to understand, less ready to make a quick decision on how to respond (but with an initial tendency to expect to change their travel patterns which was revised, on reflection, to an expectation to maintain them), less likely to assume that the purpose of the schemes would be to reduce congestion and less likely to approve of their introduction. The females also showed lower need for cognition and higher tolerance of ambiguity.

### 2.2.3 Experiment III (Dresden)

#### *Introduction*

Following the first two experiments (section 2.2.1 & 2.2.2) which analysed the impact of price differentiation, mitigated by cognitive and motivational factors, on responses to differentiated road pricing charges, the main objective of this third experiment is to validate the main findings and to extend in particular the influence of attitudes ('acceptability') on the responses to differentiated prices.

The first two experiments provide an indication that acceptance of road pricing was associated with perceptions of effectiveness. It was also found that people displaying high acceptance were more likely to say the schemes had been easy to understand, to have taken less time to estimate the charges, to claim greater certainty about their estimate (the direction of causality in these relationships was not clear). With respect to the errors which have been made in calculating the differentiated charges, the experiments show inconsistent results. To investigate this more in detail and to obtain causal evidence of the findings of experiment I and II, a third experiment was conducted where it was tried to manipulate the acceptability of urban road pricing (low vs. high).

Acceptability research has shown that when determining the acceptability of a policy or decision, two very important criteria are the (perceived) outcome and the (perceived) procedure (Schade & Schlag, 2000). People tend to support policies which promise benefits (personnel as well as societal) and

where the implementation procedure is perceived as fair (e.g. political decisions with public participation).

Therefore – in order to manipulate the acceptability of road pricing – two variables were used:

- *outcome*: a description which focuses either on the benefits or the costs of the policy;
- *procedure*: the way (decision-process) how the policy will be introduced: Either "fair" (via a public referendum) or "unfair" (decision by public administration without public participation).

Lind and Tyler (1992) have argued that justice judgments affect attitudes, behaviour, and decisions. The assumption of this study is that the higher the perceived fairness of the way how the policy will be introduced and the more benefits following a policy are expected the higher the acceptability of the policy should be and, on the contrary, if the implementation procedure is perceived as very unfair and if mainly costs are expected the acceptability of the respective policy should be very low.

### *Research Questions and Hypotheses*

Based on section 1.2 and the results of first two experiments, research questions and hypotheses were adapted and specified as follows:

**Research question 1: Does the acceptability of road pricing (via the manipulation of procedural fairness and outcome expectation) have a direct effect on responses towards differentiated pricing?**

The results of experiment I and II indicate that people who accept road pricing in general need less time in dealing with complex pricing schemes. Also in tendency these persons are more confident in their calculation of the charges and they perceive the pricing schemes as less complicated. In terms of error rate no clear statement is possible (because of inconsistent results).

Hypothesis 1: The more acceptable road pricing appears the lower the latencies will be.

Hypothesis 2: The more acceptable road pricing appears the more confident people will be about the accuracy of their price estimation.

Hypothesis 3: The more acceptable road pricing appears the lower the perceived the difficulties will be.

**Research question 2: What impact has the degree of price differentiation on behavioural responses?**

To validate the results of the first two experiments, again the following hypotheses are investigated.

Hypothesis 4: The more differentiated a pricing structure, the higher the response latencies will be.

Hypothesis 5: The more differentiated a pricing structure, the higher the error rates will be (less precise price estimation).

Hypothesis 6: The more differentiated a pricing structure, the more confident people will be about the accuracy of their price estimation.

Hypothesis 7: The more differentiated a pricing structure, the higher the perceived difficulties will be.

**Research question 3: Do people prefer simple pricing schemes over complex ones?**

Concerning preferred level of differentiation there exist rather opposed assumptions. According to economic theory individuals act rationally. Thus highly differentiated prices will be preferred because each one can choose a tariff according to her/his willingness to pay. But people do not just act rationally. There are several cognitive, motivational, personal or situational factors which influence the responses towards differentiated prices (section 1.1). Furthermore it is assumed that in general people have strong preferences to simplicity.

Hypothesis 8: People prefer simple pricing schemes over complex ones.

Additionally, the following question was analysed: *Do age and gender influence the ability and motivation to deal with differentiated pricing schemes?*

## *Method*

### Experimental setting

An artificial situation was created to manipulate the respondents' acceptability of the schemes. This was done by using four different introductory texts which varied in terms of procedural fairness (PF) and perceived benefit/cost. The first part of the introductory texts did not vary; it describes the increasing traffic problems throughout Europe and the possibility to solve these problems by road pricing. The first variant text then says that the implementation of this toll will be decided by a public referendum (i.e. high procedural fairness) and that the charge will lead to decreasing travel times and less environmental problems (i.e. benefit). The second variant states again that the introduction of road pricing will be a public decision (high procedural fairness) but suggests that the charge will lead to increasing travel costs (i.e. cost). The third variant says that the implementation of road pricing will be decided by the public administration (i.e. low procedural fairness) but that the charge will lead to decreasing travel times and environmental problems (benefit). The fourth variant states again that the implementation of road pricing will be decided by the public administration (i.e. low procedural fairness) and that the charge will lead to increasing travel expenses (i.e. a cost).

The schemes themselves were the same as those used in Experiment I in Dresden (section 2.2.1 & Appendix 5). That is, five pricing schemes varying in complexity by spatial (cordon pricing with a distance-based charge) and temporal differentiation (vary by time of day).

### Procedure and Implementation

The experiment is divided into four sections.

At the beginning of the **first section** one of the four possible introductory texts (chosen at random) was presented to the participant. The frequency distribution of participants to the four experimental conditions is shown in Table 2-37.

**Table 2-37: Assignment of Participants to the Four Experimental Conditions**

| | | Outcome expectation | | |
|---|---|---|---|---|
| | | **High (benefit)** | **Low (costs)** | **∑** |
| Procedural fairness | High | 29 | 40 | 69 |
| | Low | 47 | 34 | 81 |
| | ∑ | 76 | 74 | |

After reading the introduction, the participant had to quote general fairness (0 = 'unfair' to 100 = 'fair'), interpersonal fairness (0 = 'be more affected than others' to 100 = 'be less affected than others'), outcome expectations (0 = 'less benefits' to 100 = 'more benefits') and finally acceptability of the described measure (0 = 'unacceptable' to 100 = 'acceptable'). All of these items have been operationalised by an infinitely variable rating scale. The anticipated relationship between procedural fairness/ outcome expectation (independent variable) and general fairness, interpersonal fairness, outcome expectation and acceptability (dependent variable) is shown in Figure 2-37.

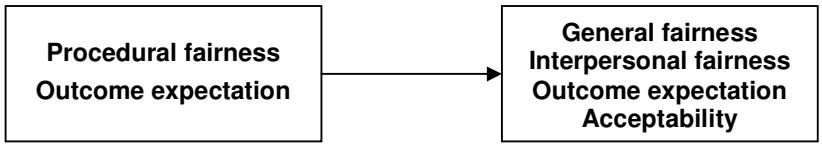



**Figure 2-37: Relation between Stimulus and Response**

The **second section** is identical to the first part of Experiment I (Dresden) described in section 2.2.1. Five pricing schemes differing in complexity were presented to the respondents in a randomized order (Table 2-26).[14] First they had to calculate by means of a hypothetic trip the costs for the trip. Then the respondents had to state how certain they are about the accuracy of their calculation / estimation (0 = 'uncertain' to 100 = 'certain'). Finally, they were asked to indicate the perceived difficulty of this cost calculation for the given scheme (0 = 'very easy' to 100 = 'very difficult'). Furthermore the time the respondents needed to calculate the charge for the trip (latency time) was measured.

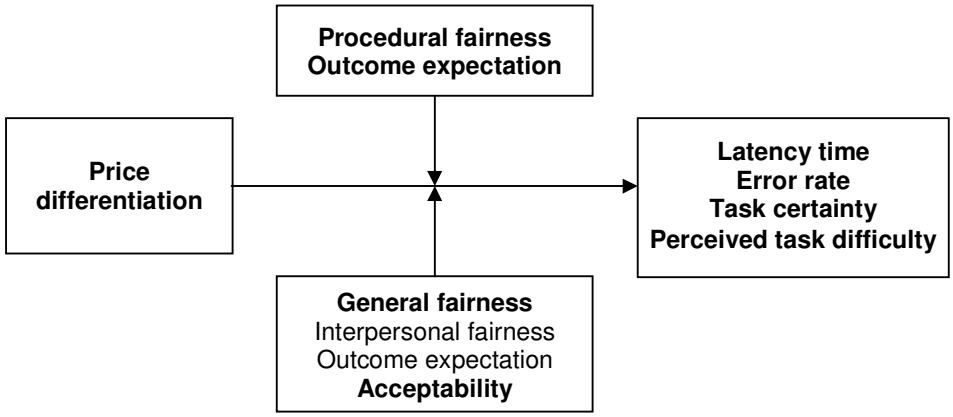



**Figure 2-38: Relation between Stimulus (Independent Variable) and Response (Dependent Variable) with Regard to Interfering Variables**

In the **third section** five differentiated pricing schemes referring to Dresden were presented to the subjects (section 2.2.1). The structure of these schemes is identical to those used in part one and differs only in the graphic presentation (Set 2 was used). Participants were asked to rank the schemes in order of preference (1 = best tariff to 5 = worst tariff).

In the **last section** socio-demographic data and travel habits were asked for.

The experiment was conducted in October 2007 at the Dresden University of Technology. Participants were approached by an advertisement in a regional newspaper. It was mentioned a 3 € reward for participating in "a 15 minute questionnaire about measures of transportation policy". The precondition for participation was that the respondents have not participated in the first experiment.

### Sample

The sample consists of 150 persons whereof 80 are female and 70 male. The analysis of the data showed that the sample is very young (88 % under 26 years), has a high level of education (98.7 % with Abitur) and has a low available income (66 % less than 500 € per month).

Furthermore most of the respondents (96.7 %) are still in education. Because of this homogeneity, it is a non-representative sample. Concerning the personal involvement by the pricing measures the results have shown that only a minority of the respondents use the car for ways from/to work (9.3 %) and for leisure activities (23.3 %). Moreover 28.7 % of the interviewed persons never move in the city centre by car and 37.3 % never move motorized during peak hours (7.00 till 9.00 and 16.00 till 18.00).

A more detailed sample description is provided in Appendix 8.

[14] A given respondent will have received five schemes out of two sets which differ only in level of price. This departure from full random choice was designed to avoid the accidental correlation between scheme complexity and price.

### Results

At first it should be analysed *if manipulation of acceptability was successful*. It is assumed that the higher the perceived fairness of the way the policy will be introduced and the more benefits following a policy are expected, the more positive the attitude towards road pricing will be. For this investigation, the impact of the manipulation of acceptability (via the four different introductions) on general fairness, interpersonal fairness, outcome expectations and acceptability is tested. Variance analysis identifies a non-significant effect on all four evaluations. Because of this, and the small sample size in each experimental condition (Table 2-37) the sample was divided into two groups only by means of the procedural fairness[15]; group 1 (who had received the first or second variant introductions and thus were primed with high procedural fairness) consists of 69 persons, group 2 (who had received the third or fourth variant introductions and so were primed with low procedural fairness) consists of 81 persons (Table 2-38).

**Table 2-38: Assignment of Participants to the Two Experimental Conditions**

| | 1. Group | | 2. Group | |
|---|---|---|---|---|
| **Procedural fairness** | ↑ | ↑ | ↓ | ↓ |
| Benefit vs. costs | ↑ | ↓ | ↑ | ↓ |
| Respondents | 69 | | 81 | |

#### Impact of Procedural Fairness on Response towards Differentiated Pricing Schemes

The impact of the manipulation of procedural fairness (low vs. high) on general fairness, interpersonal fairness, outcome expectations and acceptability was now investigated. The analysis merely shows a statistical significant effect on general fairness (p = 0,019) – with participants primed with high PF evaluating the schemes as fairer than those primed with low PF. In spite of non-significant results the tendency is obvious that persons in the first group feel rather less affected than others by the given situation, they expect rather benefits and they perceive the procedure more acceptable (Table 2-39).

**Table 2-39: Mean Values and Standard Derivation of General Fairness, Interpersonal Fairness, Outcome Expectations and Acceptability**

| | N | General fairness | | Interpersonal fairness | | Outcome expectations | | Acceptability | |
|---|---|---|---|---|---|---|---|---|---|
| | | M | SD | M | SD | M | SD | M | SD |
| PF high | 69 | 60.46 | 24.46 | 69.96 | 22.87 | 47.54 | 25.88 | 52.59 | 32.45 |
| PF low | 81 | 50.44 | 26.71 | 66.80 | 23.72 | 44.23 | 25.36 | 48.49 | 32.06 |
| Total | 150 | 55.05 | 26.10 | 68.25 | 23.31 | 45.75 | 25.56 | 50.38 | 32.20 |

The first research question deals with the influence of the acceptability manipulation on responses to differentiated prices. To facilitate this investigation, a control group of 60 people, drawn randomly from among participants in Experiment I (and who had therefore not been subject to any manipulation) was added. Latency time, task certainty, perceived task difficulty and error rate of the two PF-groups and the control group was surveyed by variance analysis with repeated measures.

Regarding latency time, the analysis identifies no effect of procedural fairness (p = 0.984). Figure 2-39 shows that the response time of persons in the low PF group and persons without any manipulation (control group) were almost identical over all steps of differentiation. Moreover it appears that people in the high PF group are slower in calculating the charges for the low differentiated schemes but faster in processing the more differentiated ones. This interaction effect of procedural fairness and level of differentiation on latency time is significant (p = 0.006).

[15] Summarising the sample by means of outcome expectation the analysis indicates no effect on general fairness, interpersonal fairness, outcome expectations and acceptability.

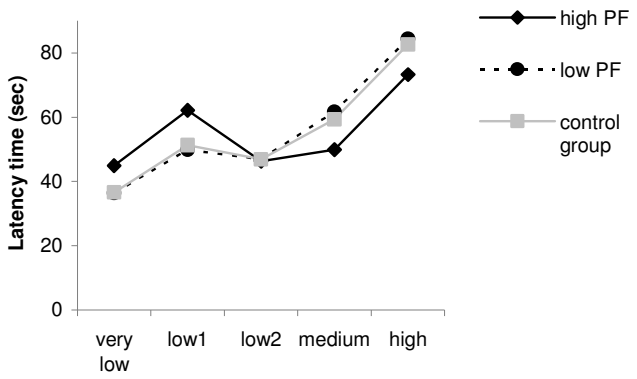



**Figure 2-39: Mean Values of Latency Time Depending on Procedural Fairness**

The relationship between PF condition and error rate was analysed by cross-classified tables and the chi-square test. The tests identify significant correlations in pricing scheme 'very low' ($p = 0.010$), 'low1' ($p = 0.028$) and 'medium' ($p = 0.043$). In seems that, with exception of the scheme with 'very low' differentiation, participants in the low PF group make more mistakes in calculating travel expenses than those in the high PF group (Figure 2-40) but that most errors are made by participants in the control group.

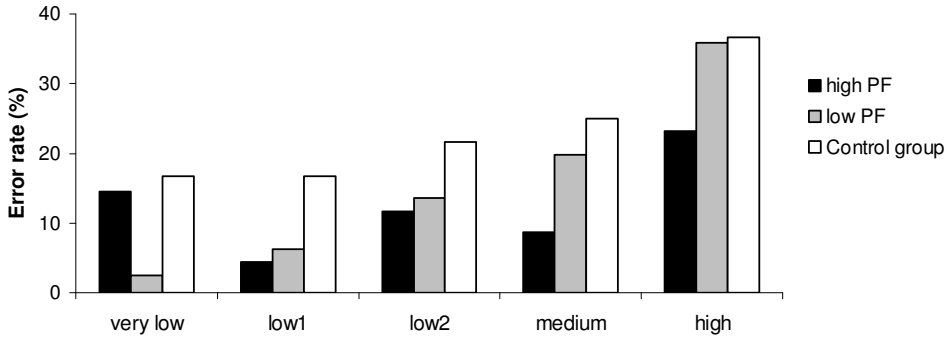



**Figure 2-40: Errors Made in Price Estimation Depending on Procedural Fairness**

Concerning task certainty ($p = 0.743$) and perceived difficulty ($p = 0.342$) also no significant effect of PF condition can be identified. People in the low PF group and in the control group report similar values for perceived difficulty (Figure 2-41).

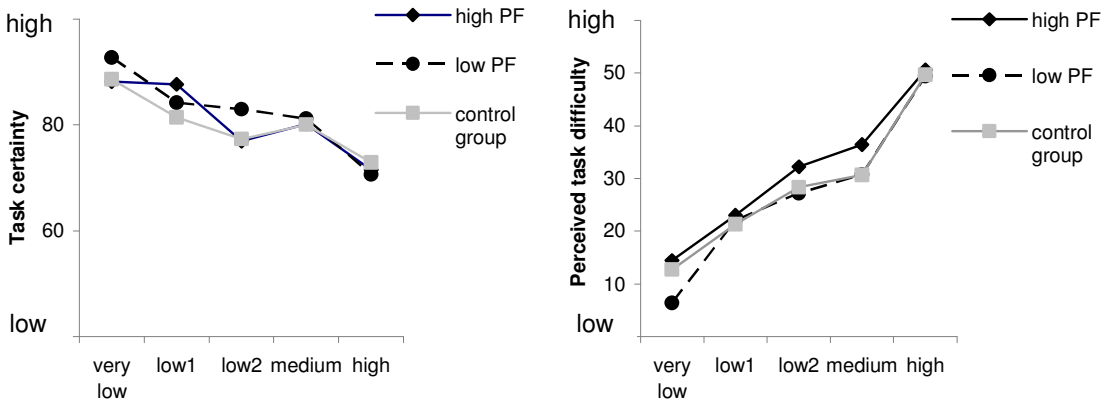



**Figure 2-41: Mean Values of Task Certainty & Perceived Task Difficulty Depending on Procedural Fairness**

### Impact of Price Differentiation on Response towards Differentiated Pricing Schemes

The relationship between level of differentiation and user response to price differentiation (research question 3) was examined using a one-factorial variance-analytical design with five steps (low to high differentiation). This analysis was designed to confirm the equivalent findings from experiment I and so, within this analysis, the impact of procedural fairness is disregarded. Significant effects of price differentiation were found for the time to calculate the travel cost ($p < 0.001$), the certainty of this calculation ($p < 0.001$) and the perceived difficulty ($p < 0.001$). The same statistically significant result appears for the error rate by the Cochran-Q-Test ($p < 0.001$). Table 2-40 shows the mean values of latency time, task certainty, perceived task difficulty and error rate. Investigation of distribution of errors within the schemes shows that more respondents underestimate the charge but that there is no significant effect of differentiation ($p = 0.319$).

In consideration of the two different sets of schemes (Table 2-26), the analyses also identify no significant effects on latency time, task certainty, perceived task difficulty and error rate. In tendency respondents from the set 1 condition need less time in calculating the travel expenses and perceive the schemes easier compared to respondents from the set 2 condition.

**Table 2-40: Mean Values and Standard Derivation of Latency Time, Task Certainty, Perceived Task Difficulty and Error Rate**

| | N | Latency time | | Task certainty | | Perceived task difficulty | | Incorrect prices in % | Correct prices in % |
|---|---|---|---|---|---|---|---|---|---|
| | | M | SD | M | SD | M | SD | | |
| Very low | 150 | 40.32 | 21.63 | 90.67 | 15.64 | 10.09 | 14.81 | 8.00 | 92.00 |
| Low1 | | 46.59 | 23.34 | 85.82 | 18.62 | 22.49 | 20.85 | 5.33 | 94.67 |
| Low2 | | 55.48 | 46.07 | 80.20 | 23.09 | 29.51 | 24.53 | 12.67 | 87.33 |
| Medium | | 56.23 | 28.40 | 80.75 | 23.10 | 33.36 | 22.78 | 14.67 | 85.33 |
| High | | 79.26 | 48.76 | 71.03 | 28.01 | 49.97 | 27.77 | 30.00 | 70.00 |
| Total M | | 55.58 | | 81.69 | | 29.08 | | 14.13 | 85.87 |

### Preferred Level of Differentiation

Regarding preferred pricing schemes (research question 4) it appears that the more highly differentiated the pricing scheme is, the less it is preferred. The very lowly differentiated scheme is the preferred tariff for nearly half of the respondents. In contrast more than 50 % appraise the most complex system as the worst one.

**Table 2-41: Individual Ranking Order**

| | Very low | | Low1 | | Low2 | | Medium | | High | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | in % | N | in % | N | in % | N | in % | N | in % |
| Best tariff | 73 | **48.67** | 14 | 9.33 | 32 | 21.33 | 6 | 4.00 | 25 | 16.67 |
| 2 | 34 | 22.67 | 35 | 23.33 | 31 | 20.67 | 32 | 21.33 | 18 | 12.00 |
| 3 | 19 | 12.67 | 45 | **30.00** | 38 | **25.33** | 29 | 19.33 | 19 | 12.67 |
| 4 | 8 | 5.33 | 28 | 18.67 | 33 | 22.00 | 69 | **46.00** | 12 | 8.00 |
| Worst tariff | 16 | 10.67 | 28 | 18.67 | 16 | 10.67 | 14 | 9.33 | 76 | **50.67** |

### Effect of Age and Gender

To analyse the influence of gender on response to differentiated pricing schemes principally the t-test for two independent samples (female or male) and the Mann-Whitney-test was used. It appears that women are more uncertain in calculating the travel costs. T-tests show that the difference between men and women is significant in the schemes ‘very low’ ($p < 0.001$) and ‘low1’ ($p = 0.014$) but that, in scheme ‘low2’, significance marginally failed ($p = 0.071$).

Regarding the impact of age, Spearman's correlation coefficient indicates a significant positive correlation to perceived difficulty of scheme 'low1' ($r_s = 0.293$; $p < 0.001$), 'low2' ($r_s = 0.300$; $p < 0.001$), 'medium' ($r_s = 0.278$; $p = 0.001$) and 'high' ($r_s = 0.233$; $p = 0.004$). Thus older people perceive the differentiated schemes as more difficult to understand. In terms of task certainty there is a significant negative correlation between age and the evaluated certainty of scheme 'low2' ($r_s = - 0.192$; $p = 0.019$), 'medium' ($r_s = - 0.224$; $p = 0.006$) and 'high' ($r_s = - 0.199$; $p = 0.015$). According to this older people are less confident of their ability to calculate the charges correctly.

### *Discussion*

The aim of this third experiment was to analyse the impact of price differentiation and motivational factors on responses to differentiated road pricing charges. It was assumed that acceptability would have an effect on behavioural responses towards differentiated pricing schemes. For this, it was attempted to manipulate acceptability of road pricing by varying the test conditions. When analysing the impact of all four conditions (procedural fairness and outcome expectation) no effect of manipulation could be established. Summarising the sample merely by means of procedural fairness, the results show that this manipulation was partly successful. Lind and Tyler (1992) showed that the decisive factor in the acceptability of a certain policy is often actually the process or procedure rather than the expected outcome. In other words, people often attach cases more importance to the process – the fairness of the procedure and `the way in which' – than to the outcome that a policy is ultimately likely to have as far as they are concerned. It is above all the procedure followed that influences the overall attitude towards a certain policy and the tendency to support a policy or not.

The results indicate that persons to whom a measure with high procedural fairness was presented evaluate this more fair. Although the results were not statistically significant, it appears that these persons feel less affected than others by the given situation (higher interpersonal fairness), they expect more benefits and they perceive the procedure fairer in general. So estimation of an option is influenced by the way the option is presented or framed (Kahneman, Slovic & Tversky, 1991). In the present case mentioning that implementation of road pricing was a public decision influenced the perceived fairness in a positive way. In contrast communicating that road pricing will be decided by the public administration appears more unfair (Tyler & Lind, 1992).

The first research question analysed the impact of procedural fairness on responses to differentiated charges. It appears that people who were confronted with a high PF condition are slower in calculating the charges for the lowly differentiated schemes but faster in processing the more differentiated ones. This interaction effect of procedural fairness and level of differentiation on latency time is significant. In addition, it is found that latency times of persons from the low PF condition and persons without any manipulation (control group) are almost identical over all steps of differentiation. Another interesting finding is that, for most schemes, persons from the control group and from the low PF condition make more mistakes in calculating travel expenses than persons from the high PF condition. However, for schemes with a very low level of differentiation, the high PF group actually had higher error rates and latency times. This might be an example of over motivation; although extra deliberation normally results in fewer errors, perhaps, when the task is very simple, too much deliberation results in more errors – leading the highly-motivated high PF group to perform less well than the less motivated people.

Overall, the results show (with some exemptions) an impact of procedural fairness on responses towards differentiated pricing schemes. If people perceive a given situation positively they will be more motivated to understand even a sophisticated charging system whereas in the other case people may be discouraged from dealing with it (Hoffmann et al., 2006). So emphasising the positive aspects of road pricing will not only improve the attitude towards it but also the handling of rather complicated and differentiated schemes.

The effect of price differentiation on latency time, error rate in calculating travel expenses, task certainty and perceived task difficulty of the given schemes were analyzed again (to confirm the results of Experiments I and II). As was anticipated, a significant increase of latency time was found to be associated with increasing complexity. Respondents required twice as long to calculate the correct price for the most complex pricing scheme compared to the simplest one. Whilst the increase in latency time of the less complex systems is more or less consistent (between 6 and 8 sec.), moving

from the medium to the complex system the latency time increases drastically (to more than 20 sec.). Increasing the degree of differentiation also caused a marked increase in error rates – with, again, a particular increase when moving from a 2*2 scheme to a 3*2 system. The subjective evaluations of the price calculations are consistent with people having had problems handling more complex pricing schemes. Increasing differentiation leads to a decrease in certainty and an increase in perceived task difficulty. In summary these results demonstrate that people are able to cope with differentiation in road pricing up to a certain extent. Problems in handling will arise if the degree of differentiation increases and if different dimensions interact. Furthermore respondents apparently have fewer problems with spatial differentiation (low1) than with temporal differentiation (low2).

Finally the preferred degree of differentiation was identified. The results reveal that people prefer low or even undifferentiated pricing schemes. The more differentiated the scheme is, the less it is liked. This finding is consistent with previous research which found that people have strong preference for simple tariffs (Bonsall & Shires, 2005). Of course, this result relates only to a general preference for simplicity – if a highly differentiated charge offered the prospect of a lower price then it might be preferred over a simple, but high price, option.

### 2.2.4 Conclusions from Laboratory Experiments

The main objective of the experiments was to explore the factors affecting public perception of the complexity, effectiveness and fairness of differentiated road charging schemes, their willingness and ability to predict the charges that would apply to specified journeys and their behavioural responses to those charges. Therefore specifically for the DIFFERENT project three computer-based experiments in a controlled laboratory environment have been conducted in Dresden and Leeds.

Regarding the impact of degree of price differentiation on behavioural responses within the three experiments almost identical results appear. Latency time, perceived difficulty and error rates in calculation travel expenses all increase drastically and certainty about correct price estimation decreases. These findings indicate that with increasing complexity the cognitive load increases. The results suggest that road user might have problems understanding highly differentiated pricing schemes and, if this happened, the behavioural adaptation anticipated by scheme designers might not occur and so the postulated effectiveness of highly differentiated charges would be in doubt. Long processing time, high error rates as well as high perceived difficulty and uncertainty in calculating travel expenses conflict with the requirements of an effective pricing system.

It appears that participants in Dresden tended to underestimate the charges while those in Leeds tended to overestimate them. This difference may be related to the fact that, compared to the Leeds sample, the Dresden sample were generally more favourably disposed to (had higher acceptance of) the charging schemes. This in turn might reflect the fact that the Dresden sample were less affected by the proposed schemes (all the Leeds participants were regular drivers in the charge area; this was true for only a minority of the Dresden sample).

Participants were randomly assigned to one of two sets of schemes (this was done in order to reduce any interaction between the levels of price and of differentiation). There was a tendency (though not statistically significant) for participants assigned to the second set to take longer to estimate the charge and to rate the schemes as more difficult to understand. This result is perhaps explained by the fact that, the calculation required to estimate the charge for one of the schemes in the second set involved a multiplication by 5/8 (which may be more difficult than the multiplication by 10/15 required for the equivalent scheme in the first set). Further studies should seek to pursue the question of the interaction between complexity and level of price.

Experiments I and II results reveal something about the relationship between participants' acceptability (approval) of road pricing and their responses to differentiated prices. Evidence was found of strong links between acceptance of the local schemes and responses to the hypothetical schemes. In both experiments the participants in the high acceptance group took less time to estimate the charges and were more confident about the accuracy of their estimates. In terms of error rate the results of Dresden and Leeds are inconsistent. In experiment I it appeared that the high acceptance group would make fewer errors than the low acceptance group. By contrast in experiment II, the high acceptance group actually made more errors than the low acceptance group. It was speculated that

the Leeds high acceptance group, having accepted the concept of charging, were making less effort to make an accurate estimate because they thought it less important to do so. Another suggestion was that the lower error rate among the low acceptance group is due to the fact that more highly educated people (made fewer errors) are more likely to drive in the charge area and so are more likely to be affected by road charging and so are more likely to be in the low acceptance group. Such a tendency might be expected to have greater effect in Leeds than in Dresden because the Leeds sample was generally more affected by the proposals.

Experiments I and II allowed some investigation of the relationship between acceptance and latency, error rate, perceived difficulty, perceived fairness and perceived effectiveness. Some interesting results emerged but it was not possible to deduce the direction of causality. For example, does acceptance cause, or result from, the level of cognitive effort expended? (if the latter is true then perhaps correlation between acceptance and low latency described above is explained by the fact that participants who had spent more time thinking about the hypothetical schemes were thereby more likely to understand the potential impact that the local schemes charges might have on them and thus likely to end up giving lower acceptability scores to those schemes).

To analyse the relationship between acceptability and response to differentiated pricing structures more precisely, the second experiment in Dresden (Experiment III) attempted to manipulate acceptability. This was only partly successful because only the variation of procedural fairness (PF) was perceived as such. However, the experiment did show that PF conditioning influenced people's perception of fairness, the time they took to estimate the charges and the errors in calculating the charges. It appears that, if people are persuaded that the scheme has been implemented in a fair manner, they are much more positively disposed to it. They are faster in calculating the highly differentiated schemes and make fewer mistakes in all price estimation (with exception of the very lowly differentiated scheme).

Another research question dealt with the impact of differentiation on the evaluation of differentiated pricing schemes. It appears that the evaluations of the schemes done by the respondents in Dresden are superficially similar to the estimations for the Leeds schemes. However, it should be noted that the Leeds data is richer because it is based on five assessments per participant rather than one and so can reveal intra-individual effects. Comparing the results of the experiments I and II (Dresden and Leeds) it is notable that acceptance of the presented pricing schemes in Dresden (mean score 50.23) was considerably higher than that in Leeds (mean score 23.39). This may be explained by the fact that the Dresden sample included a majority who might not be much affected by any road charging scheme (cf Appendix 6) and, as Jaensiriak (2002) has pointed out, people who are not directly affected by pricing measures tend to evaluate them more positively - expecting some environmental benefits but no financial cost. The Leeds sample was not only more heterogeneous but was restricted to people who would be affected by charging. In that respect the results from experiment II may be more realistic than those from experiments I or III.

Experiment III (Dresden) reveals evidence that people prefer simple tariffs over highly differentiated ones. The more differentiated the scheme was, the less likely it was to be preferred. This result reflects the findings of previous research (Bonsall and Shires, 2005) but it should be noted that this result relates only to a general preference for simplicity – if a highly differentiated charge offered the prospect of a lower price then it might be preferred over a simple, but high price, option.

Turning to the hypotheses, sub-hypotheses and research questions identified for Deliverable 4.1, it seems that the experiments have provided useful evidence on some of them.

It can be confirmed that differentiated pricing structures affect user responses but it is not possible to determine a specific threshold of complexity (main-hypothesis 1). However, the considerable problems which participants had in handling a 3*2 system argue for this being above some threshold. The results from experiment II show that people were likely to reduce the amount of driving in the charge zone if they are unsure about the size of the charge. Because of the fact that this certainty decreases with increasing complexity, the uncertainty would leads to reduction of driving.

The assumption of **sub-hypothesis 1** that the *occurrence of errors in estimating prices will be a positive function of the differentiation of the price structure* can be confirmed. As seen in all three experiments the errors in price estimation increase with increasing differentiation.

The **sub-hypothesis 2** that assumes that *an individuals´ ability to understand the charging system will be a positive function of their prior experience of similar price structures* can be affirmed in so far that the length of time that people take to estimate charges and assess behavioural responses fell with exposure to successive schemes (Experiment II).

Concerning **sub-hypothesis 3** (*An individuals´ motivation to adjust behaviour will be a positive function of their acceptance of the system.)*, the relationship between acceptance and behaviour adaptation as a result of introduction of the charges was analysed (although we had no obvious measure of participants' motivation to adjust behaviour and had to rely on their statements as to what adaptation they would make). The results show that people with high acceptance of the pricing measure have a clearer perception of how they might respond – whether it is to maintain previous behaviour or switch to another transport mode. This suggests that they have given more thought to their behavioural response.

The assumption that an *individuals´ motivation to adjust behaviour is a positive function of their personal involvement* (**sub-hypothesis 4**) can be verified by the results of Experiment I. It appears that persons who are more (spatially) affected by the differentiated charges are more willing to change their current pattern of behaviour but, at the same time, state that they will not switch to other transport mode. It might be possible that these persons would consider other alternatives of behaviour adaptation (e.g. car pooling).

With respect to **sub-hypothesis 6** (*An individuals´ engagement with the charges and their motivation to adjust behaviour will depend on their type of personality*) the results from experiment II provide evidence that identifiable character traits (need for cognition, need to evaluate and tolerance of ambiguity) affect participants' responses. The results suggest that these traits do help to identify groups of people with different levels of engagement with the charges.

**Sub-hypothesis 7** assumed that *an individuals´ motivation to adjust behaviour will be a negative function of their disposable income*. Results from experiment II supported this hypothesis in the finding that the likelihood of anticipating no change in current travel patterns is positively related to household income and that the likelihood of anticipating a reduction in driving in the charge area is negatively related to household income. The results from experiment I show similar behavioural patterns, with affluent people being less willing to change their current mobility behaviour. This is consistent with these persons having higher values of time (Calfee & Winston, 1998) and so being more willing to pay for reduced travel times (when using tolled roads).

The assumption of **sub-hypothesis 8** that an *individuals´ ability and motivation to adjust behaviour will be a positive function of their education* can be confirmed by the findings of experiment II. People with degrees are more likely to expect to reduce their driving in the charge area. However, these people tend also to maintain their existing patterns of behaviour. This seeming contradiction is explained by the fact that graduates are more than averagely likely to select a positive position rather than the "don't know". No significant results on this issue came from experiment I.

With respect to **research question 1** the results from experiment III show that people prefer simple tariffs over highly differentiated ones. So the assumption that *a highly differentiated charging system makes people avoid such a system* can be confirmed. The findings from experiment II verify this indirectly by the fact that there is a correlation between the uncertainty about the size of the charge (which increases with the level of differentiation) and the intention to reduce driving (see discussion of hypothesis 1).

**Research question 2** dealt with the *influence of age and gender on the ability and motivation to deal with differentiated pricing systems and transport behaviour*. The results from the experiments indicate that participants' age and gender affect some of their responses. Data from experiment II indicate that older people are less confident about their estimate of the charge, more likely to maintain their current patterns and less incline to expect to be worse off or to approve of the introduction of the schemes. Experiment I provides similar results in terms of task certainty. Furthermore older respondents perceive the differentiated schemes more difficult than younger and they need more time to calculate the charge by tendency. The analysis of intended behaviour identified that if road pricing is implemented younger people rather would tend to choose another mode of transport. In terms of

gender, experiment II suggests that females find the pricing schemes more difficult to understand and they rather disapprove the introduction of the charging systems. The results from experiment I verify the higher perceived difficulty by women and it appears that women are more uncertain in calculating the charge. Furthermore it becomes obvious that women are more inclined to avoid tolled roads and times. This goes along with the fact that women in general use the public transport more often and do more trips for shopping and leisure compared to men (Hamilton, 2002). These trips are more flexible and so time of travel or the used road can be changed easier.

In summary all three experiments provide convincing evidence that the level of differentiation influences user responses to pricing schemes and that both cognitive and motivational factors affect this relationship.

However, there must be a note of caution about the results from the experiments (particularly experiments I and III) because the sample for those was not representative of the total population. Also in experiments I respondents had rather little knowledge about the presented pricing measures and would not be much affected by the proposed pricing measures (Appendix 6).

# 3 FREIGHT OPERATORS

## 3.1 CASE STUDIES REGARDING FREIGHT OPERATORS' RESPONSE TOWARDS DIFFERENTIATED PRICES

### *Introduction*

The present case studies aim to provide insights into freight operators' handling with differentiated charges and their opinions about charges' effectiveness and future behavioural responses. They should help to identify any differences between commercial transport operators (e.g. freight operators) and users (non-commercial, e.g. car drivers).

The case studies conducted within the freight sector focus on freight operators' / road hauliers' perception and attitudes towards differentiated transport charges and several aspects of differentiation. The studies examine the associations between attitudes and future behavioural responses, the respondents' awareness of traffic related problems, their understanding of pricing schemes, their engagement to deal with differentiated charging schemes, and the effect of these on behavioural responses.

Due to the small sample size in the present case studies, the statements deriving from this are limited in their validity. However, the results provide first valuable hints for a better understanding of attitudinal impacts on transport behaviour also for the freight sector.

### *Research Questions*

Based on section 1.2 and in respect to available data obtained by the surveys research questions have been adapted and the following research questions have been addressed:

**Research question 1: Which impact has understandability of reference schemes to cognitive elaboration and motivation to deal with them?**

**Research question 2: Which differences are describable in operators' acceptance depending on different kinds of differentiation elements and what factor does affect their stated acceptance?**

**Research question 3: What behavioural responses depending on time perspective are probable and which factors contribute to the prediction of behavioural changes' likelihood?**

**Research question 4: Which differences are describable in operators' acceptance depending on different kinds of differentiation elements and what factor does affect their stated acceptance?**

### *Method*

The present descriptive and interference statistically analysis is based on data obtained from two separate surveys. Survey 1 was conducted by TRT (2006) and ILiM (2006) and focussed on toll differentiation in road haulage. Survey 2 was conducted by SINTEF (2006) and considered effects of road freight tolls on attitudes and behavioural responses in urban areas.

#### Questionnaires

The questionnaires used in both surveys obtain information about the company (turnover, transport activities, type of hauled goods, fleets, etc) in a first part. The second part deals with some general questions about current practise / approach to road tolls; among others, the following issues have been addressed:

- the way to calculate road tolls (survey1, 2),

- precision of calculation of road tolls (survey 1),
- share of road freight toll in total operating costs (survey 1) and
- experiences with road tolls (survey 1).

In a third part, reactions and opinions of respondents towards certain presented charging schemes are obtained. To a first sub sample of survey 1 (Italian operators), the approach of current road tolls differentiation on the TEN-R Brenner corridor was applied, to the second sub sample (Polish operators) the pricing scheme of German LKW-Maut was applied. To the sample of survey 2 an example scenario adopted from the Stockholm congestion charging trial has been presented.

Referring to the presented schemes, the questionnaires have obtained:

- Understandability of the pricing scheme,
- Ability of precise prediction of price calculation (How accurately COULD YOU predict costs?),
- Engagement / Motivation in prediction of price calculation (How accurately WOULD YOU predict costs?),
- Perceived effectiveness of the pricing schemes and
- In addition to these - within survey 1 - perceived fairness and acceptability of the pricing schemes.

During both surveys, information on likely responses of freight transport operators has been obtained - if differentiated charges will applied on other corridors crossing the Alps / throughout the EU road network (survey 1) and respectively on non – specified urban areas (survey 2). Thereby, the questionnaires differ only slightly in their specified answer categories. Mainly, both surveys have focussed on following behavioural responses:

- Changes in delivery time,
- Use of intermodal services,
- Changes in frequency of consignment/departures,
- Optimisation of loads by restructuring services,
- Alliances / agreements with other transport operators,
- Change of road vehicle and
- Renewing of the vehicle fleet (e.g. lighter vehicles, cleaner vehicles).

Within survey 1, the questionnaire includes additionally re-routing to other motorways and respectively re-routing to express / parallel roads as possible behavioural responses. Further, this questionnaire distinguishes the use of accompanied intermodal services (Rolling Motorway / Ro-Ro) from the use of non-accompanied intermodal services. Respondents of both case studies were polled on estimations of the likelihood of reactions in short term, medium term and long term.

The last part of the questionnaires focus on perceived effectiveness, perceived fairness and acceptance of the following several elements of differentiation - if differentiated charges will be applied on other corridors crossing the Alps / throughout the EU road network (survey 1) and respectively on non – specified urban areas (survey 2):

- Vehicle class,
- Emissions,
- Time of day/night (peak/peak off hours),
- Type of traffic (crossing/internal),
- Types of road (motorway/express/local roads),
- Period of year/day/week and
- Geographical (mountainous or sensitive area, only within survey 1).

### Implementation

The surveys were conducted by direct telephone interviews with key area managers of the firms contacted, or directly with single haulers. Together with the official invitation to take part in the survey, a self-administered version of the questionnaire was submitted by e-mail both to assist phone meetings and give the option of self-compilation.

### Participants

During survey 1, 30 questionnaires were sent out, a total of 17 were returned (9 by Polish operators, 8 by Italian operators). The sample for survey 2 contains a total of 18 (5 Italian operators, 5 operators from Norway, 3 operators from the UK and 5 Polish operators). For survey 1, 9 out of 12 respondents stated that their annual turnover is larger than 500 k €uro, 5 participants refused the question about yearly turnover. Half the respondents to survey 1 operate mainly on international level; about 50% of operators are mainly active on national level.

For survey 2, 12 out of 18 participants stated that their annual turnover is larger than 500 k €uro, 2 out of 18 stated that their turnover is between 100 k and 500 k €uro. 2 operators refused the question about annual turnover. Referring to the type of urban freight transport, about 55% of respondents stated that local distribution is most common for their firms with respect to the tolled (scenario) area. About 38 % (7) stated that the most common type is regional distribution for their firms. Only one respondent stated all types (Local, regional, long distance road freight transport) are common for his firm with respect to tolled area.

Due to the fact of small sample size in both surveys, it has to be noted that for interference statistical analyses data sets of both case studies have been merged into one data set. Thereby, the broad intersection of the surveys has been used to reach a more reasonable sample to test hypotheses. In terms of differences between the surveys, we have tried to construct higher-level categories as dummy variables (e.g. indices, TEN-R Brenner road toll / German LKW-Maut / Stockholm congestion charge – reference pricing scheme). However, the descriptive analyses are conducted for the present surveys separately.

## *Results*

Descriptive results considering survey 1 are already provided in more detail within DIFFERENT Deliverable 8.2 (pp. 12 - 27). Hence, here only shortened descriptive results are presented to give some insight into characteristics of the samples. For reader who is interested in more deep, Del. 8.2 (Erba, 2007) will provide a more comprehensible view about descriptive facts of this interview survey.

### Current Practise / Approach

Survey 1:

- 14 out 17 participants state that the share of road freight toll in their total vehicle operating costs is smaller than 10 %, 3 respondents estimate the share of road freight toll in total costs is between 10% and 15%.
- 14 out 17 participants state that they calculate road toll expenditures by specialist staff, 5 out of 17 participants use special software to evaluate road toll expenditures (“tick all that apply” was possible).
- Thereby, about 30% of respondents state that they calculate road toll expenditures absolutely precisely, about two third of respondents calculate road toll expenditures within 10%. Only one participant of this study state that he calculate road toll expenditures less precisely than within about 50%.
- About 41% of respondents state that they are able to increase their rates to allow for tolls immediately. About 30% of respondents are able to increase rate but only for the next year. About 24% state that they able to increase rates only over longer terms.

- Considering participants responses to road tolls, about 24% of respondents declare that their company does not take any notice (insignificant part of total costs), about 18% of respondents state that toll costs are continuously monitored and their companies respond with immediate variations at operating level. 41% of participants monitor toll costs continuously and companies respond by immediate variations in spot rates tariffs and/or introduction of toll surcharges. Moreover, 24% of respondents' companies evaluate toll expenditures ex-post connected with changes at operational and respectively at commercial level in medium/long terms. Only one operator state that toll impacts are evaluated periodically and medium / long term responses will include consideration about changes in business strategies. ("tick all that apply" was possible).

Survey 2:

- About 22% of respondents state that toll expenditures are calculated by special software, one third state that special staff calculate toll costs and about 44% of respondents use other ways to calculate toll expenditures (contrary to survey 1, respondents should tick only the item that apply most).
- About 28% of respondents are able to increase rates to allow for tolls by toll surcharges on contracts, one third of respondents are also able to increase rates but only for the next years when contracts will be revisited. About 17% of participants are only over longer terms able to increase rates. Moreover, about 17% of participants are not able to increase rates because of a tight market.

As mentioned above, interference statistically analyses are conducted across a merged sample of both surveys. Thus, basis of following analyses is a total sample of n = 35.

### Impact of Understandability of Reference Schemes on Stated Precision of Price Calculation

About 77% of respondents state that they understand the reference scheme absolutely. 20% of respondents state that they understand the presented scheme at most. Results of correlation analyses emphasises that stated precision of price calculation is linked to the understandability by respondents ($r_s = 0.531$, $p \leq 0.001$).

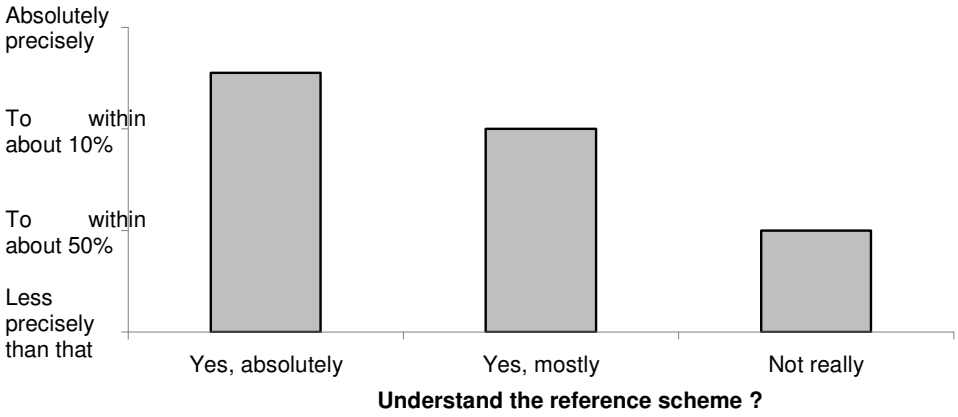



**Figure 3-1: Ability of Precision of Toll Expenditures Calculation (How COULD You Predict Prices?)**

Moreover, the motivation to evaluate toll expenditures (engagement – How WOULD you predict prices?) is also correlated to the statements referring understandability of reference schemes ($r_s = 0.473$, $p = 0.004$). Because of correlative nature of this finding, any causal conclusions are impressible. The finding however provides a first interesting hint about how motivational factors might impact cognitive elaboration of pricing signals or vice versa.

### Differences in Operators' Acceptance Depending on Different Kinds of Differentiation Elements and Factors Does Affecting Stated Acceptance

Respondents were polled on their acceptance of several differentiation elements, perceived effectiveness and fairness of differentiation elements. Figure 3-2 provides an overview of distribution of mean values of acceptance depending on kind of differentiation. This first picture shows that differentiations according vehicle class or emission are rated more acceptable by respondents than temporal or spatial differentiation. Results of variance analysis verify the effect of the factor differentiation element on stated acceptability ($p \leq 0.001$).

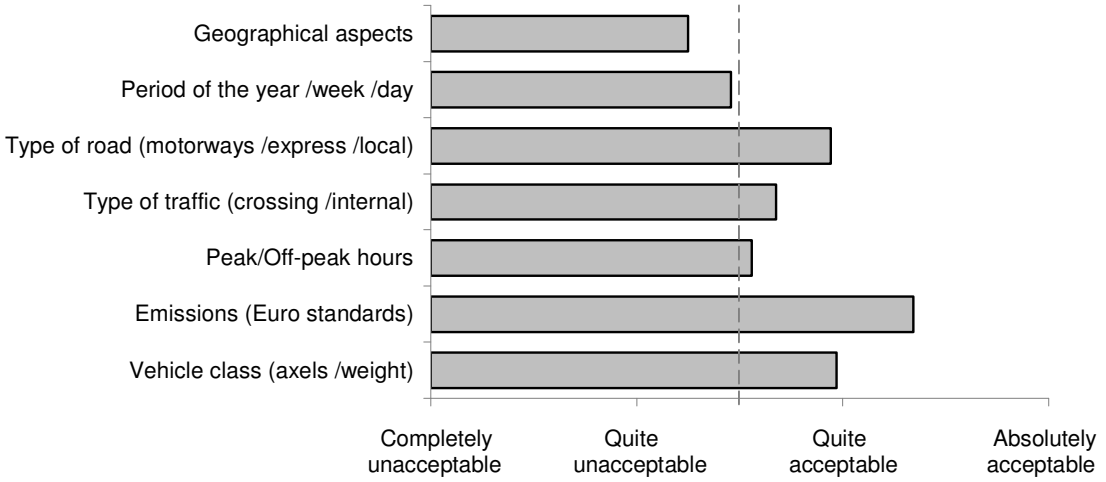



**Figure 3-2: Acceptability Depending on Aspects of Differentiation**

Further correlation analyses emphasize that stated acceptability of specified differentiation elements is strongly related to statements regarding perceived fairness. The more fair differentiation elements are assessed by respondents, the more these aspects of differentiation will be accepted. Tests of correlation between stated acceptability and perceived effectiveness refer to weaker associations than last mentioned relations. According to correlation analyses, coefficients are only in parts significant (Table 3-1). Average correlation coefficients are computed via Z-transformation, average correlation coefficient between acceptability and perceived fairness of differentiation elements is $r_{mean} = 0.641$. For the tested relationship between acceptability and perceived effectiveness, the average correlation coefficient is $r_{mean} = 0.315$.

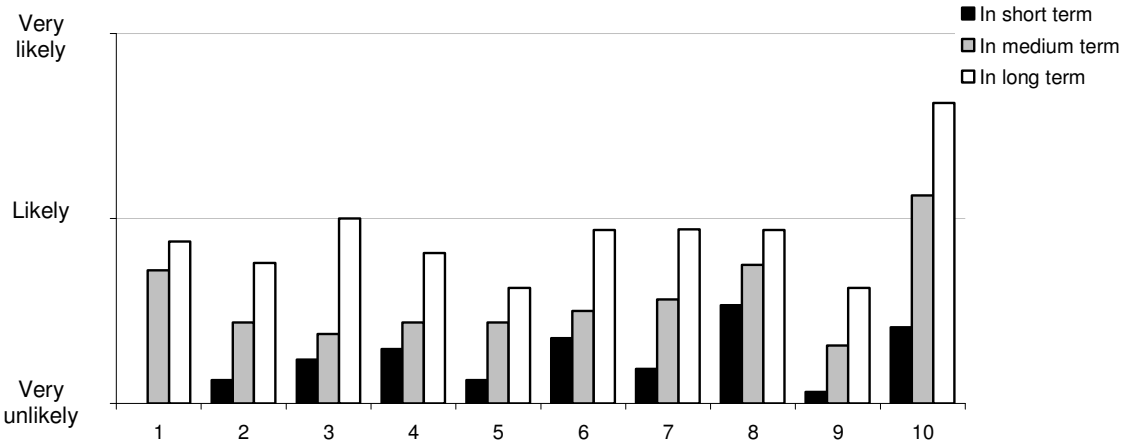
**Table 3-1: Correlation Coefficients: Acceptability, Fairness and Effectiveness**

| | Relation Acceptability ~ Fairness | Relation Acceptability ~ Effectiveness |
|---|---|---|
| Geographical aspects | **.663**** | **.497*** |
| Period of the year/week/day | **.556**** | .309 |
| Type of road | **.396*** | .054 |
| Type of traffic | **.642**** | **.543**** |
| Peak/Peak-off hours | **.833**** | **.380*** |
| Emissions (Euro standards) | **.630**** | .198 |
| Vehicle class | **.654**** | .159 |

### Prediction of Stated Likelihood of Behavioural Changes

Future behavioural responses to reference pricing schemes have been obtained in order of short term, medium term and long term response separately. As Figure 3-3 shows, behavioural changes in the short term are rather unlikely, whereas the likelihood of behavioural changes increases with increasing time horizon. Moreover, fleet renewal seems to be the most probable response to presented scheme in the long term as well as in the medium term. For the short time perspective, not only fleet renewal

but also changes in frequency of consignments / departures shows slightly higher values of stated likelihood compared to other responses.




| | | | |
|---|---|---|---|
| 1 | Re-routing to other motorways* | 6 | Changes in frequency |
| 2 | Re-routing to parallel/express roads* | 7 | Optimisation of load by restructuring |
| 3 | Changes in delivery times | 8 | Alliances with other operators |
| 4 | Use of intermodal services (accompanied) | 9 | Change of road vehicle (LDV/HDV) |
| 5 | Use of intermodal services (non-accomp.)* | 10 | Fleet renewal (EURO standards) |

* obtained only within survey 1

**Figure 3-3: Stated Likelihood of Future Behavioural Responses if References Schemes Will Be Apply**

To afford important predictors of short, medium and long term responses on basis of the both sub data sets, comparable higher-level categories (dummy variables) have been created. In terms of behavioural responses (dependent variables), three indices (mean values) have been computed. These indices provide a global value of the likelihood of behavioural changes by a respondent (company).

(1) $$BR_t = \frac{1}{n_{br}} \sum p_{t,br}$$

Where:

- BR… Index Behavioural Response
- t… in short term, in medium term or in long term
- p… likelihood of behavioural response by certain obtained item (br) regarding to time perspective (t)
- $n_{br...}$ number of obtained items

In next steps, several factors have been tested simultaneously regarding its impacts for prediction of likelihood of behavioural changes by stepwise regression analyses. In an explorative way, theoretically relevant variables (Hoffmann et al., 2006) are included in a first regression model. After that, the number of predictors is stepwise reduced by criteria of non-significant changes in total explained variances. Start regression model includes following predictors:

- Acceptability of differentiated toll charges,
- Understandability of reference scheme,
- Engagement / motivation to deal with reference scheme and
- Perceived effectiveness of reference scheme.

Due to the fact that acceptability for the reference scheme was not obtained by survey 2, a similar procedure as mentioned above has been applied to get a comparable indicator of acceptability across both surveys: a mean value about acceptability statements to several aspects of charge differentiation

has been computed. This index of acceptability serves as a means for approximation of a global value of acceptability towards differentiated toll charges by respondents.

*Prediction of Short Term Response (BR short term)*

A regression model to predict likelihood of short term responses provides unsatisfactory results. These results suggest that the likelihood of short term response is not predictable by independent variables included in the regression equation. Not one of predictors shows a beta-weight at significant level. Concerning these results, it has to be noted that operators' perceptions respectively opinions about a toll differentiation pricing scheme do not affect their (stated) likelihood of behavioural changes in the short term.

**Table 3-2: Regression Coefficients: Prediction of Short Term Behavioural Responses**

| Start model | Standardised coefficients | T | Significance |
|---|---|---|---|
| | Beta | | |
| (constant term) | | 6.578 | .000 |
| Acceptability | .259 | 1.384 | .178 |
| Understandability | .154 | .704 | .488 |
| Engagement | -.134 | -.624 | .538 |
| Perceived effectiveness | .153 | .804 | .429 |

*Prediction of Medium Term Response (BR medium term)*

Results of regression analysis of medium term response show a significant multiple correlation coefficient between obtained values and values predicted by all independent variables together(start model, R = 0.618, p = 0.012).

The explained variance of this model (adjusted $R^2$) is 0.287: suggesting that about 29% of the variance in stated likelihood of behavioural changes is explainable by variances of the predictor variables. Moreover, the stepwise reduction of predictors does not change the value of explained variances significantly. In terms of tested variables, consequently that means that the likelihood is predictable effectual just by operators' index of acceptability towards differentiated toll charges.

**Table 3-3: Regression Coefficients: Prediction of Medium Term Behavioural Responses**

| Start model | Standardised coefficients | T | Significance |
|---|---|---|---|
| | Beta | | |
| (constant term) | | 3.883 | .001 |
| Acceptability | .523 | 3.363 | .002 |
| Understandability | .239 | 1.317 | .199 |
| Engagement | -.230 | -1.285 | .210 |
| Perceived effectiveness | .251 | 1.586 | .125 |

**Table 3-4: Summary of Regression Models: Medium Term Behavioural Responses**

| Model | R | $R^2$ | Adjusted $R^2$ | Changes in F | Changes in significance of F |
|---|---|---|---|---|---|
| Start model | .618* (a) | .382 | .287 | | |
| 2 | .585**(b) | .342 | .269 | 1.650 | .210 |
| 3 | .573**(c) | .328 | .280 | .584 | .451 |
| 4 | .536**(d) | .287 | .262 | 1.721 | .200 |

a Predictors: Acceptability, Understandability, Engagement, Perceived effectiveness
b Predictors : Acceptability, Understandability, Perceived effectiveness
c Predictors : Acceptability, Perceived effectiveness
d Predictor: Acceptability
** significant at 1% level, * significant at 5%

### *Prediction of Long Term Response ($BR_{long\ term}$)*

Regression analysis of long term response shows also significant multiple correlation coefficients between obtained and predicted values of behavioural changes' likelihood. Compared with last reported results, the fit of regression equation is once stronger: correlation coefficient R = 0.674 and adjusted explained variance by all predictors together (start model) in index $BR_{long\ term}$ is $R^2 = 0.371$. Admittedly, stepwise reduction of predictors by above named criteria suggests that mainly acceptability contributes essential to the prediction of behavioural change index: changes in explained variances are not significant by reduction of predictors – except variable acceptability. So, these findings are very similar to the results o regression analysis considering medium term responses.

**Table 3-5: Regression Coefficients: Prediction of Long Term Behavioural Responses**

| Start model | Standardised coefficients | T | Significance |
|---|---|---|---|
| | Beta | | |
| (constant term) | | 2,047 | ,051 |
| Acceptability | .580 | 3.971 | .001 |
| Understandability | .212 | 1.243 | .225 |
| Engagement | -.256 | -1.520 | .141 |
| Perceived effectiveness | .255 | 1.714 | .098 |

**Table 3-6: Summary of Regression Model: Long Term Behavioural Responses**

| Model | R | $R^2$ | Adjusted $R^2$ | Changes in F | Changes in significance of F |
|---|---|---|---|---|---|
| Start model | .674**(a) | .455 | .371 | | |
| 2 | .650**(b) | .423 | .358 | 1.544 | .225 |
| 3 | .633**(c) | .400 | .357 | 1.048 | .315 |
| 4 | .597**(d) | .356 | .334 | 2.054 | .163 |

a Predictors: Acceptability, Understandability, Engagement, Perceived effectiveness
b Predictors : Acceptability, Engagement, Perceived effectiveness
c Predictors : Acceptability, Perceived effectiveness
d Predictor: Acceptability
** significant at 1% level, * significant at 5% level

## *Discussion*

The present case studies consider freight operators' opinions and perceptions of differentiated toll charges as well as selected elements of differentiation. Furthermore, current practices in dealing with toll charges and potential future responses towards differentiated pricing in freight sector are focused.

It has to be noted that the scope of this case study is strongly limited because of small sample sizes of survey 1 and 2. Nevertheless, data sets of both surveys have been merged to reach a more reasonable sample size for statistical analyses. In addition to this, it was necessary to reduce some information of the obtained variables in order to make both surveys comparable. Despite the mentioned limitations, the findings provide first useful insights into operators' dealing with toll charges, their perception of toll charges and interrelations to potential behavioural changes as responses toward differentiated pricing in the freight sector.

Results show that a global index of acceptability of differentiation elements is particularly strongly correlated to the likelihood of future behavioural changes in medium terms as well as in long terms. These findings underline that positive attitudes towards differentiated prices are also in the freight sector relevant for prospective success and effectiveness of pricing measures. Further, variables which investigated aspects of direct handling with differentiated toll charges by operators (e.g. understandability, engagement to deal with schemes) do not considerably contribute to the prediction of stated likelihood of behavioural changes. That might suggest that the understandability of charging schemes respectively the engagement to deal with them is less important for freight operators than for individual car users or transport passengers. A further fact supports this assumption: a vast majority of respondents states that they have special staff calculating and evaluating road toll expenditures. So, cognitive burden by differentiated pricing schemes seems not to be a major issue for freight companies. It is identified as a necessary separate task - allocated in companies structures separately. Moreover, differences in likelihood of behavioural responses between several time horizons imply that effects of differentiated pricing in the freight operator sector affect behaviour more in the long run than in short term.

Further findings show that the attitudes of the surveyed freight companies towards various elements of differentiation differ. E.g., differentiation according emission or vehicle class seems to be more acceptable than any other differentiation element. Differentiation in terms of geographic (e.g. mountainous or sensitive areas) or time aspects (period of year / week / day) are rather less acceptable to road freight operators. It is interesting to note that differentiation elements which relate to changes at vehicle side are rated as more acceptable than differentiation elements which refer to concrete behavioural changes.

One possible explanation might be that freight operators perceive more control to respond towards vehicle based price differentiation than to a price differentiation which relates to changes in the operation of HGV. Comparison of certain future responses hints also in this direction: so, fleet renewal is seen by far as most likely responses to reference schemes in medium terms as well in long terms.

## 3.2 CONCLUSIONS FROM THE CASE STUDIES IN THE FREIGHT OPERATOR SECTOR

Due to small sample sizes of case studies generalisations of results are strongly limited and findings should be interpreted with caution. Further studies on a broader sample would be useful to expand and consolidate findings on freight operators' responses towards differentiated pricing.

Overall, behaviour in the short term seems to be rather inflexible and behavioural adaptations to charging schemes are less probable. Behavioural adjustments to charging schemes become more likely with increasing time horizon.

Considering motivational factors, case studies provide evidences that particularly acceptability of differentiation elements is considerable positive related to the stated likelihood of behavioural changes at least in medium terms and long terms.

Acceptability of a certain differentiation aspect is considerably positively correlated to perceived fairness of that differentiation aspect.

Understandability of pricing schemes and engagement to deal with pricing schemes seems to be less important to behavioural adjustments. These findings are supported by descriptive results: if asked, majority of freight operators indicated that special staff is responsible to evaluate matters concerning charges and charging schemes.

Considering acceptability and fairness, different kinds of differentiation elements are perceived differently. Differentiation aspects which target on vehicle side adjustments like emission class or vehicle class are more accepted than differentiation aspects targeting situational aspects like day time.

Further studies are needed to examine casual relationships between motivational factors and behavioural responses towards differentiated charging schemes. It might be possible that acceptability affect behavioural responses in sense of higher willingness to deal with charges and thus behavioural adaptation will become more likely. On the other hand it might be also plausible that certain kinds of behavioural adaptation strategies are perceived as more realisable and therefore certain charging schemes corresponding to realisable adaptation strategies are more accepted. Moreover, it is also probable that both variables interact.

# 4 FERRY AND RAILROAD PASSENGERS

## 4.1 CASE STUDIES REGARDING FERRY AND RAILROAD PASSENGERS RESPONSE TOWARDS DIFFERENTIATED PRICES

### 4.1.1 Case Study „Stagecoach Forth Hovercraft Trial“

#### *Introduction*

The current case study mainly focuses personal and habitual impacts on users' preferences to price differentiations. Data of Stagecoach Hovercraft trial is used. In 2007, a hovercraft ferry link between Kirkcaldy and Portobello (Edinburgh, Scotland) across the Firth of Forth was arranged on a trial basis. The link between Kirkcaldy and Edinburgh is high frequent used by commuters but also in terms of leisure and shopping purposes. Objective of the trial was to identify public needs for an additional link (in addition to existing possibilities to cross the Forth) and to identify important aspects of customer requirements. An accompanying survey conducted by Transport Research Institute of Napier University (Wilmsmeier, 2007) was realised in order to provide stakeholder essential background information on prospective customer perception for the further implementation of the hovercraft link.

The current analyses use survey data to examine how potential users' habits, situational and respectively personal factors affect their stated preferences to differentiated pricing schemes. Further, importance of several attributes of pricing schemes from users' perspective is compared.

#### *Research Questions and Hypotheses*

In order to the used questionnaire, research questions and hypotheses from section 1.2 are adapted on available data. Additionally, data from the hovercraft trial enable to compare the importance of pricing schemes attributes from users' perspective.

**Research question 1: How do motivational factors affect users' stated preferences regarding price differentiation?**

Individuals' habits are one aspect of motivational factors and thus – as stated in Del 4.1 (Hoffmann et al., 2006) - might influence individuals' dealing with differentiated prices. To examine the effect of habits on stated preferences, users' stated frequency of crossing is considered as an independent variable. Due to the explorative characteristic of the research question, two opposite hypotheses are formulated:

Hypothesis 1a: The more often individuals use means of transport, the more they will prefer undifferentiated pricing schemes. Because high frequent users are more affected by cognitive effort in association with pricing scheme examination, they will more motivate to minimise effort and will more likely tend to prefer simple schemes than low frequent users.

Hypothesis 1b: The more often individuals use means of transport, the more they will prefer differentiated pricing schemes. Potential to minimise transport costs by behavioural adaptation increases with increasing amount of differentiation. High frequent users are more affected by transport cost than low frequent users. Deriving from this, high frequent users will more probable prefer highly differentiated pricing schemes than low frequent users.

To examine these hypotheses, extreme group comparisons is conducted by non-parametric procedures. Extreme groups are built up in order to distribution of crossing frequency and comprise one group of high frequent traveller and one group of low frequent traveller.

**Research question 2: How do situational factors affect users' stated preference regarding price differentiation?**

As stated in Del. 4.1 (Hoffmann et al., 2006), a very important situational aspect is the type of the intended journey as trips range in their value. Commuting trips are higher-value trips and therefore inflexible even when conditions change. Lower value trips such as for occasional shopping or recreation trips will only occur if prices are low (otherwise they forgo them or shift to a cheaper mode or destination), high value trips will occur even if user costs are high (Litman, 2006; Stradling, 2002). Given that commuting trips tend to be less elastic than shopping or recreational trips, commuters will more probable choose simple pricing schemes than individuals who mainly travels in terms of leisure activities. Due to stronger constrains of commuting trips, commuters are less able to adjust their mobility behaviour regarding to aspects of price differentiation. Deriving from this, it is assumed that commuter perceive uncertainty in terms of transport costs by less behavioural options to react to pricing schemes.

Hypothesis 2: Individuals who travel mainly for commuting purposes will prefer more likely less differentiated prices than individuals who travel mainly in means of leisure or shopping.

To test this hypothesis, non-parametric comparison in stated preferences between group of respondents who mainly travel for commuting purpose and group of respondents who mainly travel for leisure / shopping purpose is conducted.

Furthermore, current analyses address following explorative research questions:

**Research question 3: How does age (personal factor) affect users' stated preference regarding price differentiation?**

To examine research question 3, non-parametric ANOVA is conducted, whereas age group is the independent variable and stated preferences is the dependent variable.

**Research question 4: Which are most important attributes of pricing schemes form users' perspective?**

To examine research question 4, non – parametric global comparison (repeated measures) by Friedman – Test within four obtained attributes is conducted.

## *Method*

### Procedure

From 16th July to 28th July 2007 a new hovercraft service between Kirkcaldy and Portobello was arranged on trial basis by Stagecoach. Both Portobello and Kirkcaldy are east of Edinburgh. The journey by the hovercraft service across the Forth takes about 20 minutes – an hour quicker than some bus connection between Kirkcaldy and Portobello. During the 14-days trial more than 32,000 passengers used the Kirkcaldy - Portobello trial service with both commuters and leisure travellers.

At the same time an accompanying online survey was conducted and sought for peoples views on the new service. A web portal was arranged (www.forth-hovercraft.s-and-w.org) whereas participants were polled on their views by an online questionnaire. In addition to this, participants could stated their opinions and experiences in an open blog. During the questionnaire survey 291 complete views were elicited.

### Questionnaire

First part of the online questionnaire comprises some general information on source of awareness about new service, intention to use, preferred infrastructural options to tackle congestion problems and preferred connection points of new service. Furthermore, habits and personal characteristics of users' mobility behaviour are obtained:

- Frequency of crossing the Forth and
- Main purpose of crossing.

The second part of the questionnaire introduces five pricing schemes. The pricing schemes differ in degree of differentiation from undifferentiated to high differentiated (Table 4-1). The participants should consider the possibility that they were able to choose a pricing scheme for the hovercraft service. In doing so they should state which pricing scheme they would prefer and respectively which scheme is most attractive to them. Further, participants' preferences and perceived attractiveness regarding pricing schemes which differ in integration to other transport modes are obtained. Moreover, participants should rate several attributes of pricing schemes regarding their importance. Following attributes were presented:

- Fair,
- Easy to understand,
- Integrated with other modes of transport and
- Simple.

The final part of questionnaire sought for information on participants' age and occupation. Further, the option was given to write personal opinions on the installed hovercraft link.

**Table 4-1: Differentiation of Pricing Schemes**

| Name | Pricing scheme | Differentiation |
|---|---|---|
| **Simple** | Round trip: £ 4.50 | *No (1)* |
| **Frequent traveller** | Round trip: £4.50<br>Week ticket: £25.00<br>Month ticket: £90.00 | *Little (2)* |
| **Time matters** | Time: 6 am - 10 am / 10 am - 4 pm / 4 pm - 7 pm / 7 pm - 9 pm<br>All days: £5.00 / £2.50 / £5.00 / £2.50 | *Medium (3)* |
| **Time and day matters** | Time: 6 am -10 am / 10 am to 4 pm / 4 pm to 7 pm / 7 pm to 9 pm<br>Weekday: £5.00 / £2.50 / £5.00 / £2.50<br>Weekend: £3.00 | *High (4)* |
| **Time, day and age matters** | Time: 6 am -10 am / 10 am to 4 pm / 4 pm to 7 pm / 7 pm to 9 pm<br>Weekday Adults: £5.00 / £2.50 / £5.00 / £2.50<br>Weekday Children: £1.00 / £0.50 / £1.00 / £0.50<br>Weekend Adults: £3.00<br>Weekend Children: £1.00 | *Very high (5)* |

### Participants

Overall, 290 individuals participated in the online survey. The median of the age distribution is in age category "35 to 44 years" (Figure 4-1).

About 40% of participants state that they mainly cross the Forth for leisure / shopping purposes. About slightly more than one fourth of participants (26.9 %) indicate that they cross the Forth for commuting purposes. About 15% of participants mainly cross the Forth because of visiting friends / relatives and slightly more than one tenth (11.4%) because of socialising and entertainment purposes.

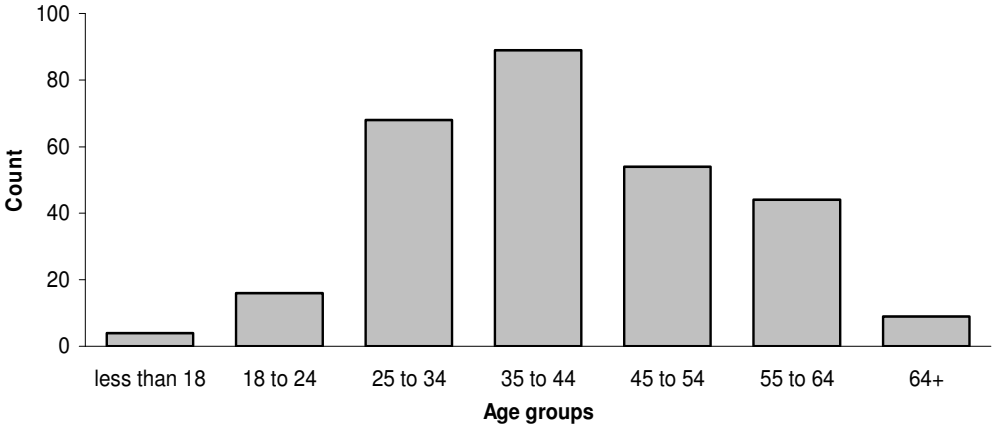



**Figure 4-1: Age Groups of Online Sample**

The frequency distribution of crossing the Forth by the respondents is shown in Figure 4-2. Hence, 21% of participants state that they cross the Forth daily, 39% of participants indicate that they cross the Forth infrequently.

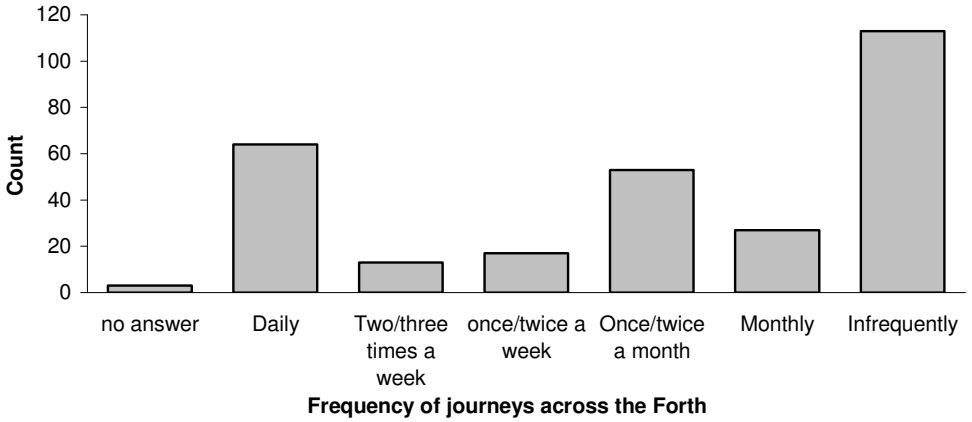



**Figure 4-2: Stated Frequency of Journey of Online Sample**

### *Results*

Overall, considering the preferred pricing schemes for the total sample median of distribution is in answer category “high differentiation” (MD = 4.0, QA = 3.0). The most frequently chosen pricing scheme was the highest differentiated one (41.2 %). Distribution of answers regarding the most attractive pricing scheme shows nearly the same results. Here the highest differentiated scheme was also the most attractive one to the participants (38.3 %).

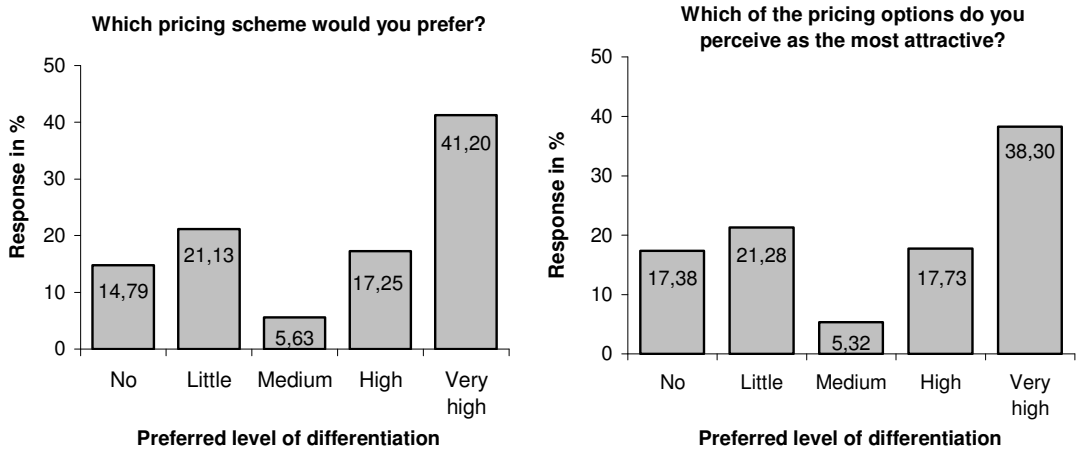



**Figure 4-3: Response Distribution: Stated Preferences Degree of Differentiation**

### Effect of Users' Habits on Stated Preferences

At first extreme group comparison between low frequent users and high frequent users has been conducted. The groups were built up by statistical indicators of frequency distribution (low frequent users: ≤ 25$^{th}$ percentile, high frequent users: ≥ 75$^{th}$ percentile). So, the group of high frequent users contains participants who stated that they cross the Forth two/three times a week or daily (n = 77), whereas group of low frequent users contains respondents who stated that they cross the Forth infrequently (n = 110). Due to the fact of non-Gaussian distributions and unequal sub samples, non – parametric tests (Mann-Whitney-test) have been used.

The results of statistical tests show that high frequent users differ from low frequent users in their preferences regarding degree of differentiation. The mean rank considering preferred pricing schemes was 84.94 within the group of high frequent users and significantly smaller than the mean rank within the group of low frequent users (100.34). According to these results, high frequent users chose less probably high differentiated pricing schemes than low frequent users. The same pattern is given considering the attractiveness of pricing options. High frequent users rated high differentiated schemes less attractive than low frequent users. However, last reported difference was weaker and failed confirmation by significance test.

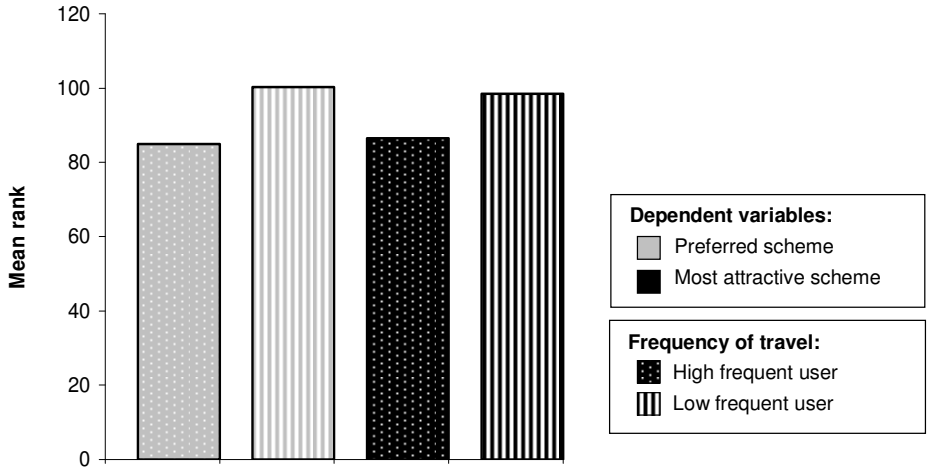



**Figure 4-4: Mean Ranks of Preferences and Attractiveness of Pricing Schemes Depending on Travel Frequency**

**Table 4-2: Tests of Differences _ Grouping Variable: Frequency of Travel**

| | Frequency of travel | N | Mean rank | Sum of ranks |
|---|---|---|---|---|
| Preferred scheme | Low frequent users | 110 | 100.34 | 11037.50 |
| | High frequent users | 77 | 84.94 | 6540.50 |
| | Total | 187 | | |
| Most attractive scheme | Low frequent users | 109 | 98.46 | 10732.00 |
| | High frequent users | 77 | 86.48 | 6659.00 |
| | Total | 186 | | |

| | Preferred scheme | Most attractive scheme |
|---|---|---|
| Mann-Whitney-U | 3537.500 | 3656.000 |
| Wilcoxon-W | 6540.500 | 6659.000 |
| Z | -1.996 | -1.551 |
| Asymptotical Significance (two-tailed) | **.046** | .121 |

a. Grouping variable: Frequency of travel

### Effect of Journeys' Purpose on Stated Preferences

Because of non-Gaussian distributions, hypothesis 2 was also tested by non-parametric statistical methods. The results show that participants who travel mainly in terms of leisure activities rated differentiated pricing option more attractive and preferred them more probably than participants who travel mainly as commuters. The difference for preferences as well as the difference for attractiveness between both groups is statistically significant.

**Table 4-3: Tests of Differences _ Grouping Variable: Main Purpose**

| | Main purpose | N | Mean rank | Sum of ranks |
|---|---|---|---|---|
| Preferred scheme | Commuting | 78 | 83.88 | 6543.00 |
| | Shopping/Leisure | 115 | 105.90 | 12178.00 |
| | Total | 193 | | |
| Most attractive scheme | Commuting | 78 | 83.62 | 6522.00 |
| | Shopping/Leisure | 114 | 105.32 | 12006.00 |
| | Total | 192 | | |

| | Preferred scheme | Most attractive scheme |
|---|---|---|
| Mann-Whitney-U | 3462.000 | 3441.000 |
| Wilcoxon-W | 6543.000 | 6522.000 |
| Z | -2.825 | -2.782 |
| Asymptotical Significance (two-tailed) | **.005** | **.005** |

a. Grouping variable: Main purpose

These results verify hypothesis 2. However, it should be take into consideration that the main purpose of journeys and the frequencies of journeys are obviously interrelated. In case of this sample, commuters state a significant higher frequency of crossing the Forth than respondents who travel mainly in terms of leisure. It is suggested that differences reported above are commonly caused. The differences might be caused – as assumed in sub hypothesis 1 – by more effort in cases of high frequent usage or – as assumed according hypothesis 2 – by fewer probabilities of behavioural adaptations in case of commuting trips.

Further, it should be considered that the pricing schemes used within this case study differ not only in its degree of differentiation but also in overall price. That means that the overall price of the several pricing schemes is not constant. So it might be possible that the highest differentiated scheme is not the most frequent chosen one because of degree of differentiation and the possibility to save money by behavioural adoption but it is the most chosen because it is the cheapest per se.

Anyway, despite the lack of causal conclusions the results also suggest that situational constraints affect the preferences and the perceived attractiveness of pricing options.

### Effect of Age on Stated Preferences

Focussing on the possible effects of age on preferences, response distributions depending on age groups have been compared. As show in Figure 4-5 individuals who are less than 18 years old preferred the high differentiated pricing option uniformly. On the one hand, that is not surprising because one aspect of differentiation is age. On the other hand, the result should be interpreted with caution because of very small sample size of this group (n = 4). Further, results suggest that - from a certain age group - the percentage of preferences for very high differentiated pricing scheme decreases. This trend was only interrupted by age groups of 18 to 24 years old and 25 to 34 years old participants. At the same time, within the age group of 64+ the highest percentage of preference for undifferentiated pricing option has been found.

However, statistical global test of differences in responses distribution has failed statistical confirmation (Kruskal-Wallis-Test, p = 0.148). The group of less than 18 years old participants was excluded from the test because of sub sample size < 5.

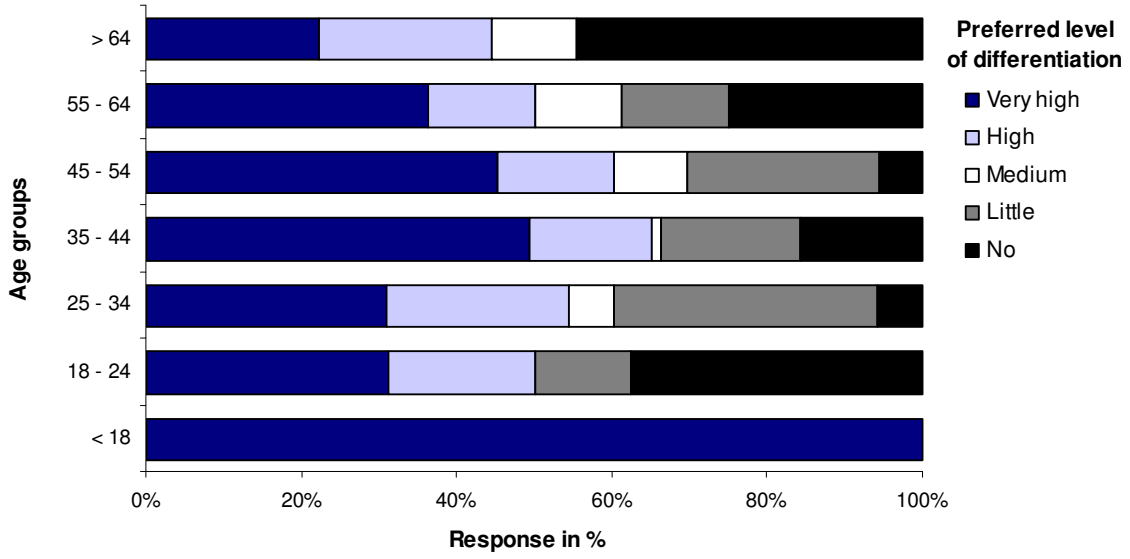



**Figure 4-5: Stated Preferences Depending on Age**

### Attributes of Pricing Schemes

Regarding important attributes of pricing schemes, participants were polled on which are the most important characteristics of a pricing scheme for the new ferry service from their perspective. Each out of four options ("Fair", "Easy to understand", "Integrated with other transport options" and "Simple".) should be rated on a five-point scale from very important to not important. In main tendency, all four attributes were perceived as very important or as important by respondents.

Comparisons between the several attributes show that the integration with other transport options was the most important attribute. 62.7% of respondents stated it is very important to them that pricing schemes integrates also the access to other modes of transport. For 57.7% of participants it is very important that pricing schemes are fair. Further, for 48.2% of respondents the easiness to understand is a very important attribute and 39.8% of respondents perceived simple pricing schemes as very

important. The results of global test between response distributions show that the differences are statically significant (Table 4-4, Friedman-Test, $p \leq 0.01$).

**Table 4-4: Global Comparison - Attributes of Pricing Scheme (Friedman-Test)**

| | Mean rank | | |
|---|---|---|---|
| Fair | 2.38 | N | 271 |
| Easy to understand | 2.52 | Chi - Square | 59.030 |
| Simple | 2.85 | df | 3 |
| Integrated with other transport options | 2.25 | Asymptotical Significance | **.000** |

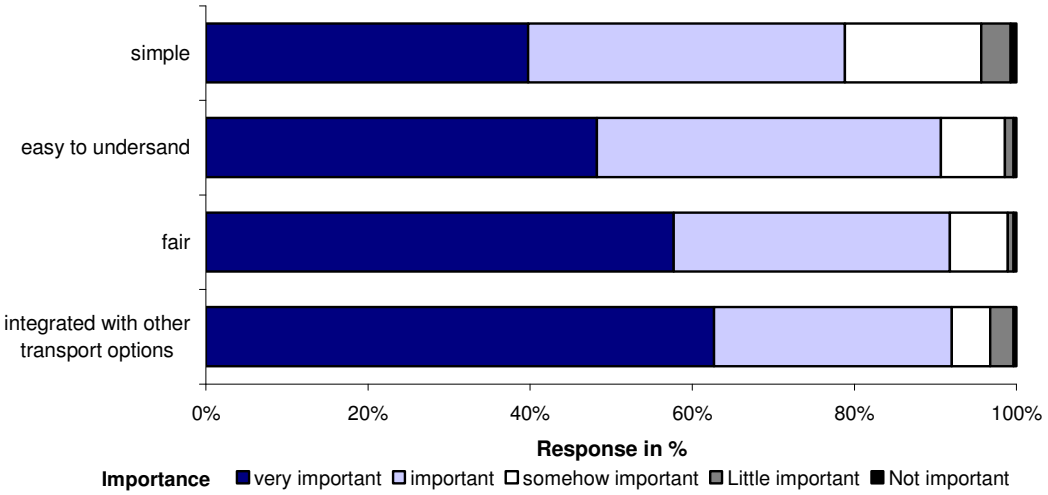



**Figure 4-6: Response Distributions – Importance of Characteristics of Pricing Scheme**

### *Discussion*

The current analyses aim to giving some insights into ferry passengers' perceptions on differentiated pricing. Therefore data from an accompanying online survey of the Kirkcaldy – Portobello hovercraft trial is used. Effects of travel frequency, travel purpose and users age on stated preferences are examined. It has to be acknowledged that self-selection biases are not excludable because the data was collected via Internet. Further, it must be taken into consideration that the examined effects on stated preferences are obviously confounded by price levels and that confounding effects impose considerable restrictions on informative value of the present results.

The results suggest that a majority of participants prefers highly and very highly differentiated prices. These findings are partly contrary to results from other sectors. As mentioned above one reason might be confounding effects of price level on stated preferences. So it is obviously that respondents have been choosing pricing schemes according their needs and, in association to this, according cost minimising principles – regardless to the degree of differentiation. Another possible explanation for the contrary results is that people's perception of the price of the presented hovercraft link differs for instance from people's perception of road charges. Obtained statements to open questions concerning users perception of the new hovercraft link emphasise that users perceive the link as a new, valuable and innovative solution that provides an additional facility to already existing facilities (Wilmsmeier, 2007). That might be an essential difference to the introduction of charges on infrastructure which people used to use for free. So, it seems plausible in cases of additional and innovative perceived facilities that people are more prepared and more motivated to deal even with higher differentiated pricing schemes. Further studies should attempt to decompose the effects of price levels and price differentiation on stated preferences and, beyond this, on users' response towards differentiated pricing.

Statistical test give some hints that users' stated frequency of travel has an effect on their stated preference. Individuals who travel more often prefer less probable highly differentiated prices than individuals who travel infrequently. It might be possible that this effect reflects the motivation of high frequency users to minimise cognitive effort by choice of simple fares. On the other hand it is shown that commuters prefer less differentiated prices more than respondents who mainly travel for leisure or shopping purposes. Due to the interrelation of frequency of journey and main purpose of journey, it seems also plausible that the effect of journey frequency is caused by stronger inflexibility of commuting trips. Considering this, the same as mentioned above holds true: further studies would be useful to decompose causal relation between potential factors which influence responses towards differentiated pricing schemes.

Further, it has been considered whether age has an effect on stated preferences regarding differentiated prices. Although statistical evidences have failed, the response distribution of stated preference depending on age indicates a decrease in preferences towards highly differentiated pricing schemes by age. This result is in line with other results whereby older people appear more likely to have more difficulties dealing with differentiated prices.

### 4.1.2 User Reactions towards Yield Management in the Long-Distance Rail Passenger Sector

#### *Introduction*

This case study investigates the user reactions towards differentiated fares and prices in the rail passenger long-distance sector. The most common form of price differentiation introduced in the rail passenger long-distance sector in recent years is yield management. The general aim of a yield management scheme is optimise capacity provision and use and to maximise average revenues per seat. This management principle was developed and has successfully been applied to the airline industry. Yield management has been introduced in the rail passenger sector in order to respond to increasing intermodal and intramodal competition from low-cost airline and market liberalisation (Sauter-Servaes & Nash, 2007).

The user reactions towards the introduction of yield management so far are mixed. Whereas the attempts to introduce yield management pricing on the long-distance network by the French and German rail operator SNCF and Deutsche Bahn failed due to strong public opposition. Yield management was successfully introduced on selected services such as the French TGV, Eurostar and overnight sleeper trains, the Austrian Sparschiene programme, the Megatrain Service from Stagecoach in the UK (Sauter-Servaes & Nash, 2007). Therefore, the aim of this case study is to explore the underlying reason for these differences in user reactions towards yield management in the rail passenger sector.

In Deliverable 4.1 it has been concluded that differentiated pricing does not per se influence behaviour. Instead behavioural adaptation is constrained by a number of cognitive and motivational factors (Hoffmann et al., 2006). That means transport user reaction is determined by people's ability and willingness to adapt their travel behaviour to differentiated pricing. Previous research has shown that in the rail passenger sector motivational factors are of importance (e.g. Bonsall, Shires, Maule, Matthews & Beale, 2007b). One factor that seemed to be relevant for the reactions towards the introduction of yield management is the perceived freedom of action. In particular the travel flexibility in terms of times and destinations, trip combinations and interruptions enabled by the extensive rail network is regarded as a main advantage/reason for travellers to choose the rail as transport mode. The application of yield management on the other hand introduces new characteristics such as compulsory reservations, commitment to a certain train or high cancellation fees that restrict passengers' travel flexibility and thus their freedom of action. A psychological theory that explains how people react if they perceive their freedom of action as threatened or restricted is reactance theory (Brehm, 1966; Miron & Brehm, 2006). In consumer research wide-spread applications of reactance theory already exist, for example reactance against persuasive communication or promotional influence (Clee & Wicklund, 1980; Lessne & Venkatesan, 1989). Recently studies have shown that financial incentives can also lead to psychological reactance (e.g. Kivetz, 2005; Wendlandt & Schrader, 2007). Thus reactance theory provides a promising theoretical framework to explain the user reactions towards yield management in the rail passenger sector. This theory will be applied to

the introduction of yield management of the Deutsche Bahn AG to illustrate the moderating effect of psychological reactance on user reactions towards differentiated pricing.

This section is structured as follows. In the next section the yield management principle and its application to the rail passenger sector is introduced. Two high-profile yield management schemes are described: *Socrate* by the French railway provider SNCF and *PEP* by the German railway provider Deutsche Bahn AG. It will reveal striking similarities between the design, implementation and failure between the two pricing schemes. Furthermore, the experience from Great Britain which has a fairly long tradition of complex rail fares and Switzerland which takes another path of development is reviewed. Then the theoretical background, the reactance theory, on which this case study is based, will be introduced. Based on the experience in the EU states and the theoretical background in a following section the research questions and hypotheses are formulated. Furthermore, the methods for investigating the research questions will be explained. After a presentation of all results, the section finishes with a discussion and conclusions.

## *Background*

### Yield Management in the Passenger Rail Sector

Rail transport service as product is characterised by high fixed costs of providing service. Furthermore, once it is produced it cannot be stored or otherwise held in stock. That means in order to make profits an increase in the numbers of passengers and an optimal capacity utilisation is a crucial factor. The situation in the rail sector however is, that in peak times trains are overcrowded whereas in off-peak times capacity is underutilised. For example the average capacity utilisation of trains of the Deutsche Bahn AG is only about 40%, but at peak-times, e.g. Friday afternoon; it is sometimes over 160% (Seidel, Wieland, Matthes, & Schlag, 2004). There are no financial or other incentives for travellers to switch to earlier or later trains.

A management principle that has been developed for such services with high fixed costs is yield management. It has been successfully applied in the airline industry since the 1980s (see for example Mitev, 2004). The aim of yield management is to maximise revenues by steering price as well as capacity utilisation. The idea behind is to use people's differences in their willingness to pay for the same service depending on their own particular circumstances. The same service will now be to offer for different prices depending on restrictions that are set to match the personal circumstances of passengers determining their willingness to pay. For example, it is assumed that on a Friday afternoon people are willing to accept higher prices for their journey because at that time it has a higher value for them than the same journey on Wednesday afternoon.

The main characteristics of yield management in the passenger rail sector are:

- Change of fare calculation basis from a distance-based to a point-to point or origin-destination based calculation: In order to consider people's different willingness to pay a change from the current principle of linear unit price (a fixed rate per kilometre) is necessary. That gives the railway operators the flexibility to modulate the price according to the passenger's willingness to pay.
- Customer segmentation with restrictions matching personal circumstances: In order to determine different prices for different customers it is necessary to divide passenger into segments with a different willingness to pay. To do this restrictions for certain types of ticket are introduced that match personal circumstances and thus the willingness to pay of passenger. Examples for such restrictions are compulsory reservations; cancellation fees as well as travel dates that need to include a weekend. Since people are only willing to accept restrictions if they are compensated for it the ticket price will be lower the more restrictions are put on passengers and vice versa. Thus the assumption is that passengers will choose the type of ticket and amount of restrictions associated with it according to their willingness to pay for rail transport service.
- Setting quotas: The amount of tickets in each fare groups, especially discounted fares is restricted by quotas that are calculated on the basis of the segmentation. These quotas are adjusted depending on demand. For example at peak times the amount of discounted fares will be lower in order to utilise the higher willingness to pay for traveller. In off-peak times the amount of discounted fares is higher in order to utilise capacity.

There are however significant differences between the airline and the rail sector. The airline sector is a closed system. The passenger can only board and exit the airplane at the origin and destination. In contrast the rail is an open system. That means, there are a higher number of connections, creating a dense network with several stop between origin and destination. Passengers can board or exit the train at any of these intermediate stops (Sauter-Servaes & Nash, 2007). This creates an exponential number of origin-destination connections for one trip for which fares and quotas need to be managed. Furthermore, railway operators are constrained in setting special price for only segments of the whole trip that do compete with other modes because it may affect the revenue of the whole trip negatively (Antes, Friebel, Niffka & Rompf, 2004). Thus in order to implement yield management in such an open system as the railway operators need to introduce restrictions such as compulsory reservations, commitment to a certain train, high cancellation fees etc. that did not exist before. The question is how users do react to these new fare systems and what explains their reactions.

*France*

The French rail operator SNCF introduced limited price differentiation already in the 1980s. SNCF introduced a simple tricolour calendar that corresponded to three differentiation zones according to time: red for peak periods, white for normal periods and blue for off-peak periods. These periods were determined by passenger counts and ticket sales figure and published yearly. No discounts were available in the red period, some discounts were available in the white period and only in the blue period all types of discounts were available. Further price differentiation was introduced with the opening of the TGV network in the 1980s and 1990s including a special fare for the TGV train (price differentiation according to type of train), compulsory and chargeable seat reservation and different supplements according to the time and the day of travel.

SNCF aimed at extending principle of yield management to the whole long-distance network and not only to include TGVs. In order to this SNCF started in 1989 the project called *Socrates.* The aim was to introduce yield management to maximise revenues, to compete with the airline industry and reposition and prepare SNCF for future intramodal European competition.

The introduction of yield management principle requires detailed information about passengers travel behaviour and price sensitivity in order to implement and change seat quotas and prices dynamically. Thus a new computer reservation system (CRS) called Socrate was developed. The basis for this system was on Sabre, the American Airlines computerised reservation system, which is regarded as the most decisive influential advantage of over competing airlines (Mitev, 2004). The idea was to reproduce the success of yield management in the airline industry and to develop a distribution platform based on yield management that other railways might decide to use as well. It took several years to adapt it to the context of the rail industry and a semi-public sector institution.

In April 1993 the new fare system including the new computer reservation system was introduced in conjunction with the opening of the new Paris-Lille TGV north connection. The implementation however failed due to the spectacular number and types of problems. The new CRS system was not working smoothly, resulting in long queues of angry passengers, online reservations that failed, booked ticket for non-existing trains while other trains ran empty. These events were widely reported the media. The training for sales staff was too short to fully understand the new pricing system and to deal with the new computer interfaces and ticket forms which differed considerably from the original ones. Finally, the staff took the side of the passengers, joined in protest and went on strike by issuing open, unrestricted tickets (Mitev, 1996).

Passenger organisations initiated legal actions against SNCF for the design of the tickets, i.e. not distinguishing between fares and reservation charges, but also against yield management in principle. They argued that this management principle was not in line with the requirements of the public transport law. In August 1994 a compromise was reached after negotiations between SNCF and the passenger organisations. But also the politicians took part in the discussion. For example, the government issues a public hearing.

Finally, SNCF carried out an audit of the new pricing scheme and set up consultative committees with passengers. The audit recommended that commercial optimisation should only be applied to the TGV network and for the time being should be suspended from the rest of the network. Subsequently SNCF reversed its differential pricing policy, reviewed fares and ticketing and simplified the tariffs. These price simplifications and decreases of fares were accounted for 3.5% increase in long-distance

traffic in 1999 and 4.3% increase in revenue (Mitev, 2004). Since that time SNCF has introduced a number of elements of yield management with little resistance from passenger organisation. For example, cancellation arrangements have been restricted for reduced fares up to the point that no reimbursement is offered (SNCF, 2007). Kilometre-based fares are still valid on regional and intercity trains (TER & Corail). However the usage of Corail trains has gradually been reduced in favour of the refurbished and upgraded Corail Téoz trains and the TGV which fares are destination-based and part of the SNCF's yield management. Furthermore, a number of bargains are offered whose number is restricted by quotas (Pfund, 2006).

*Germany*

Since the railway-reform of 1994, the railway market and hence the Deutsche Bahn AG (DB) has undergone a transformation process. The DB was supposed to transform itself from a public enterprise to a privately organized company, which is supposed to maximise and could subsequently be floated on the stock exchange. At the moment, the DB is still a monopolist in long distance passenger railway transport and fully owned by the German State.

Since the end of the 1990s the DB had been ambitiously working on developing a new fare system. They therefore founded the new "Department for Revenue and Yield Management" headed by managers that came mostly from the airline industry. In October 2002 the DB management presented the new fare system PEP[16] with all the details and final prices. Despite negative press reports and the protest of consumer lobbies, advance bookings for tickets started on 1st November 2002 as planned (Seidel et al., 2004). Six weeks later on 15th December, the new fare system was launched.

The key elements of the new fare system were the following (see also Table 4-5):

1. The principle of a fixed price per kilometre was abandoned. The standard price was now based on a declining price curve, i.e. the price per kilometre declines with the distance travelled. This however came only into effect in the case of distances over 200km.
2. The former BahnCard 50, a bonus card which offered a 50% discount on the standard price, was abolished and substituted by the BahnCard 25, which only offers a 25% discount.
3. Passengers could obtain further discounts if they booked in advance and specified a particular train. The discount depended on the time remaining until the journey began.
4. For each segment only a certain quota of tickets was available for each train, i.e. it was possible that even when there were more than 7 days before the planned trip the segment with the 40% discount was already sold out. Tickets for the standard price without any discount were always available.
5. A cancellation fee of € 45 was payable if someone wanted to use a different train than the one specified in the advance booking. This cancellation fee was also applicable when someone missed his train and wanted to take the next one. In addition to this, he or she was also obliged to pay the difference between the price of the discounted ticket and the full standard price.

A new feature was that all different kinds of discounts could be combined, which could ideally lead to discounts of up to 73% on the standard price, when travelling in a group. This was communicated by the DB marketing. However, many conditions needed to apply and the discount system seemed to be too complex for most people to understand (see Table 4-5 for a comparison of the old and new fare system).

[16] PEP – German abbreviation Price and Revenue Management for Passenger Transport

**Table 4-5: Comparison of the Different Fare Systems of the Deutsche Bahn AG**

| | Old fare system | New fare system | Revised fare system |
|---|---|---|---|
| BahnCard 50 | 140€ | abolished | 200€, no combination with other discounts |
| BahnCard 25 | - | 60€, combination with other discounts possible | 50€, combination with other discounts possible |
| Advanced booking | - | Specification of a particular train for round trip<br><br>10% discount / 1 day<br>25% discount / 3 days<br>40% discount / 7 days + needs to include a weekend | Specification of a particular train for round trip<br><br>25% discount / 3 days<br>50% discount / 3 days + needs to include a weekend |
| Cancellation fees | - | 45€[a] + price difference to the new ticket | 45€ + price difference to the new ticket |
| Fellow passengers | 50% discount for up to 4 fellow passengers | 50% discount for up to 4 fellow passengers,<br>also in combination with P&S[b] and BC[c] | 50% discount for up to 4 fellow passengers,<br>also in combination with P&S and BC |
| Quotas | - | at least 10% for P&S | at least 10% for P&S |

[a] the cancellation fee was reduced to 15€ soon afterwards
[b] P&S = advanced booking fare called Plan & Spar
[c] BC = BahnCard

The new fare system of the DB the new system met with substantial opposition from the public, passenger associations. They did not assess the new fare system as being very effective in improving railway services and offering incentives to travel by train. Furthermore, the launch of the system coincided with many other negative events from a customer's point of view. At that time the DB was faced with other problems and controversial decisions such as rising delays and cancellations due to the largest change in the general time table for 10 years, bad weather conditions, the abolishment of the regional trains "Interregio", the abolishment of dining-cars, etc. These problems were perceived as more urgent than a new fare system. The perception of the passengers was that an already non-transparent fare systems was changed to yet another one but with additional restrictions (Matthes, Wieland, & Seidel, 2004).

The investigations by different passenger or consumer organisations such as "ProBahn" or "Stiftung Warentest", confirmed this negative perception. They found out in independent and repeated tests that the DB service staff was not able to recommend or sell the cheapest fare in combination and/or the most comfortable connection for the passengers needs (VCD, 2003, 2004).

These investigations as well as the new fare system as such received intense media attention. The DB AG itself employed a very controversial information policy before and during the implementation process contributing to the overwhelming negative press reporting (Seidel et al., 2004). One of the debatable decisions was to restrict TV reporting on the launch day. About 60-70 TV camera teams asked for accreditation for filming at the railway stations on this day, but the DB only gave two camera teams permission. This ban led to great indignation on the part of the journalists.

The economic success of the new fare system failed to appear. The sales figures of the first quarter in 2003, three months after the launch, differed from those which had been desired. The turnover declined by 13.1% compared to the same months in the previous year. Furthermore, about 7 % fewer passengers were reported for long distance train transport during the first three months of 2003 and this figure remained the same for the mid-year report (Deutsche Bahn AG, 2003).

The DB management however announced not to make any changes after a trial period from at least one year. Finally the government felt obliged to intervene (even though it had been declared at the time of privatisation that the purpose of the formal privatisation was to give the DB more entrepreneurial freedom). For example, senior politicians disputed with the CEO via the media.

Furthermore in May 2003 a public hearing of the Commission for Consumer Protection of the German parliament took place.

Finally, revisions of the new fare system were announced; for example the re-launch of the BahnCard 50 and the reduction of cancellation fees (see Table 4-5). Overall the DB AG redesigned the fare system based on two classes of fares in principle (Ehrhardt, 2003). The first class of fares was still based on the principles of yield management, but simplified. Now there were only two types of advanced booking fares with the same time period. These fares were targeted at less frequent and leisure travellers. With the reintroduction of the BahnCard 50 the DB AG opened up a second class of fares which were targeted at frequent travellers. With the BahnCard 50 passengers could again get a discount on the standard fare and be flexible. Since the BahnCard 50 could not be combined with advanced booking discounts a boundary was set between the two classes of fares. That means passengers (Ehrhardt 2003). The launch of the revised fare system on 1st August 2003 put an end to the public discussion about the DB's fare system and the topic vanished from the agenda. Surveys indicate that the majority of train users perceived the revised system as an improvement (Matthes et al., 2004).

Another consequence of the PEP introduction was a change of the communication policy of the Deutsche Bahn AG. One major criticism was the lack of consultation with passengers and passenger organisations within the design process of the new fare system. Thus, in 2004 the DB AG set up a passenger panel consisting of business and leisure travellers. The aim was to provide immediate customer feedback of existing and planned developments within the DB's passenger sector.

#### *Great Britain*

In the UK the national rail operator British rail has been privatised already in 1993. Since then certain fares (mostly commuter season fares) are regulated whereas standard fares are not (Hatano, 2004; Whelan, Toner, Shires, Batley, Wardman, and Nash, in press). While average fare prices have changed little since privatisation, there are substantial differences between the types of fares. The price of open fares with no restrictions concerning day or time of travel has risen sharply. Saver fares are discounted fares for off-peak periods but available right up until the time of departure. These fares have been regulated and the price remained constant. However, in recent times franchise operators have changed the definition of off-peak periods making them a much smaller "window" of the day. Passenger associations blame rail operators to undermine the regulation and usefulness of these fares for passengers in this way (House of Commons Transport Committee, 2006a). In contrast, there has been rise in the amount of advance purchase fare, particularly on long-distance rails. In comparison before privatisation the fares structure within a rail operator as well as between rail operators have been more complex. That is because especially in the long-distance sector rail operator make heavily use of yield management techniques.

Passenger reactions appear to be mixed. On the one hand rail traffic has increased by 40% in the years since privatisation. The numbers of passengers has increased significantly as well as the frequency of trains (House of Commons Transport Committee, 2006b). Furthermore passenger surveys show that the overall satisfaction with long-distance services is rather high. On the other hand passengers rate the value for money in the long-distance sector rather low (Passenger Focus, 2007b). Furthermore, research conducted by passenger organisations indicates that passengers often do not feel to get the best value ticket, because of the variety and complexity of fares structure, a feeling that was more pronounced among commuter and business travellers compared to leisure travellers (Passenger Focus, 2006a, 2006b).

The House of Commons Transport Committee launched an official investigation into the fare policy of railway operators (House of Commons Transport Committee, 2006a). The report concludes that in particular the structure of the fare system is too complex and especially the quotas are not transparent. Furthermore, flexible fares are overpriced or increasingly restricted. The House of Commons asked for a stricter regulation and a cap of open fares. As a response to that investigation the British government announced negotiations with train operators to simplify and harmonise the fare systems but on a voluntarily basis. However, no changes in the institutional or legal framework are envisaged (House of Commons Transport Committee, 2006b). In summary, the fare systems of British rail operators seems to develop from a sophisticated level based on yield management back to more simple and harmonised systems in order to accommodate customer needs (see Passenger Focus, 2007a for recommendations).

#### *Switzerland*

Another path of development is taken by the Swiss rail operator SBB. In a comparison of the fare system of the SBB and other European fare systems the SBB concludes that their network and service is not suitable for the introduction of yield management (Pfund, 2006). The SBB network is smaller and thus the distances between cities are smaller as well. Thus the SBB network is more comparable to an S-train system with high frequency aiming at frequent travellers. The current and future fare system takes this characteristic into account. It is tailored to the needs of frequent travellers. That means, the standard fares are relatively high though not highest in Europe. However, the threshold for a discount card is lowest. Consequently the usage of travel card offering 50% discount and a network-wide travel card is highest in Europe. SBB concludes that the characteristics of the rail network and type of service and passengers using the rail, mostly frequent travellers is not suitable for introducing yield management in the Swiss national rail network. Thus for the national rail sector SBB will not introduce compulsory reservations and price differentiation according to time in the near future (Pfund, 2006).

### The Theory of Psychological Reactance

The starting point of reactance theory is the observation that people strive for behavioural freedom. Behavioural freedom in this context means that their relevant behavioural options could be potentially implemented (Brehm, 1966). These options constitute the individuals' freedom of action. That means behavioural freedom is a subjective concept, it describes how much freedom a person perceives to have. In this respect reactance is comparable with other psychological control concepts such as perceived behavioural control (Ajzen, 2001) or self efficacy (Bandura, 1997).

If the freedom of action is threatened or restricted, an individual will experience psychological reactance. Reactance is an intense adverse motivational state. Reactance has strong motivational properties and leads to attempts to restore one's behavioural freedom. An important prerequisite for the development of reactance is that people perceive the threatening of their behavioural freedom as unfair, unjust or unreasonable. If, however, the restrictions are logical or otherwise made plausible less no reactance is predicted (Miron & Brehm, 2006).

The restoration of behavioural freedom can be done in very different ways. Reactance theory distinguishes between direct and indirect ways. Direct actions to restore the threatened behavioural options are the most effective way of reducing reactance. However, it is assumed that reactance is reduced more likely through indirect reactions because of situational and social constraints that restrict direct behavioural reactions. The first option for an indirect way of reducing reactance is restoration by implication. This means an indirect restoration of perceived behavioural freedom by refusing to act, watching others restoring the freedom or motivating others to restore freedom. Another possibility to reduce reactance is anger or hostility towards the person, institutions or situation that threatens behavioural freedom. It is believed to be an emotional vehicle that reduces reactance. The last option is cognitive reorganisation in a way that the eliminated alternatives are evaluated more positively whereas the alternatives that one is forced to take is evaluated more negatively. Thus by preferring the eliminated over the new or remaining behavioural alternatives behavioural freedom is restored indirectly.

In consumer research wide-spread applications of reactance theory already exist, for example reactance against persuasive communication or promotional influence (Clee & Wicklund, 1980; Lessne & Venkatesan, 1989). Recently studies have shown that financial incentives can also lead to psychological reactance (e.g. Kivetz, 2005; Wendlandt & Schrader, 2007). Thus reactance theory provides a promising theoretical framework to explain the user reactions towards yield management in the rail passenger sector.

## *Research Questions and Hypotheses*

So far two examples of a network-wide implementation of yield management in the long-distance rail passenger sector have been described, the Socrates project of the French railway operator SNCF and the new fare system PEP of the German railway operator Deutsche Bahn AG. In both cases passengers did not react as planned. Thus this case study investigates why passengers did not accept yield management principles in the long-distance passenger rail sector.

**Research Question 1: How do rail passengers react towards yield management in the long-distance sector?**

Hypothesis 1: Rail passengers will perceive the new fare systems as restrictions of their perceived behavioural freedom and react with psychological reactance.

In order to implement yield management in a railway system restrictions are necessary such as compulsory reservations, commitment to a certain train, high cancellation fees etc. A number of passengers however perceive these restrictions as unjustified restrictions of their behavioural freedom. It conflicts with their perception of the rail as a flexible transport mode and perception of rail operators providing public service. Thus they will react with direct and indirect actions, hostility or cognitive strategies in order to restore their threatened behavioural freedom.

**Research Question 2: Which are the main characteristics of the new fare system that caused the negative reactions from passengers?**

Hypothesis 2: The restrictions set by the railway operator to implement yield management principles will have the biggest impact on passenger's reactions compared to other elements of the new fare system.

In line with the predictions of reactance theory it is hypothesised that the restrictions on travel flexibility will be perceived by passengers as threat to their behavioural freedom. Thus they will have the biggest impact on passenger's reaction compared to other elements of the new fare system.

**Research Question 3: Are there any situational characteristics that cause the reaction towards yield management?**

Hypothesis 3: Frequent travellers will react more strongly towards yield management than less frequent travellers.

Travel mode choice and subsequent travel behaviour was found to be habitual in nature (e.g. Aarts & Dijksterhuis, 2000). That means passengers choose the time and day of travel that has proven to be successful in the past. Thus it is hypothesised that frequent travellers have stronger rail travel habit. Therefore, they react more strongly with psychological reactance towards restrictions of behavioural freedom, since that requires a change of their travel habit. Habits and travel habits in particular are rather stable behavioural dispositions once they have been developed (see for example Verplanken, Aarts, & van Knippenberg, 1997).

## *Method*

This section describes the methods that were used to investigate psychological reactance in response to the introduction of yield management of the Deutsche Bahn AG.

### Questionnaire and Procedure

A questionnaire study was conducted in January and February 2004 with 460 participants. A standardised questionnaire was administered consisting of three parts (see Gehlert, Francke, & Schlag, 2007 for details). The Ratings were obtained on a five-point scale from -2 (strongly disagree) to +2 (strongly agree).

In the first part of the questionnaire the participants were asked about their opinion in respect of relevant characteristics of the new pricing scheme. A pilot study analysing the complaints brought forward to the passenger association PRO BAHN revealed the most controversial characteristics of the new scheme (PRO BAHN, 2002/2003). These were: i) the advanced purchase requirements for discount tickets, ii) the high rebooking and cancellation fees and iii) the abolishment of the BahnCard 50.

The second part of the questionnaire measured psychological reactance. Since there are no existing scales measuring psychological reactance as reaction towards a specific situation existing scales

measuring psychological reactance as personality trait were used (Dowd, Milne, & Wise, 1991; Hong & Faedda, 1996; Merz, 1983). These scales were reformulated to reflect the characteristics of the new pricing scheme and the possible user reactions towards it.

Theory of reactance distinguished between direct behavioural effects and indirect subjective reactance effects. It is assumed that psychological reactance is reduced more likely through indirect subjective reactions because of situational and social constraints that restrict direct behavioural reactions. Therefore, the items of the questionnaire focus on indirect subjective reactance effects. Here the theory describes two possible reactions, aggression and hostility or changes in the attractiveness of the object. The results of the pilot study point in the direction of a diffuse aggression of the passengers as reaction towards the new pricing scheme. Therefore, the items of the questionnaire measure psychological reactance as aggressive tendency towards the new pricing scheme.

The third part of the questionnaire consisted of questions concerning the attitude towards rail and the Deutsche Bahn AG, private cars, the old and the new pricing scheme as well as the perceived knowledge of rates and prices. In addition questions about the socio-demographic characteristics and travel patterns were included.

#### Sample Characteristics

On average the participants were 28.0 year (Min: 18 years, Max: 80 years). The majority of participants ranged between 21 and 30 years (70%). The study consisted of 257 female and 203 male participants. 62.6% of the participants were pupils, apprentices or students, 25.2% were employees. The remaining participants were retired, self-employed, unemployed, civil servants or homemakers. The monthly net income was below 1'000€ for almost half of the sample (45.4%). The majority of this low income group consisted of students, pupils and apprentices (91.5%). Participants indicated leisure activities (45.7%) and private affairs (24.4%) as the most prominent reasons for rail travel. Business trips were mentioned from only 13.0% of the participants. More than half of the sample had permanent access to a private car in their household (56.5%) whereas 43.4% had only temporarily or no access. 29.8% of the participants possessed a BahnCard, an annual discount card.

In summary this sample consists mainly of students who use the train for private and leisure trips. Even though this sample is not representative for all passengers of DB, it is a highly relevant target group. The price-sensitive private passengers to which young passengers with low-income and low car availability belong compose the largest passenger segment with a share of 33%. Furthermore, it know that with the old fare system only 1.6% of the regular customers, such as the ones with the BahnCard, undertook 39% of all trips (Ehrhardt, 2003).

### *Results*

#### Empirical Structure of the Questionnaire

In the first step a factor analysis was conducted to confirm the theoretical assumptions on which the questionnaire was based using principal component analysis and varimax rotation. The analysis resulted in six factors:

Psychological reactance: All items representing diffuse aggression against the new pricing scheme loaded on this factor.

1. Positive attitude towards the DB AG: This factor unified the items asking about the attitude towards the rail, private cars, and the Deutsche Bahn AG in particular.
2. Problems with the advanced purchase requirements: This factor combines all items about the passenger's problems with the advanced booking requirements and the restrictions to a certain train.
3. Problems with rebooking and cancellation fees: Again, this factor combines all items about the passenger's problems with the rebooking and cancellation fees.
4. Old pricing scheme preferred: This factor consists of the statements that the abolishment of the BahnCard 50 was a mistake and the old pricing system was better.

5. Price-sensitive but uninterested customer: This factor includes statements that the rail is too expensive and that no rail pricing scheme satisfied the passenger. Furthermore, it also included an item about the BahnCard 50, stating that the type of pricing scheme does not matter, as long as the BahnCard 50 is in place. Apart from value for money for tickets, there is no further interest concerning the DB AG.

The factors "psychological reactance", "advanced purchase requirements" and "problems with rebooking and cancellation fees" were the ones that represented the underlying theoretical structure best. Interestingly, the data revealed no single BahnCard factor as predicted. Instead one BahnCard item was assigned to the factor "old pricing scheme preferred" whereas the other one is assigned to the factor "price-sensitive but uninterested customer". That illustrates the hybrid character of the BahnCard 50. First, it represents the old pricing scheme, which was perceived as allowing for travel flexibility at any time combined with good value for money. Second, in particular frequent travellers have received indeed considerable discounts with the discount card.

Table 4-6 describes the descriptive statistics for the extracted factors. The results indicate the tendency to agree with the items expressing psychological reactance, problems with the advanced purchase requirements as well as the rebooking and cancellations fees. Furthermore, on average the old pricing is preferred and the participants describe themselves as price-sensitive, but uninterested customers. The participants do on average not agree with a positive attitude towards the DB AG. The psychometric quality of the scales is satisfactory. Only the two factors "old pricing scheme preferred" and "price-sensitive but uninterested customer" exhibit internal consistencies below .50. These two factors are less grounded in reactance and yield management theory which may explain the lower quality. However, since these factors represent important features of the passenger reaction they are included in further analyses.

**Table 4-6: Variables and their Descriptive Statistics**

| | No. of Items | Internal consistency $\alpha$ | M (SD) | Cumulative explained variance |
|---|---|---|---|---|
| Psychological reactance | 5 | .74 | 0.47 (1.08) | 18.8% |
| Positive attitudes towards the DB Bahn AG | 6 | .74 | -0.03 (1.17) | 32.2% |
| Advanced purchase requirements | 4 | .72 | 0.25 (1.28) | 39.0% |
| Old pricing scheme preferred | 2 | .32 | 0.77 (1.09) | 44.4% |
| Price-sensitive but uninterested customer | 3 | .32 | 0.58 (1.10) | 49.4% |
| Rebooking and cancellation fees | 2 | .51 | 1.06 (1.05) | 54.2% |

Note: Ratings were obtained on a five-point scale from -2 (strongly disagree) to +2 (strongly agree)

### Reactance as User Reaction towards Yield Management

In the next step it has been analysed whether the characteristics of the new fare system can predict psychological reactance towards it and how this relationship might be moderated by the attitude towards the DB AG. A multiple linear regression analysis has been conducted with psychological reactance as dependent variable and the four characteristics of the new fare system as independent variables. Table 4-7 presents the results.

**Table 4-7: Stepwise Multiple Regression with Psychological Reactance as Dependent Variable**

| Predictor variables | $R^2$ | B | $\beta$ |
|---|---|---|---|
| Advanced purchase requirements | .17 | .24** | .29 |
| Rebooking and cancellation fees | .26 | .24** | .28 |
| Old pricing scheme preferred | .28 | .15** | .15 |
| Price-sensitive but uninterested customer | .30 | .14** | .13 |
| Constant term | | -.05 | |

*F* total = 48.19**; *df* = 4/455; ** = $p < .01$;

The results show that psychological reactance increases if:

- Participants have problems with the advanced purchase requirements and the rebooking and cancellation fees,
- evaluate of the old pricing scheme positively and
- describe themselves as price sensitive, but uninterested customer.

These variables explain 30% of the variance. As expected the main characteristics of yield management, the advanced purchase requirements and the rebooking and cancellation fees, contribute most the development of reactance.

Furthermore, it was hypothesised that the attitude towards the Deutsche Bahn AG might moderate the relationship between the new pricing scheme and psychological reactance. That means, participants who hold a positive attitude towards the DB AG are expected to show less reactance that participants with a negative attitude. However, the results show highly significant relations between the characteristics of the new fare system and psychological reactance even if the attitude towards the DB AG is taken into account (see Table 4-7). That means participants exhibit an equal level psychological reactance as a result of the new fare system if their attitude towards the DB AG is taken into account (see Table 4-8).

**Table 4-8: Partial Correlation of Attitude toward the DB between the New Fare System and Psychological Reactance**

| Predictor variables | Correlation with reactance (*r*) | Partial correlation with reactance (*r*) |
|---|---|---|
| Advanced purchase requirements | .41** | .43** |
| Rebooking and cancellation fees | .25** | .30** |
| Old pricing scheme preferred | .19** | .13** |
| Price-sensitive but uninterested customer | .41** | .41** |

** $p < .01$

### Motivational Factors

Travel habits have been identified as important variable moderating the impact of differentiated charging and behavioural adaption. That means passengers choose the time and day of travel that has proven to be successful in the past. Thus it is hypothesised that frequent travellers have stronger rail travel habits. Therefore, they react more strongly with psychological reactance towards restrictions of behavioural freedom, since that requires a change of their travel habit. Even though this sample consists mainly of participants that use rail rather often compared to the general public there are differences in usage of the rail. This becomes apparent with regards to the percentage of participants holding a BahnCard, the travel discount card. It is assumed that BahnCard holders are more frequent travellers, since the travel card is only beneficial if the saving outweigh the price. This needs a certain amount of trips. In the sample there are 137 BahnCard holders (29.8%) and 328 (72.1%) participants that did not possess a BahnCard.

Table 4-9 presents the descriptive results for both groups. There are significant differences in the reaction towards yield management between both groups. Compared to participants without a BahnCard, BahnCard holders:

- are significantly more positive towards the DB AG,
- have more problems with the advanced purchase requirements,
- prefer the old scheme more strongly, and
- describe themselves as less price sensitive, but uninterested.

There are no significant difference between the two groups in psychological reactance and the problems with the rebooking and cancellation fees. Thus there are differences in the evaluation of the new fare system. Psychological reactance however is developed in the same way.

**Table 4-9: Difference between BC and non-BC Holders**

| Variables | BC | M | SD | df | F | p |
|---|---|---|---|---|---|---|
| Psychological reactance | Yes | 0.55 | 0.84 | 1 | 2.31 | n.s. |
| | No | 0.44 | 0.72 | | | |
| Positive attitude towards the DB AG | Yes | 0.62 | 0.65 | 1 | 190.93 | .00 |
| | No | -0.30 | 0.66 | | | |
| Advanced purchase requirements | Yes | 0.57 | 0.87 | 1 | 24.25 | .00 |
| | No | 0.11 | 0.94 | | | |
| Rebooking and cancellation fees | Yes | 1.00 | 0.91 | 1 | 1.07 | n.s. |
| | No | 1.09 | 0.83 | | | |
| Old pricing scheme preferred | Yes | 1.07 | 0.78 | 1 | 31.41 | .00 |
| | No | 0.64 | 0.74 | | | |
| Price-sensitive but uninterested customer | Yes | 0.27 | 0.75 | 1 | 42.62 | .00 |
| | No | 0.72 | 0.65 | | | |

Note: BC = BahnCard

### Other Reactance Effects

Reactance theory predicts not only emotional reactions such as anger and hostility towards perceived restrictions of behavioural freedom. Further reactions are predicted:

1. Direct actions: This is the most effective way of reducing reactance. In the case of rail passengers could switch to alternative modes of transport such as private car or air. And indeed the sales figures of the first quarter in 2003, three months after the launch, were different than those which had been desired. The turnover declined by 13.1% compared to the same months in the previous year. Furthermore, about 7 % fewer passengers were reported for long distance train transport during the first three months of 2003 and this figure remained the same for the mid-year report.
2. In the survey participants were asked retrospectively whether or not they have changed their rail travel behaviour after the introduction of the new fare system. 31.4% of the participants stated to have travelled less with rail after the introduction of the new fare system, 65.3% have stated no changes and 3.5% stated to have travelled more. Given the fact that this sample consists of mainly students with limited alternatives the share of participants using the rail less often of one third is remarkable.
3. Restoration by implication: This means an indirect restoration of perceived behavioural freedom by refusing to act, watching other restoring the freedom or motivating other to restore freedom. In particular the role of the media and the passenger associations could be seen in this perspective (Seidel et al., 2004). They have presented themselves as advocates of the passengers, actively protesting against the new fare systems.
4. Cognitive strategies: The last option is a cognitive reorganisation in a way that the eliminated alternatives are evaluated more positively. Thus by preferring the eliminated over the new or remaining behavioural alternatives behavioural freedom is restored indirectly. The BahnCard 50 that was abandoned and shortly afterwards reintroduced could serve as indicator for changes in attractiveness. And indeed in the first two days of the revised system's implementation the DB sold more than 50,000 reintroduced BahnCards 50 to customers.
5. The survey results confirm the increase in attractiveness of the BahnCard 50 as well. Participants that regularly used a BahnCard 50 were asked whether they have bought a BahnCard50 before it was abandoned and whether they have bought one after it was reintroduced. 37% of the participants still bought a BahnCard 50 before it was abandoned and 21% bought a BahnCard 50 right after its reintroduction.

## *Discussion*

This case study has described user reactions towards the network-wide introduction of differentiated charging in the long-distance passenger rail sector in the form of yield management. The experiences

from the French and German railway providers SNCF and DB AG clearly demonstrate that passengers and in particular frequent travellers did not accept yield management and did not adapt their behaviour to it.

Rail managers wanted to adapt the principles of yield management and the success from the airline industry to rail sector. Consequently they also brought the airlines knowledge in with SNCF buying the American airlines computerised reservation system and DB AG with hiring former Lufthansa managers. The rail manager assumed that people are already used to the principles of yield management through the airline industry.

There are however significant differences between the airline and the rail sector. In comparison to the airline rail is an open system. That means, there are a higher number of connections, creating a dense network with several stop between origin and destination. Passengers can board or exit the train at any of these intermediate stops.

In order to implement yield management in such an open system the railways introduced artificial boundaries such as compulsory reservations, commitment to a certain train, high cancellation fees etc. Passengers however perceived these boundaries as unjustified restrictions of their behavioural freedom. It came in conflict with their perception of the rail as a flexible transport mode and perception of rail operators providing public service. Psychological reactance theory provided a sound theoretical framework to explain the passenger's reactions.

Based on the experience with the network-wide introduction rail operators are implementing yield management more carefully, often starting with all-reserved service such as high speed services like the overnight sleeper trains. Examples are SNCF's TGV and EuroStar or the Austrian National Railroad's (ÖBB) SparSchiene (Sauter-Servaes & Nash, 2007). These services are accepted by passengers as well as economically successful.

There are two possible reasons why these services have been accepted. First, compared to the whole rail network they are more comparable to the airline sector where yield management stems from. First, there are fewer connections and fewer intermediate stops limiting the potential complexity of a yield management system. Furthermore, the services complement the standard rail service rather than compose it. Thus they aim more strongly at leisure and less frequent travellers who are able and willing to determine their train and departure in order to get a discount.

## 4.2 CONCLUSIONS FROM THE RAIL AND FERRY PASSENGERS SECTOR

Knowledge about user responses and users reactions towards differentiated pricing is not transferable across transport sectors in a simplified manner. Unique characteristics and, thus, specific perception by users of a certain mode of transport should be taken into consideration.

Characteristics of pricing schemes which restrict passengers' travel flexibility and thus their (perceived) freedom of action induce unacceptability, reactance and lead to failure of behavioural adaptation.

Passengers' travel habits and situational aspects of journeys like mean purpose of travel affect their preferences of pricing schemes. Particularly, high frequent travellers and commuters were more likely to prefer simple schemes. However, it remains unclear whether these effects are determined by motivation to minimise cognitive burden or by perceived inflexibility to respond according differentiated prices. Hence, further studies would be useful to decompose causal relations between independent variables.

Overall, only a few previous studies considering passengers responses towards differentiated pricing are conducted and respectively available. For a better understanding of user responses towards pricing it seems essential to intensify research activities not only concerning car sector but also concerning passenger sector and its several fields (Ship / Ferry, Railroad, Aircraft etc.).

# 5 SYNTHESIS AND CONCLUSION

## 5.1 OVERVIEW

In the transport sector differentiated pricing is increasingly used to influence behaviour in order to manage users' demand for infrastructure capacity. However, there is a likely conflict between the theoretical desirability of highly differentiated pricing structures and the ability and the motivation of users to respond effectively to them.

The aim of this report is to explore a) which are (some of) the relevant psychological factors that determine the relationship between price differentiation and user reaction, and b) up to what degree of complexity are people able and willing to understand and to respond to differentiated transport charging structures.

Based on the theoretical background, several hypotheses and research questions concerning cognitive, motivational, personal and situational factors on users' responses have been formulated. To test assumptions, data from 10 case studies have been analysed, whereby user responses within the car driver sector, freight operator sector and passenger sector (ferry and railroad) have been considered. According to the empirical results, conclusions are deduced and, finally, based on these conclusions, recommendations for effective introduction of differentiated pricing schemes are given.

Results from field experiments and surveys emphasise that the degree of differentiation affects users' information processing and thus their handling of differentiated pricing. Further findings from the case studies suggest that motivational factors, particularly concerning the acceptability of pricing measures, affect people's likelihood and willingness to respond towards differentiated charges. Furthermore, the relationship between acceptability and user responses seems to be moderated by situational factors and users' perception of these factors. These results indicate the importance of the provision of opportunities to respond adequately to charging schemes by users. Hence, the effectiveness of charges will strongly depend on whether people perceive that they are able to adapt their behaviour and whether they will perceive a supportive situation. Otherwise, if users perceive restrictions on their travel behaviour and / or restrictions of their freedom of action by charging schemes, undesirable and contrary effects like reactance and failure of behavioural adaptation will become probable.

Regarding the impact of degree of price differentiation (spatial and temporal) on behavioural responses almost identical results appear within the three laboratory experiments. The time to calculate the charges for using a specific road, errors in this calculation as well as perceived difficulty of the differentiated schemes and uncertainty about correct price estimation increase drastically with increasing level of differentiation. So far, it can be confirmed that differentiated pricing structures affect user responses. Moreover, the results from experiments indicate that besides cognitive also motivational factors have impacts on user responses towards differentiated prices. Some contrary findings remain unexplained, but it appears that, especially in case of highly differentiated prices, a positive attitude towards road pricing improves the handling of the charging schemes.

Although results do not provide direct evidence regarding effects of the degree of differentiation on users' responses towards pricing schemes, they however indicate important influences of cognitive and motivational aspects on users' handling of differentiated pricing schemes and how these psychological aspects moderate user responses towards differentiated prices. Additional data would help to clarify some of the outstanding questions.

Table 5-1 provides a summarised overview about empirical findings across case studies and experiments presented within this report.

**Table 5-1: Overview about Empirical Findings across Case Studies and Experiments**

| CASE STUDIES | Main hypotheses (Price signal→Response) | Sub-hypotheses | | |
|---|---|---|---|---|
| | **Price signal→behavioural adaptation (Price signal→stated preferences) (Price signal→examination)** | **Cognitive factors** | **Motivational factors** | **Situational and personal factors** |
| 1 AKTA road pricing experiment | • Modus of payment → behaviour<br>• Differentiation → behaviour<br>• Modus of Payment → acceptability | | • Acceptability → behaviour | • Gender → acceptability<br>• Income → acceptability |
| 2 Newcastle survey | • No. of charge levels, No. of zones, distance based elements → perceived complexity<br>• Differentiation → behaviour<br>• No. of time periods → perceived complexity | • Experiences → perceived effectiveness<br>• Experiences → behaviour<br>• (Hints to disadvantages of differentiation that is not in line with principles of easy human information processing – distance based elements, elements which are cross linked to each other) | • Fairness → behaviour<br>• Fairness → perceived easiness<br>• Attitudes (towards cost) → willingness to pay<br>• Attitudes(towards costs) → behaviour<br>• (Engagement → behaviour) | • Need to evaluate, Tolerance of ambiguity → behaviour<br>• Income, education → behaviour<br>• Gender, age → behaviour<br>• Type of trip → willingness to pay<br>• Education, Age, Gender → perceived difficulty |
| 3 Edinburgh demonstration trial | | | • Acceptability → behaviour<br>• Problem awareness → behaviour<br>• Personal involvement → behaviour | • Destination of trips → behaviour<br>• Type of trips → behaviour<br>• Time of trips → behaviour<br>• Trip frequency → behaviour |
| 4 DfT / GRACE surveys | • Distance based charges → complexity<br>• Thresholds of prices/Complex price signal → disengagement<br>• Complex price signal → behaviour | • Easiness to predict charges → effort in consideration of alternative travel arrangements | | • Income → sensitivity to charges, behaviour,<br>• Type of trip → behaviour<br>• Gender → behaviour, sensitivity to price<br>• Age → sensitivity to price<br>• Education → ability to predict charges, behaviour |

| CASE STUDIES | Main hypotheses (Price signal → Response) | Sub - hypotheses | | |
|---|---|---|---|---|
| | **Price signal→behavioural adaptation (Price signal→stated preferences) (Price signal→examination)** | **Cognitive factors** | **Motivational factors** | **Situational and personal factors** |
| 5 Laboratory experiment I (Dresden) | • Differentiation → latency time, error rate in price estimation, perceived task difficulty, task certainty in price estimation<br>• Differentiation → behaviour, perceived effectiveness & comprehension, acceptability | • (Hints to advantages of differentiation build on already existing cognitive maps) | • Acceptability ←or→ latency time, *error rate, perceived task difficulty, task certainty* in price estimation<br>• Personal involvement → behaviour | • Income → behaviour<br>• Gender → perceived task certainty, difficulty, behaviour<br>• Age → latency time, behaviour |
| 6 Laboratory experiment II (Leeds) | • Differentiation → latency time, error rate, perceived task difficulty, task certainty<br>• Differentiation → behaviour, perceived effectiveness & comprehension, acceptability<br>• Task certainty → behaviour | • Experiences → comprehension | • Acceptability ←or→ latency time, error rate, *task certainty*, behaviour, perceived task difficulty<br>• Effectiveness → behaviour | • Income, education → behaviour<br>• Gender → perceived difficulty, acceptability<br>• Age → perceived certainty, behaviour, acceptability |
| 7 Laboratory experiment III (Dresden) | • Differentiation → latency time, error rate, perceived task difficulty, task certainty | • (Hints to advantages of differentiation build on already existing cognitive maps) | • Acceptability via procedural fairness → latency time, error rate, task certainty, perceived task difficulty | |
| 8 Surveys of freight operators | • Differentiation elements → acceptability | • Comprehension → stated precision of toll calculation, engagement | • Acceptability → behaviour (in medium term, long term)<br>• Understandability, perceived effectiveness → behaviour<br>• (Fairness, perceived effectiveness → acceptability) | • Time horizon → behaviour |
| 9 Kirkcaldy hovercraft trial | • Differentiation → stated preferences | | • Personal involvement → stated preferences | • Type of trip → stated preferences |
| 10 Yield management railroad | • Differentiation / restrictions → reactance, behaviour | | • Personal involvement → reactance | |

NOTES: Black font indicates that the effect has been verified; black italic font indicates that the effect only just missed the significance threshold; grey font indicates that effect could not be supported by empirical data.
Text in brackets indicates hints which are derived from further interpretation of effects found.
For further information concerning the direction of effects see relevant sections of the report.

## 5.2 OVERALL CONCLUSIONS ACROSS SECTORS

- Motivational factors, particularly **acceptance, affect user responses** towards differentiated prices. People who support road charges are more likely to have a firm view on how (or whether) they would adapt their behaviour. Moreover, people who accept infrastructure charges have fewer problems in dealing with differentiated pricing schemes than people who do not support them.
- The degree to which **acceptance** influences user response **depends on perceived behavioural control** and thus on situational aspects and **perceived opportunities to respond to schemes under certain situational conditions**.
- **Lack of perceived behavioural control over the response to pricing schemes**, and scheme characteristics that restrict people's perceived freedom of action, **will lead to reactance** and failure of behavioural adaptation.
- Commercial examination of infrastructure charges (freight operators) differs from individual examination of infrastructure charges (car users, passengers). Understandability of charging schemes and motivation to deal with charging schemes do not play the same role for companies as they do for single individuals. Within transport companies, examination of charges is identified as necessary task and is allocated to special persons or teams within the companies. Concerning responses towards differentiated charges, transaction costs in terms of cognitive effort are less essential.
- **Cross-sectional transfer of charging scheme principles** and thus the transfer of expectations in behavioural changes **seem not to be appropriate,** if unique characteristics and specific perception of users on (specific) transport mode are not taken into consideration.

## 5.3 SPECIFIC CONCLUSIONS FOR THE CAR DRIVER SECTOR

- If the **degree of differentiation** increases, **inaccuracy and time to respond (latency time) in examination of pricing scheme**s will increase as well as perceived difficulty and perceived uncertainty of price predictions.
- Differentiation of prices can be based on several dimensions like space, time or user characteristics. Considering complexity of pricing schemes, results emphasise that the handling of **different dimensions of differentiation is perceived as differently difficult by users**. For instance, price differentiation that includes per-mile / per-km-elements seems to be particularly difficult for respondents.
- **Users' experiences** of any dimension of differentiation **reduce the effect of complexity in that dimension**. Price differentiation which builds on already existing cognitive structures and mental maps of users are advantageous. It must therefore be recognised that cognitive structures and mental maps could differ with the users' different background (regional, cultural etc.)
- Overall, **simplicity of pricing schemes is preferred**. Unless a complex scheme offers them a clear price advantage, people will prefer schemes to be as simple as possible.
- People's **approval of road charges affects their perception of pricing schemes**. The more people accept road charges,
  - the less they perceive pricing schemes as complex,
  - the more they perceive pricing scheme as effective and
  - the more likely they are to have a strategy for responding (or not responding) to the pricing schemes.
- Users' motivation to deal with pricing schemes and **users' responses towards pricing schemes depends on personal price thresholds.** If charges fall below a certain price level (personal threshold) and the cognitive effort to deal with them is high, it will become more likely that individuals continue to travel as before.

- The effect of the price level on likelihood of behavioural response is moderated by the perceived difficulty of the pricing schemes. Compared to a classic "rational" response, **complex pricing schemes lead to over-response within low-price domains but to under-response within high price domains**.

## *5.4* LIMITATIONS

As already mentioned, conclusions and generalisation of findings are limited, among others, by methodological issues. In particular, case studies considering user responses in other sectors than the car sector are underrepresented and, in part, marked by small sample sizes. Further studies and research activities would be useful to broaden the knowledge in these transport sectors.

Moreover, most of available studies are characterised by correlative design (questionnaire surveys) and – strictly speaking – do not allow to conclude causal relations. Further research activities should focus on studies where factors are systematically manipulable.

## 6 RECOMMENDATIONS

Recommendations for the design of differentiated charging schemes:

a.) **Do not introduce unnecessary differentiation.** The more complex pricing schemes are, the more difficulties in dealing with them will occur. Thus, unexpected behavioural responses or failure of behavioural adaptation might become more likely.

b.) **Build gradually on existing differentiation.** Types of differentiation people are familiar with provide advantages concerning behavioural adaptation to schemes. If the design of pricing schemes is built on already existing cognitive structures, they will ease the dealing with them and counteract the perception of complexity by users. Also, during the introduction phase of road pricing, low levels of differentiation (or even undifferentiated prices) are recommended to ensure better understanding and habituation to the new situation. When road users have become familiar with the new situation a successive differentiation of the charges can occur.

c.) **Avoid differentiation elements which are not in line with an easy human information processing.** For example**,** avoid elements which:

- vary non-linearly (e.g. if price is an non-linear increasing function of speed),
- vary unpredictably (e.g. with price as a function of current congestion),
- are not clearly observable (e.g. with price based on current emissions),
- are based on values which are not readily known (e.g. with prices expressed per km – because people do not have good knowledge of journey distances),
- are based on spatial divisions which may not be widely known (e.g. with cordons or zone boundaries which do not follow well-known boundaries), and
- which imply complex cross-linking to other elements (e.g. with different time bands applying in different zones - people have difficulties dealing with variables which are linked and interact with each other).

d.) **Do not expect precise calculation of charges that were designed to provide complex pricing signals.** Results show that precise calculation of prices at least within the individual transport sector is unlikely. People prefer predictability of prices (by heuristics) which will prove satisfactory at a certain level with regard to the necessary cognitive effort rather than precise prediction by accurate calculation. This is particularly true if the differences between the price levels are low – people will not think it worth the effort to calculate the precise value. As a generalisation, one should expect under-response to complex prices in high-price domains and over-response to prices in low price domains (unless the expected price is so low that it is ignored completely).

e.) **Make pricing schemes familiar to users by assistance and helpful advice.** Results indicate that as people become more familiar with pricing schemes they become better able (and willing) to deal with them.

f.) **Provide adequate information and advice about the price structure of the charging schemes.** This is to help users see/understand the underlying “pattern” and thus make the details easier to recall (especially in case of highly differentiated prices).

g.) **Provide information to stress the justification for the scheme** (e.g. information on benefits, use of revenue, protection for vulnerable groups, scientific justification, political support). This is to make the scheme seem more acceptable to users and so increase their understanding and willingness to engage.

h.) **Provide (and publicise) opportunities to change behaviour according to the differentiated charging schemes.** Perceived opportunities for users to respond to pricing schemes are essential to avoid psychological reactance and failure to engage.

i.) **Cross sectional transfer of charging scheme principles** and thus expectations in behavioural changes **should be carefully and critically checked** and unique characteristics of specific transport mode should always be taken into consideration.

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# APPENDIX 1 - NEWCASTLE QUESTIONNAIRE

**Screening Questionnaire Content**

s1 Gender (*no need for a question , just observe and note! – do not start interview if quota for that gender is already full*)

a) Male
b) Female

s2 Roughly, how many miles do you drive in the built up areas of Newcastle in an average week?

a) less than 10
b) 10-25
c) 25-50
d) over 50

s3 (***omit if s2 = "c" or "d"***) Do you drive a private car or van on at least four days a week in the built up area of Newcastle (each two-way trip counts as only a trip

a) yes
*b)* no (***STOP***)

s4 In a typical month, for which of the following purposes do you drive within the built up areas of Newcastle?(*indicate all that apply.* ***Terminate interview do not mention "a" and quota for non-work trips is already full****)*

a) driving to work
b) driving children to or from school
c) shopping trips
d) driving in the course of work
e) other purposes (*if they choose this please ask them to specify the purpose and code a one word answer (e.g. "college") as* ***s4b****)*

s5 Which of these purposes accounts for the most miles you drive in the built up areas of Newcastle ? *(should not be necessary to read out options!)*

a) driving to work
b) driving children to or from school
c) shopping trips
d) driving in the course of work
e) other purposes

s6 Who ends up paying for the petrol and any parking charges?

*a)* yourself
*b)* share with another family member
*c)* company or client **(*STOP*)**.

s7 Which band on showcard 1 does your age lie in?
***(if they are not in any band (i.e. under 17) then stop)***

| band | |
|---|---|
| H | 17 – 24 years |
| K | 25 – 34 years |
| B | 35 – 54 years |
| W | 55 – 64 years |
| X | 65+ years |

s8 How many people are there in your household ? (***if you are asked what is a household , say "people of any age who live together and share main meals"***)

| |
|---|
| |

s9 Which band on showcard 2 does your household income fall into?
***(terminate if quota for their income band already full)***

| | £ per week | £ per month | £ per year |
|---|---|---|---|
| H | under 250 | under 1200 | under 14,000 |
| X | 251-390 | 1201-1700 | 14,000 – 19,999 |
| B | 391-580 | 1701-2500 | 20,000 – 29,999 |
| W | 581-960 | 2501-4170 | 30,000 – 49,999 |
| K | over 960 | over 4170 | 50,000 or more |

s10 We would like to conduct a further interview with you, by phone at a time to suit you, and we can offer a £5 thank you if you agree, the interview would last about 20-25 minutes and would go into more detail about motoring costs, are you interested?

b) Yes
c) No **(*if No, thank and STOP*)**

***If yes ask***

s11 What is your phone number?.....
s12 Who should I ask for?.....
s13 When would be a good time to phone?.....

Thank you, we will be touch.

***Software completes Qs s15, s16, s17 and s18***

s15 *(**a random number between 1 and 8 inclusive**)*
s16 ***(a random number between 1 and 8 inclusive excluding s15**)*
s17 *(**a random number between 1 and 8 inclusive excluding s15 and s16**)*
s18 ***(a random number between 1 and 8 inclusive excluding s15, s16 and s17**)*

***Briefing material to be handed out at end of screening interview***

- *letter containing details of appointment for telephone interview and instruction to have briefing materials to hand for that interview. Letter should also contain: identification of survey company, confidentiality statement, and disclaimer ("The road pricing schemes described on the cards enclosed with this letter are entirely hypothetical. they were devised by an international team for the purposes of a research project and have not been discussed with the Newcastle authorities." )*
- *"card 1". Side A contains a map of the Newcastle area showing a pink Zone covering the city centre and an orange zone covering the rest of the built-up area. Side B is a showcard listing qualifications – to be referred to in question^2 of the main interview),*
- *4 scheme descriptions (random selection, defined by s15, s16, s17 and s18)*

**Main questionnaire content:**

Can I just confirm that you have got the briefing pack to hand and that you can refer to it during the interview? (***if not please ask them to get it, if they cant find it then terminate interview and arrange to send new pack***)

1 Do you think there is a congestion problem in Newcastle
- a) no, not really
- b) yes but not very serious
- c) yes, and it is very serious

2 Which of the following best describes <u>your</u> experience of congestion in Newcastle?
- a) It does not affect me very much
- b) It has a significant affect on me
- c) It has a very serious affect on me

3 If the local Council introduced road charges in Newcastle, which of the following reasons do you think that they would have for doing it? (*tick all that apply*)
- (a) to raise revenue for investing in public transport
- (b) to raise revenue for investing in roads
- (c) to raise revenue for non-transport purposes
- (d) to reduce the amount of traffic on the roads.

4 And which do you think would be their <u>main</u> reason for doing it?.
*(CATI to display only the answers ticked in Q3 )*

| |
|---|
| |

5 And would you think it would probably…
- (a) make your own journeys quicker, <u>or</u>
- (b) not make your own journeys quicker, <u>or</u>
- (c) don't know

6 And do you think it would be…
- a) Absolutely fair
- b) Quite fair
- c) Quite unfair
- d) Completely unfair

7 And , on balance, do you think it would be ….
- a) …. good for Newcastle
- b) …. bad for Newcastle
- c) or not sure?

Now some questions about the trips you make by car

Please look at the map on Card 1

8 Do your {insert "journeys to work" if s5=a, "school run journeys" if s5=b, "shopping or personal business journeys" if s5=c, a "social or leisure journeys" if s5=d, "s4b journeys" if s5=e} involve driving in the orange zone shown on the map?
- a) yes
- b) no

9 Do your {insert "journeys to work" if s5=a, "school run journeys" if s5=b, "shopping or personal business journeys" if s5=c, a "social or leisure journeys" if s5=d, "s4b journeys" if s5=e} involve driving in the pink zone shown on the map?

c) yes
d) no

I want you to think about the last time you drove {insert "to work" if s5=a, "the school run" if s5=b, "for shopping or personal business" if s5=c, a "for social or leisure purposes" if s5=d, " a s4b journey" if s5=e}in Newcastle.

10 Did you ……
a) drive all the way to the destination, or
b) use park and ride?

11 At what time did you start the journey? (*code as 24 hr clock*)

12 How long did it take you to get to the destination? (*code as mins*)

13 How important was it that you got to the destination by a particular time?
a) very important, or
b) quite important, or
c) it didn't really matter what time you got there.

14 How far do you think you drove – please be as precise as you can? (*code as miles and fractions of miles*)

15 How sure are you about that distance?
a) to within ¼ of a mile.
b) to within ½ mile
c) to within 1 mile
d) to within 5 miles
e) less precisely that that.

16 (***omit if Q10 is a***) How far do you think that you travelled on public transport? – please be as precise as you can? (*code as miles and fractions of miles*)

17 What do you think that the car journey will have cost you (include all the relevant costs (***if Q10 is "b" add*** *" but exclude the public transport part"*)? (*code as pence. do not assist in saying which costs are relevant)*

18 (***omit if Q10 is a***) How much do you think that the public transport part of the journey will have cost you? (*code as pence*)

19 How often do you make that journey?
a) at least 4 times a week
b) between once and three times a week
c) less than once a week – but at least once a month
d) less than once a month

Suppose that you had to make the (***if Q10 is "b" add*** *" whole")* journey by public transport…..

20 Which of the following methods of transport would you have to use? *(read all and record all those that they would use*)
a) bus
b) metro
c) train

21 And how long do you think it would take to make the (***if Q10 is "b" add*** *" whole")* journey by public transport (door to door)? (*code as mins*)

Now I want you to think about how this trip would be affected if the council were to introduce road charges (I want you to assume that the road conditions stay as they are now).

If the Council introduced a very low charge it might not affect your choice, but if it was a high charge you might consider making the journey less frequently or perhaps using a different method of transport – despite the inconvenience it might cause you.

22 What maximum daily charge would you be prepared to pay before deciding to make the journey less often or use a different mode of transport? (*code as pence per return journey, if they say "wouldn't pay anything, enter "0")*

23 (*omit if Q22 is less than 20p*) What if the charge varied depending on which route you use, and suppose that you could reduce the daily charge to [Q22 x 0.75 rounded] by taking a route that was 10 minutes longer than your current route, do you think you would ….

a) stick to your existing route (and pay [Q22]), or
b) use the longer route (and pay [Q22 x 0.75 rounded]) ?

24 (a) (*omit if Q22 is less than 20p or Q23 is b*) OK, suppose that you could reduce the daily charge to [Q22 x 0.50 rounded] by taking a route that was 10 minutes longer than you current route, do you think you would ….

a) stick to your existing route (and pay [Q22]), or
b) use the longer route (and pay [Q22 x 0.50 rounded]) ?

24 (b) (*omit if Q22 is less than 20p or Q23 is a*) OK, suppose that you could reduce the daily charge to [Q26 x 0.90 rounded] by taking a route that was 10 minutes longer than you current route, do you think you would ….

c) stick to your existing route (and pay [Q22]), or
d) use the longer route (and pay [Q22 x 0.90 rounded])?

25 (*omit if Q22 is less than 20p*) What if the charge varied depending on what time you travel, and suppose that you could reduce the daily charge to [Q27 x 0.5 rounded] by travelling an hour earlier, do you think you would ….

a) stick to your existing time (and pay [Q22]), or
b) travel an hour earlier (and pay [Q22 x 0.5 rounded]) ?

*(if they ask about the timing of the return journey say "assume you also make that journey an hour earlier and this is reflected in the cost)*

26 *(a)* (*omit if Q22 is less than 20p or Q25 is b*) OK, suppose that you could reduce the daily charge to [Q22 x 0.25 rounded] by travelling an hour earlier, do you think you would ….

a) stick to your existing time (and pay [Q22]), or
b) travel an hour earlier (and pay [Q22 x 0.25 rounded]) ?

*(if they ask about the timing of the return journey say "assume you also make that journey an hour earlier and this is reflected in the cost)*

26 (b) (*omit if Q22 is less than 20p or Q26 is a*) OK, suppose that you could reduce the daily charge to [Q26 x 0.75 rounded] only by travelling an hour earlier, do you think you would ….

c) stick to your existing time (and pay [Q22]), or
d) travel an hour earlier (and pay [Q22 x 0.75 rounded]) ?

*(if they ask about the timing of the return journey say "assume you also make that journey an hour earlier and this is reflected in the cost).*

Just suppose that the council had used some of the revenue to improve public transport considerably and had managed to add new services which were much quicker, more frequent, more direct and completely reliable (cutting average door-to-door journey times by 50%). Perhaps that would make you happier to use public transport.

27 If public transport was improved in this way, what maximum daily charge would you be prepared to pay before deciding to make the journey less often or use a different mode of transport? (*code as pence per return journey, if they say "wouldn't pay anything, enter "0")*

Now let's suppose that the council had achieved this improvement in public transport and had also managed to cut car journey times by 10%.

28 In such circumstances, what maximum daily charge would you be prepared to pay before deciding to make the journey less often or use a different mode of transport? (*code as pence per return journey, if they say "wouldn't pay anything, enter "0")*

In everything that follows I want you to think about all the driving you do in Newcastle – not just the journey(s) we have been talking about.

Please look again at the map on Card 1

29 What proportion of your regular mileage is in the orange zone shown on the map?

a) all of it
b) most of it
c) some of it
d) none of it.

30 What proportion of your regular mileage is in the pink zone shown on the map?

a) all of it
b) most of it
c) some of it
d) none of it.

31 If the Council introduced a system of daily charges covering an unlimited number of journeys on any one day (and it cost you about [*£60 if s4 includes "a", otherwise £20*] a month to carry on driving as you do now), do you think you would try to avoid driving on some days?

a) yes
b) perhaps
c) probably not

32 And do you think that, overall, you would be think that you would make….

a) fewer car journeys
b) the same number of car journeys, or
c) more car journeys (because, once you have paid the charge on a particular day you might as well get your money's worth!)?

I am now going to ask you to look at some descriptions of charging schemes that might be introduced in Newcastle and to think about what that might mean for you.

33 Can you confirm that you have got Cards 2.{s15}. 2{s16}, 2.{s17}, and 2.{s18}? (***You might need to tell them that the card number is printed in the top left hand corner. If something has gone wrong and they cannot find all of them, ask them to read out the numbers of the cards that they have got and record the ones stating with "2." here, otherwise skip to Q34):***

| |
|---|
| 33.1 |
| 33.2 |
| 33.3 |
| 33.4 |

***Software allocates 33.5, 33.6, 33.7 and 33.8 as follows:***
***IF nothing recorded in 33.1 THEN 33.5=s15, 33.6= s16, 33.7=s17, 33.8= s18***
***ELSE 33.5=33.3, 33.6= 33.1, 33.7=33.4, 33.8= 33.2***

34 Please select card 2.X {***X =Q33.5 ) Pause to give them time, continue only when they are ready***)

If this scheme was introduced, roughly how much do you think it would cost you to carry on driving as you do now?

a) less than £20 a month
b) between £20 and £40 a month
c) between £40 and £60 a month
d) between £60 and £80 a month
e) over £80 a month

35 How easy it would be to work out exactly what it would cost you?

a) very easy
b) quite easy
c) quite difficult
d) very difficult
e) impossible

36 If the scheme was in place, do you think that you would change your travel patterns at all?

a) no – I don't think I would change my travel patterns
b) perhaps I might change my travel patterns
c) yes - I would change my travel patterns
d) I really don't know (*try to get them to choose a b or c*)

37 ***(omit if a or d at Q36)*** Do you think you would still be making the same number of car journeys?

a) certainly the same
b) probably the same
c) probably fewer
d) definitely fewer

38 ***(omit if a or d at Q36)*** Do you think you would change the timing of your car journeys to avoid the charges?

a) no
b) probably not
c) probably yes
c) I certainly would

39 And, on balance, how effective do you think this scheme would be at reducing congestion in Newcastle?

a) very effective
b) quite effective
c) not very effective
d) not at all effective

*40-45* (***repeat questions 34-39 with X = 33.6) with the "omit" on Q43 and Q44 relating to Q42)***

*46-51* (***repeat questions 34-39 with X = 33.7) with the "omit" on Q49 and Q50 relating to Q48)***

52-57 (***repeat questions 34-39 with X = 33.8) with the "omit" on Q55 and Q56 relating to Q54)***

And, finally I have some more general questions

58 Which of the following best describes your attitude to motoring expenses?
- a) I like to know exactly how much each journey is costing me, or
- b) I like to have some idea of how much each journey is costing me, or
- c) I don't really think very much about the cost of each journey I make.

59 In general, would you say that you are the sort of person who likes to work out all the pros and cons before making any decision?
- a) yes certainly
- b) yes
- c) no
- d) certainly not

60 In general, when you complete a task that has required a lot of mental effort, do you feel satisfied - or relieved that it is over?
- a) mainly satisfied
- b) mainly relieved
- c) half and half.

61 In general, would you say that you are the sort of person who likes to work on a problem only if there is a possibility of coming up with a clear-cut and unambiguous answer
- a) yes certainly
- b) yes
- c) no
- d) certainly not

62 Which of the following best describes your employment status?
- a) employed
- b) self employed
- c) retired /unemployed
- d) student
- e) home maker

Please look at the showcard (on the back of card 1)

63 And finally, which of the rows on the showcard best describes your educational background?

Thank You very much for taking part in this interview. To what name and address should we send the £5.
name…….
address…….

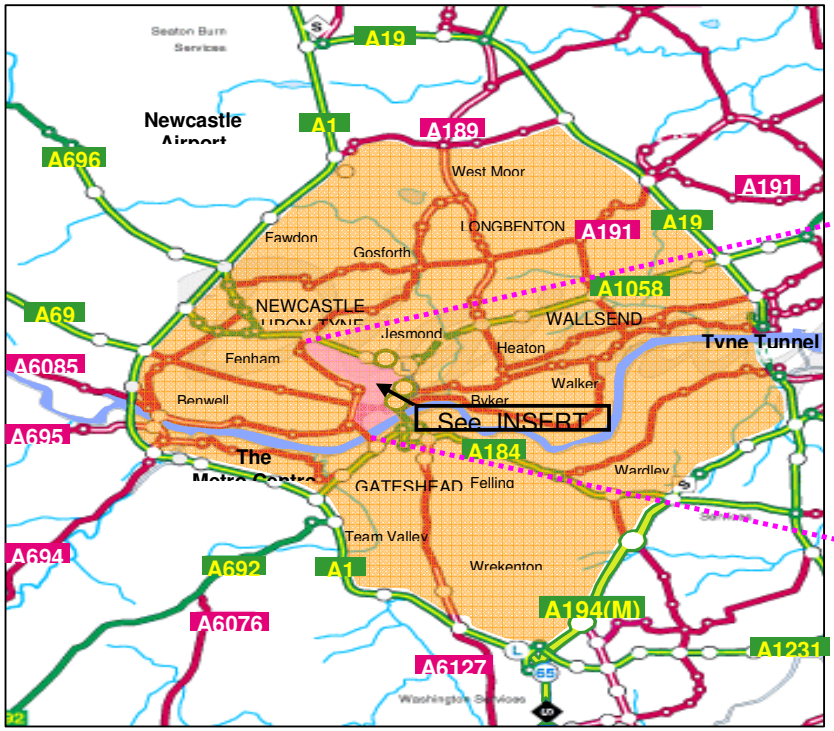
Finally, I must just assure you that the road pricing schemes that we have been discussing are entirely hypothetical. They were drawn up by academics for the purposes of the questionnaire and have not even been discussed with the Newcastle authorities.

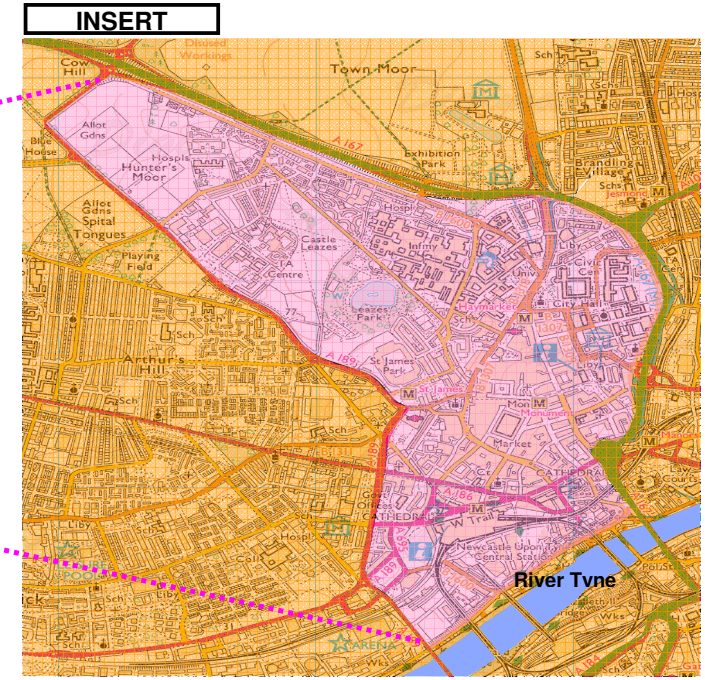
# APPENDIX 2 - EXAMPLE OF CHARGING SCHEME PRESENTED TO NEWCASTLE QUESTIONNAIRE RESPONDENTS

**The following charges apply on weekdays during peak hours (0700-1000 and 1600 to 1830):**

In the **pink** zone the charge would be £2 to drive anywhere.
In the **orange** zone the charge would be: 5p per mile to drive on **green** roads
10p per mile to drive on **red** roads and
20p per mile to drive on any other roads

(note that the roads around the outside edge of the orange zone are free and those around the edge of the pink zone are charged as being inside the orange zone).



# APPENDIX 3 – DfT QUESTIONNAIRE

This questionnaire is phrased for use in Oxford. It would need to be adjusted to suit the area where it is being used.

## Introductory blurbs

a. text of advance letter: Official headed letter? …..name BMRB and ITS?…. research into costs of motoring in the (Oxford) area…want to interview people in this area of Oxford…'thank you' of £10 (in high street vouchers?) will be given to those who take part... will call round next week …. alternatively – phone x to arrange specific time for a phone interview

a. script for doorstep: good afternoon, my name is… from BMRB we sent a letter …DFT … motoring costs …mention reward. . is now convenient?

NOTE it is very important that this initial blurb is kept as simple as is possible – consistent with accuracy and clarity (we do not want to bias the sample by frightening people who don't like complexity)

## 1. First stage interview (CAPI)

F1. Do you drive a car from this address to anywhere that is at least three miles away, between 7.30 and 9 am, on a regular basis? (by "a regular basis" I mean at least once a week)
(a) Yes
(b) No *(if no stop)*

F2. Including petrol and parking, do you pay the costs for any of these journeys out of your own pocket? (That is, without being reimbursed by an employer or by the taxman)?
(a) Yes
(b) No (*stop)*

F3 If you regularly drive, and pay for, more than one such journey, please think about the one that you have done most recently.
Which of the following best describes the main purpose of this journey?

*Showcard F3*:

| | |
|---|---|
| (a) | To or from work |
| (b) | To or from School or college |
| (c) | Transporting children (e.g to/from school) |
| (d) | A shopping trip |
| (e) | A leisure trip (e.g. visiting friends or family) |
| (f) | Other |

F4 How many passengers normally travel with you for at least part of this journey? …….. *(people).*

F5 Where does this journey begin and where does it end?
a) start at ……(place name eg "your home")
b) end at ……(place name eg "your workplace" "shopping centre")……
*(prompt for postcode if possible, otherwise street names if within Oxford, otherwise town name if outside Oxford)*
c) postcode or detailed address of origin……
*d)* postcode or detailed address of destination…….

F6. How many times do you drive to [F5b] in a typical week?.....

F7. Does your usual route to (F5b) make use of roads inside the Oxford ring road (*show map if necessary*)
a)Yes
b) No

F9 How long (in minutes) does the journey from (F5a) to (F5b) usually take, door to door, at the time of day that you usually travel?…….. *(mins)*

F10 About how far (in miles) do you think it is from {F5a} to {F5b}? ……..*(miles) (prompt for an answer even if they are unsure)*

F11 How accurate would you say your estimate of that distance is? (*prompt to code if necessary*)
- (a) Within half a mile
- (b) Within one mile
- (c) Within two miles
- (d) Within five miles
- (e) Less accurately than that

F12. Do you think that the route you usually take is the shortest possible route to (F5b) in terms of number of miles? (*prompt to code if necessary*)
- (a) Yes - definitely
- (b) Yes – probably
- (c) Probably not - I expect there are shorter routes
- (d) Definitely not – I know there are shorter routes

F13 And would you think that, on most days, it is the quickest possible route in terms of the time it takes you? (*prompt to code if necessary*)
- (a) Yes - definitely
- (b) Yes – probably
- (c) Probably not, I expect there are quicker routes
- (d) Definitely not , I know there are quicker routes

F14 Do you generally make this journey at the same time of day each time you do it?
- (a) yes
- (b) no

F15 ***(ask only if (a) at F14)*** At what time do you normally set off when you make this journey? ……:….. *(24 hr clock)*

F16. ***(ask only if (a) at F14)*** Do you have any choice about when you set off? (*prompt to code if necessary*)
- (a) No -none
- (b) Yes- a little
- (c) Yes – a fair amount
- (d) Yes – a lot

F20 If, for some reason, you couldn't drive for a month or so, how would you make this journey? (*pause and then prompt to code if necessary*)
*If respondent says different modes on different days, ask for the one they would do most often.*
*If respondent says different modes for journeys out and back, record for the journey out.*
*If respondent would use more than one mode on a given day (eg walk-bus-walk- train-walk) record them all*
- (a) get a lift from someone else / car share
- (b) bus
- (c) train
- (d) walk
- (e) cycle
- (f) taxi
- (g) would not make the journey
- (h) other (specify)

F20b ***(Ask if more than one mode recorded at F20)***Which of these is the longest in terms of distance (*read out list of modes recorded at F20 and record their response)*

F21 ***(ask if selected g in F20)*** Do you really mean that you would NEVER make the journey? (*no need to prompt*)

(a) yes, (meaning they wouldn't make the journey at all if they couldn't drive it)
(b) no (meaning they would make it sometimes)

F22 (***omit if selected (a) at F21***) What method of transport would you use when you do make the journey? (*pause and then prompt to code if necessary)*
*If respondent says different modes on different days, ask for the one they would do most often.*
*If respondent says different modes for journeys out and back, record for the journey out.*
*If respondent would use more than one mode on a given day (eg walk-bus-walk-train-walk) record them all*

(a) get a lift from someone else / car share
(b) bus
(c) train
(d) walk
(e) cycle
(f) taxi
(g) other (specify)

F22b ***(Ask if more than one mode recorded at F22)***Which of these is the longest in terms of distance (*read out list of modes recorded at F22 and record their response)*

F23 How long do you think it would take, door to door, to make the journey from (F5a) to (F5b) by [mode indicated at F20 or F22]?
…… *(mins)*

F24 ***(omit if said (a) at F21, or if said (a) , (d) or (e) at F20 or F22 )*** How much do you think it would cost you to make the journey (there and back) by this method?..... *(£&p)*

F25 Now I want to ask you a question about your motoring costs;
*Showcard F25*
Which of these statements best describes how much notice you take of the costs of taking different routes when you are driving? By "costs" I mean petrol, wear and tear on your car, tolls and anything else that might differ depending on the route you take

When choosing a route, I think about the cost ….
(a) always.
(b) only if I expect the costs to be significantly different on different routes.
(c) rarely.
(d) never.

F25b Thank you. Finally, I want to ask you a couple of hypothetical questions:. If you were to make your journey [to F5b] when the roads were completely clear and all the traffic lights were in your favour, how much shorter do you think the journey would be? ….(*mins*)

F25c Just suppose that, by clever management of the traffic, the Highway Authorities could cut x [round number approx half F25b] minutes off the normal journey time from [F5a] to [F5b]. That would save you about [round number approx F25b x F6 x 2] minutes a week. How much (max) would be prepared to pay to save those [round number approx F25b x F6 x 2] minutes? …… *(£ and pence*)

F26 Thank you, that is all the questions that I have at this stage. We would like to ask you some more questions about the costs of motoring in Oxford, it will take about x minutes of your time and we could conduct the interview by phone at a time to suit you. As you will recall from the

letter, we are offering a small (£10) thankyou for people who agree to participate in our survey. Are you happy to help us by answering some more question?

(a) yes
(b) no

*If yes* :

F27 when would be convenient? between ..... and .....*(24 hr clock)*

F28 What number should I call ……*(incl code)*

F29 Who should I ask for? ……. *(name)*

F30 *Record gender* ….M/ F

F31 *Record estimated age category*; under 30 / 30-50 / 50-70

## (*If they agree to follow-up*):

I would like to leave some information with you and would like you to read it carefully before the next interview. Here it is (*select the scenario indicated and them a bundle of the appropriate type)*

*(software should allocate a scenario using the following rules:*
*(1) complete set is A B C or D; (2) if F7 is (b) remove A and C; (3)randomly select from those that remain (3) record result as "F32" and display it on screen (this algorithm is adequate for the prepilot. a more sophisticated version will needed in the dress rehearsal to avoid under-representation of A and C (e.g. by keeping a record of the number of each type of scenario already issued– and may be revised if scenarios are modified)*

*Take the respondent through the items in the bundle (i.e. letter, instructions on what to do to prepare for stage 2, description of a hypothetical charging scheme, and (for CATI sample only) show cards required for stage two interview.*

*Emphasise that we do want them to study the document and think about:*

*(1) the implications that the charging scheme would have for their regular journey , and*
*(2) how, if at all, they would adjust their travel arrangements if the charge came in (BUT being realistic about the practicality of any changes they might make*

*In prepilot only:*
*Note how long interview has taken unless software does this automatically*

## 2. Second stage Interview (test CATI and CAPI)

if data is not carried forward from the first stage, C3 will have to be revised and an extra question C2b would be needed to pick up F32. Question C6 could be omitted to reduce length or could be replaced by a question on annual mileage. Also, some questions could be moved from first interview into the second interview – provided they are not needed to help target people for stage 2 (pros and cons to this – it would probably reduce cost and possibly increase agreement to participate in stage two, but would reduce sample for the questions moved and might reduce quality of stage two data)–

**General notes for interviewers on how to respond to possible queries from interviewees:**

- *If you are asked what the revenue would be used for, say: " it's only a hypothetical scheme , but if it was real I suppose the revenue would go towards reducing Council Tax and other taxes on motorists, and to fund transport improvements".*

- *<u>If you are asked whether they should assume that congestion is reduced due to the charge:</u> say "no – even though that is what would probably happen, the researchers want to know how you are reacting to the charge – not to any reduction in congestion - so please assume that journey times stay as they are now"*
- *<u>If you are asked whether they should assume that public transport is able to cope</u> with the increased demand due to the charge: say "if it were a real scheme the public transport capacity would surely be increased, but the researchers want to know how you are reacting to the charge – not to any effect on public transport - so please assume that the frequency, journey time and chance of getting a seat stay as they are now"*
- *<u>If you are asked whether there would be any discounts or exemptions</u> for key workers; say "that would be a policy matter to be decided if this were a real scheme, but the researchers want you to assume that your journeys would NOT be exempt"*

C1 **(Intro Blurb)**: Good morning / good afternoon (name)<u>.</u> My name is _____ . I am from BMRB. I am calling on behalf of the Department for Transport who have asked us to undertake a survey into motoring costs. I understand that you have agreed to take part in this survey and would like to conduct the survey now if that is convenient for you? Y/N
*If no – then rearrange the interview, If yes – proceed.*

C2 Before we begin can I just check that you have the briefing sheets we sent you earlier this week, as I will need to refer to them during the interview? Y/N
*If no – ask them to locate them. If they can't arrange to send them out again and rearrange the interview. If yes – proceed*.

C2b Can I just take a note of the type of form you received (*look at scenario sheet, of if CATI, ask them to do so, and record Scenario Code (A, B, C or D*))……(software should record this as F32).

C3 I am going to be asking you some questions about the regular trip that you told us about in the last interview. My notes say that it is from { F5a} to { F5b} and that you drive it {noted in F6} times a week. Have I got that right?

(a) yes
(a) no *(something has gone wrong! need to record amended details or, if they are no longer in scope, terminate the interview)*

I would like to begin by asking a few questions about you and the other people in your household

C5 Which of the following age categories do you belong to? *(showcard)*

a) 17 – 24 years
b) 25 – 34 years
c) 35 – 54 years
d) 55 – 64 years
e) 65+ years

C6 How many years driving experience do you have?

(a) Less than 1 year
(b) 1 year but less than 2 years
(c) 2 years or more

C7. Which of the following <u>best</u> describes your employment situation? *(showcard)*

| | |
|---|---|
| (a) | Employed full time (30+ hours a week) |
| (b) | Employed part time (less than 30 hours a week) |
| (c) | Self-employed full time (30+ hours a week) |
| (d) | Self-employed part time (less than 30 hours a week) |
| (e) | Looking after family / home full-time |
| (f) | Student |
| (g) | Not in paid work |
| (h) | Retired from paid work |

C8. How many people live in your household including yourself?

Number of adults ……..

Number of children ……

C9 How many of them hold full car driving licenses? …….

C10 How many cars are available to people in your household? ……

I'd now like to ask you some questions about your attitude to costs and value for money.

C11 When you are choosing a supplier for services like gas, electricity, and telephone, how much effort do you take to work out the best deal? *(prompt to code if necessary)*

(a) I always make a lot of effort
(b) I usually make some effort
(c) I sometimes make an effort
(d) I rarely make much effort

C13a I'm going to ask you a question about the fixed costs of owning and maintaining a car (that is things like road tax, car insurance, depreciation and any interest payments, – but NOT running costs). Would you find it easier if I ask it in terms of costs per month or costs per year?

(a) Per month
(b) Per year

*<u>If asked</u> say fuel is part of running costs – so shouldn't be included*

C13b1 ***(ask if said (a) at C13a)*** How much do you think these fixed items cost you per month (dont worry if it is not a very precise estimate) ? ……..*(£).*
(G*ive them up to a couple of minutes to think about it. Try to get them to give an estimate. Do not assist but, if asked whether to include initial purchase price, answer"no but do include depreciation. If asked whether to include fuel or wear and tear, answer"no – I just want you to consider the fixed costs")*

C13b2 ***(ask if said (a) at C13a)*** How certain are you about that estimate (please pick the most appropriate line from the showcard)?

| | |
|---|---|
| (a) | To the nearest £1 |
| (b) | To the nearest £5 |
| (c) | To the nearest £10 |
| (d) | To the nearest £25 |
| (e) | To the nearest £50 |
| (f) | To the nearest £100 |
| (g) | Less precisely than that. |

C13c1 ***(ask if said (b) at C13a)*** How much do you think these fixed items cost you per year (dont worry if it is not a very precise estimate) ? ……..*(£)*
(*Give them up to a couple of minutes to think about it. Try to get them to give an estimate. Do not assist but, if asked whether to include initial purchase price, answer"no but do include*

*depreciation. If asked whether to include fuel or wear and tear, answer "no – I just want you to consider the fixed costs")*

C13c2 ***(ask if said (b) at C13a)*** How certain are you about that estimate (please pick the most appropriate line from the showcard)?

a) To the nearest £10
b) To the nearest £50
c) To the nearest £100
d) To the nearest £200
e) To the nearest £500
f) Less precisely than that.

C14 And how precisely do you know how much you personally spend on fuel for your car in an average month? *showcard C13.b (or could use a cut down one omitting 50 and 100)*

C15a Now, some questions about your regular journey from [F5a] to [F5b].
How much do you think it cost you to make the journey, there and back, last time you made it – (including fuel, parking, wear and tear but not the fixed costs of insurance, road tax etc)?"
Please give us an estimate for the total amount in £s & pence. …….. £ and pence (*try to persuade them to make an estimate even if they are unsure)*

C15b How certain are you about that estimate? (please choose an option from showcard C15b).

(a) To the nearest 10 pence (+ or -)
(b) To the nearest 50 pence (+ or -)
(c) To the nearest £1 (+ or -)
(d) To the nearest £5 (+ or -)
(e) Less certain than that

C15c I am now going to ask how this journey would be affected if the road charges outlined in the leaflet we sent you were in force.

Please take a moment, if you need it, to refresh your memory about the scheme – the key features are described on page X of the leaflet. OK? *(pause if necessary)*

How much do you think the daily charge would be for the journey to {F5b}and back if you were using your usual route and timing?

Please give me an estimate for the total amount in £s & pence. ……£s……pence (*try to persuade them to make an estimate even if they are unsure, and even if they say they wouldn't make the journey)*

C16 How certain are you about that estimate? (please choose an option from showcard C15b).

C17a. Do you think there are any alternative routes from [F5a] to [F5b] for which the charge would be lower than on your usual route? *(if they choose (b) or (c) check to make sure they do really mean that they think there are no such routes – we are asking whether such routes exist - not whether they would use them)*

(a) yes
(b) No
(c) Don't know.

C17b (***omit if chose (b) or (c) at C17a***) By how much, maximum, do you think you could reduce your total daily charge if you took a different route between {F5a} and {F5b). …… *(try to persuade them to make an estimate if they are unsure and even if they say they wouldn't use the alternative route)?*

C18 (***omit if chose (b) or (c) at C17a***) How certain are you about that amount? Please choose an option from showcard C15b

C19 (***omit if, at F15 they said they already travel off peak***) The charge for your journey would be lower if you could travel at a cheaper time of day. How much do you think the charge would be to travel from [F5a] to [F5b] and back at the cheapest times of day? …. £ and pence (persuade them to give an answer even if they are unsure and even if they say they couldn't travel at the cheapest time of day. Also, if asked, say we mean by their usual route)"

C20 (***omit if, at F15 they said they already travel off peak***) How certain are you about that amount? Please choose an option from showcard C15b

C21a ***(ask if answered anything other than (a) in C16 or C18 or C20)*** Which of the reasons listed on the card make it difficult for you to be more certain? Please mention all that apply.

(a) the calculation was complicated
(b) the rules were complicated
(c) I am unsure which route I would take
(d) I am unsure about the precise length of my route
(e) I am unsure about where the charges apply
(f) I am unsure about the speed limit on particular roads
(g) I am unsure about the time at which I would be using particular roads
(h) other – please specify

C21b ***(ask if answered anything other than (a) in C16 or C18 or C20)*** And, using the same card, can you say which problem you found most serious?
(showcard 21a)

C23 How much would you have to be paying per month for your journeys to {F5b}before you begin to think seriously about changing your travel arrangements? ……. (£s) (*insert "£1" if they say they would immediately think about changing their travel arrangements*)

C24a ***(omit if C23 was £1)*** Which of the reasons on card 24a explain why you would not consider alternative travel arrangements if the monthly cost was less than [C23]? Please mention all that apply.

It is not worth the effort of thinking about it because……
(a) .. I don't have any choice about making the journey.
(b) .. the effort of working out the saving would outweigh the possible saving.
(c) .. I know I can not work things out that precisely.
(d) .. I cant be bothered to think carefully about trivial sums of money.
(e) .. other (please specify).

C24b ***(omit if answer to C23 was £1)*** And, using the same card, can you say which reason was most important? (showcard 24a)

C25 I am now going to ask some questions on what you think you would be doing about your journey to (F5b) a few months after the charges had come in.

.

In answering these questions please think about the practicalites of any change that you might make. (For example, you will remember that in the briefing note we asked you to think about the implications that a different departure time might have for your colleagues or other people in your household).

I want you to assume that the charges would cost you about {round number approx *C15c x F6 x 4* } a month to carry on making the journey exactly as you do now - though with the actual cost depending on the route and timing

Using *showcard C25*, How likely is it that you would be making the journey by car exactly as you do now (the same route, same time and same frequency)?

| | |
|---|---|
| (a) | Very likely |
| (b) | Fairly likely |
| (c) | Fairly unlikely |
| (d) | Very unlikely |

C26 And how likely is it that you would still be making the journey by car but using a different route that takes a few minutes longer if that reduces the charges significantly? *(if respondent asks what "significantly" means, say "significant to you")*
*showcard C25*

C28 And how likely is it that you would still be making the journey by car but departing at a different time if that reduces the charge significantly? *(if respondent asks what "significantly" means, say "significant to you")*
*showcard C25*

C31 And how likely is it that you would still be making the journey by car but less often?
*showcard C25*

C33 And how likely is it that you would still be making the journey by car but reducing the cost by sharing with another driver or a paying passenger?
*showcard C25*

C34 And how likely is it that you would be making the journey by some other means such as the bus, train, cycling, walking etc.?
*showcard C25*

C34a And finally, how likely is it that you would have stopped making the journey altogether?
*showcard C25*

C34b ***(Ask if answered a or b to C34a or to C31)*** Would you be
(a) Going to a different destination using a route with a lower charge?
(b) Going to a different destination using a route with no charge at all?
(c) Or staying put?

C27 ***(ask if answered (a) or (b) to C26)*** You said earlier that you would be {C26} to be taking a longer route if that reduced the cost, what is the maximum additional daily journey time you would put up with in order to reduce the charge by half? …… mins. (*if they ask: explain that we are talking about taking a more time consuming route in order to reduce the payment )*

C29 ***(ask if answered (a) or (b) to C28)*** You said earlier that you would be [C28] to be setting off at a different time if that reduced the cost. What reduction in your total daily charge would be just enough to persuade you to set out an hour earlier? ……(£ and pence).

C30 ***(ask if answered (a) or (b) to C28)*** and what reduction in your total daily charge would be just enough to persuade you to set out an hour later ? ……..(£ and pence)

C32 ***(ask if answered (a) or (b) to C31)***. You said earlier that you would be [C31] to be making the journey less often, for every ten times that you drive to {F5b} now, how many times do you think that you would drive there if the charges were imposed? ……..journeys.

C33b ***(ask if answered (a) or (b) to C33)***. You said earlier that you would be [C33] to be sharing with another driver or paying passenger, which of those two is the most likely? *(prompt to code if necessary)*

(a) sharing with another driver
(b) a paying passenger
(c) equally likely

C33c *(**ask if answered b or c in C33b**)* Would you accept payment from existing passengers, or would it be only from new passengers? *(prompt to code if necessary)*

(a) existing passengers
(b) new passengers
(c) both

C35 ***(ask if answered anything other than (a) to C16 or C18 or C20 )*** You said earlier that you were not absolutely sure what charge you would have to pay if the charge system described in the leaflet was in force. Using showcard C16, how precisely do you think you could predict the charge for your journey to {F5b}and back if the charge hadn't varied by time of day?

C36 ***(ask if F32 is D AND they answered anything other than (a) to C16 or C18 or C20 )*** Again using showcard C16, how precisely do you think you could predict the charge for your journey to {F5b} and back if there hadn't been different charges for different types of road?

C37 ***(ask if F32 is C AND they answered anything other than (a) to C16 or C18 or C20 )*** Again using showcard C16, how precisely do you think you could predict the charge for your journey to {F5b} and back if you had known precisely where the charge points were?

C37b ***(ask if F32 is A, B or D AND they answered anything other than (a) to C16 or C18 or C20)*** Again using showcard C16, how precisely do you think you could predict the charge for your journey to {F5b} and back if you had known your exact mileage for the trip?

C38 If it was easier to predict the charges, would that make you more likely or less likely to think carefully about the pros and cons of the alternatives?

(a) more likely
(b) less likely
(c) no difference

C39a ***(omit if C23 is £1)***You said earlier that you would seriously consider alternative travel arrangements if the charges for your existing journey to and from [F5b] was {C23} or more per month. Which of the options on *showcard C39a* would you try out if you were not quite sure of the exact monthly saving but thought it was likely to be between {C23 x 0.9} and {C23 x 1.1}? Please mention all that you would try

(a) take an alternative route that costs less
(b) travel at a cheaper time of day
(c) travel less often
(d) share costs with another driver or passenger
(e) travel by some other means - e.g. bus, train or walk

C39b (***omit if C23 is £1 OR C38 was c***) And which of the options would you try out if you were not quite sure of the exact monthly saving but thought it was likely to be between {C23 x 0.75} and {C23 x 1.25}? again please mention all that you would try.
*showcard C39a*

C39c (***omit if C23 is £1 OR C38 was c***) And which of the options on would you try out if you were not quite sure of the exact monthly saving but thought it was likely to be between {C23 x 0.5} and {C23 x 1.5}? agin, please mention all that you would try
*showcard C39a*

C45 Looking back at the description of the charge (on page X of the leaflet), how easy would you say it was to understand? *(prompt to code if necessary)*

(a) Very easy
(b) Fairly easy
(c) Fairly difficult
(d) Very difficult

C46 (***ask if answered c or d at C45***) What was particularly difficult about it? *(free text)……*

C47 Finally, I would like to ask you a hypothetical question! I want you to imagine there are two routes (A &B) to the same place, identical in all respects except the charge payable. Unlikely, I know, but please imagine they are identical
The cost of using route A varies randomly but you know that it is always somewhere between £1 and £2,
The cost of using route B is always £1.50, it never changes.
Which route would you choose?

(a) A
(b) B

C48a ***(ask if they chose (a) at C47)*** If you knew that the cost of B was {previous value minus 5p} which would you choose?" ***Keep on repeating C48a, reducing the cost of B by a further 5p each time until they choose B***

C48b ***(ask as follow up to C48a)*** If you knew that the cost of B was {previous value plus 1p} which would you choose?" ***Keep on repeating C48b, increasing cost of B by a further 1p each time until they choose A, then stop***

C49a ***(ask if they choose (b) at C47)*** If you knew that the cost of B was {previous value plus 5p} which would you choose?" ***Keep on repeating C49a, increasing the cost of B by a further 5p each time until they choose A***

C49b ***(ask as follow up to C49a)*** If you knew that the cost of B was {previous value minus 1p} which would you choose?" ***Keep on repeating C49a, reducing the cost of B by a further 1p each time until they choose B, then stop***

C50 That's it! But I do have one final optional question which I would like you to answer,), Which of the categories on the showcard (*showcard*c50) does your household's total income fit into?

| | Per Week | Per Month | Per Year |
|---|---|---|---|
| M. | Up to £259 | Up to £1124 | up to £13,499 |
| C. | £260 - £576 | £1125- £2499 | £13,500 - £29,999 |
| E. | £577 - £961 | £2500- £4166 | £30,000 - £49,999 |
| K. | £962 - £1,442 | £4167- £6249 | £50,000 - £74,999 |
| F. | £1,443 or more | £6250 or more | £75,000 or more |

**THANK YOU FOR YOUR TIME**

The following questions are included in the pre-pilot but would not be included in the main interview precise wording of questions to be suggested by BMRB.

# APPENDIX 4 - EXAMPLE OF CONGESTION CHARGING SCHEME PROVIDED TO DfT - QUESTIONNAIRE RESPONDENTS

## Congestion Charges Information (please also read notes overleaf):

**OUTER ZONE CHARGES –** The following charges would apply to all roads in the Outer Zone (shaded in Orange in Map 1):

| | |
|---|---|
| Green roads | 10 pence per mile} Applies During the Peak Hours (7.30 am to 10am & 5pm to 6pm) – free at all other times |
| Red roads | 15 pence per mile} Applies During the Peak Hours (7.30 am to 10am & 5pm to 6pm) – free at all other times |
| Other roads | 25 pence per mile} Applies During the Peak Hours (7.30 am to 10am & 5pm to 6pm) – free at all other times |

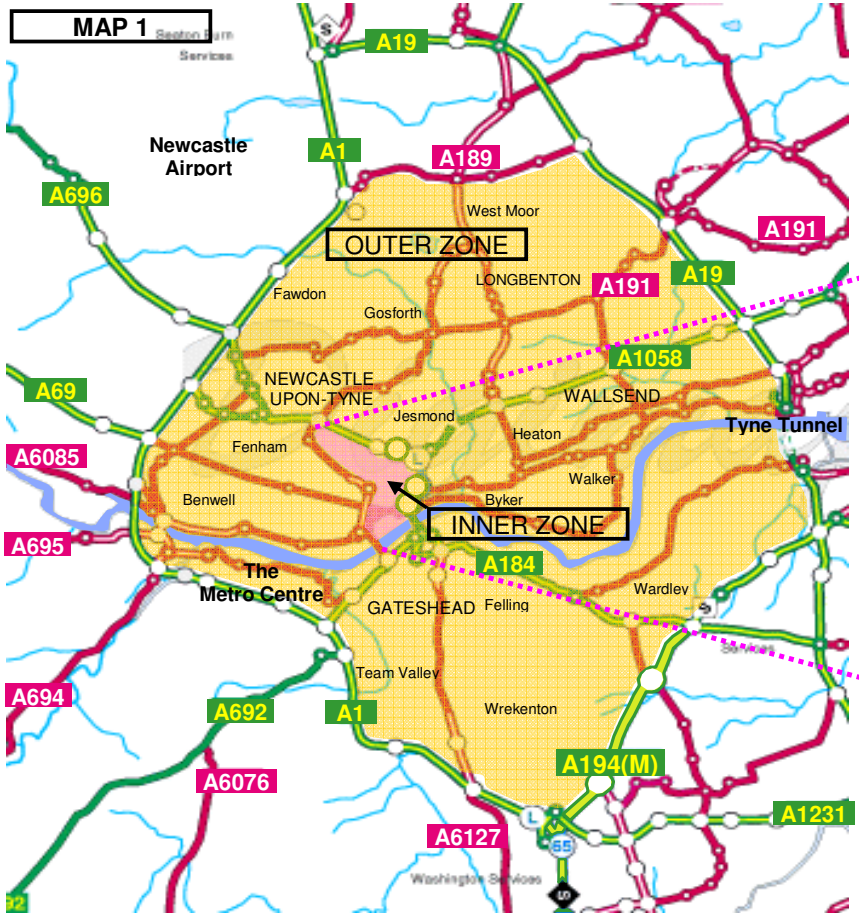
**INNER ZONE CHARGES –** A daily charge of **£2** to drive on any roads in the Inner Zone (shaded in pink in maps 1 & 2).
Please note that payment of this daily charge would cover you for multiple visits during that day.

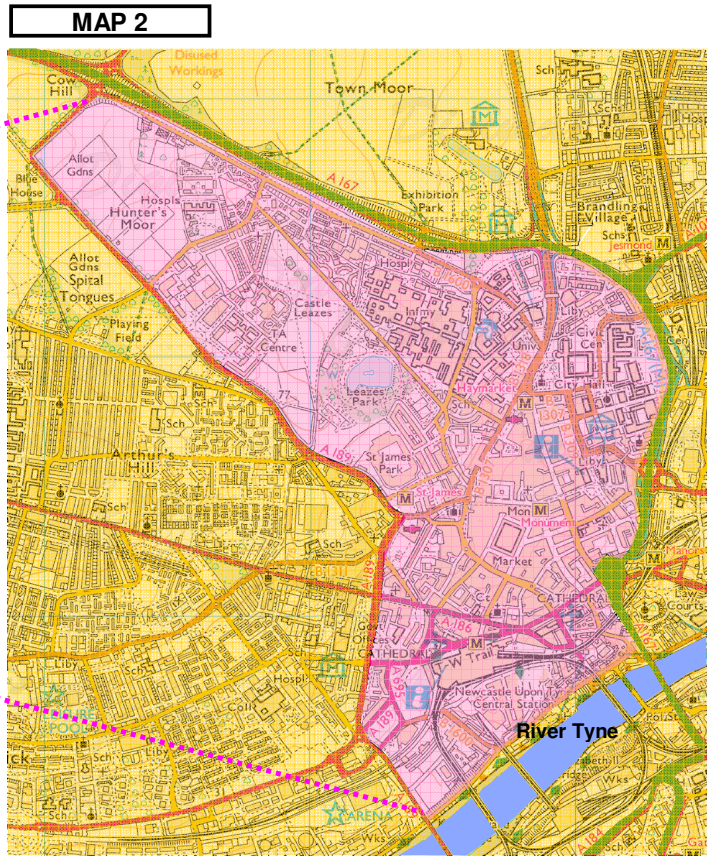
The initial screening sought respondents who:

(a) drove their own car to a specific destination from their home address a distance of at least 3 miles, between 7.30 am and 9.30 am in the UK & Greece, and between 7:00 am and 17:30 pm in Germany, on a regular basis (at least once a week);
(b) paid the costs for any of these journeys out of their own pocket (with no reimbursement from employers or the taxman); and
(c) entered or passed through the congestion charging area when making the journeys outlined in (a).

[2] The fact that our surveys indicate that a majority of people are risk averse, but only a minority appear to follow this through by avoiding exposure to charges which they cannot predict, is not inconsistent if it is accepted that the disengagement which prompts people to ignore the uncertain charges is, almost by definition, is incompatible with a careful assessment of risks.

[3] This analysis is restricted to data from Newcastle and Cologne because it relies on some data which is not available for Thessaloniki.



# APPENDIX 5 - DIFFERENTIATED CHARGING SCHEMES DRESDEN

| Charging Regime | Charge in cents per mile in specified zone and period: | | | | | | Summary | | |
|---|---|---|---|---|---|---|---|---|---|
| | Yellow zone (10 kms) | | Purple zone (5 kms) | | Red zone (5 kms) | | Number of zones | Number of time periods | True price (€) |
| | 0700-0800 | 0800-0900 | 0700-0800 | 0800-0900 | 0700-0800 | 0800-0900 | | | |
| | | | | | | | | | |
| 1 | 10 | 10 | 10 | 10 | 10 | 10 | 1 | 1 | 2.00 |
| 2 | 15 | 15 | 20 | 20 | 20 | 20 | 2 | 1 | 3.50 |
| 3 | 5 | 10 | 5 | 10 | 5 | 10 | 1 | 2 | 1.50 |
| 4 | 10 | 15 | 15 | 20 | 15 | 20 | 2 | 2 | 3.00 |
| 5 | 1 | 8 | 8 | 15 | 15 | 20 | 3 | 2 | 1.85 |
| | | | | | | | | | |
| 6 | 5 | 5 | 5 | 5 | 5 | 5 | 1 | 1 | 1.00 |
| 7 | 15 | 15 | 20 | 20 | 20 | 20 | 2 | 1 | 3.50 |
| 8 | 15 | 20 | 15 | 20 | 15 | 20 | 1 | 2 | 3.50 |
| 9 | 5 | 8 | 8 | 10 | 8 | 10 | 2 | 2 | 1.50 |
| 10 | 1 | 8 | 8 | 15 | 15 | 20 | 3 | 2 | 1.85 |

Note that the schemes were described in the simplest manner commensurate with containing sufficient information to define the charge. Thus, where the 0800-0900 charge was the same as that for 0700-0800, the period was defined as 0700-0900; when the same charge applied in the green and red zones, the purple zone was defined as a 10 km zone; and when the same charge applied in the yellow, purple and red zones, the yellow zone was defined as a 20 km zone.

# APPENDIX 6 - SAMPLE DESCRIPTION DRESDEN I

| Attribute | Category | n | % |
|---|---|---|---|
| Gender | male | 44 | 41.5 |
| | female | 62 | 58.5 |
| Age | 18 - 20 | 15 | 14.4 |
| | 21 - 25 | 51 | 48.1 |
| | 26 - 30 | 26 | 24.5 |
| | Over 30 | 14 | 13.2 |
| Employment status | Employed | 14 | 13.2 |
| | Self-employed | 3 | 2.8 |
| | Retired/ unemployed | 3 | 2.8 |
| | Student | 86 | 81.2 |
| Educational background | Hauptschulabschluss | 1 | 0,9 |
| | Real-/Mittelschulabschluss | 6 | 5.7 |
| | Abitur | 73 | 68.9 |
| | Fachhochschulabschluss | 7 | 6.6 |
| | Universitätsabschluss | 19 | 17.9 |
| Household Income per month | Up to € 500 | 58 | 54.7 |
| | € 500 - € 1.000 | 35 | 33.0 |
| | € 1.001 - € 2.000 | 10 | 9.5 |
| | More than € 2.001 | 3 | 2.8 |
| Travel via | Motor vehicle | 20 | 18.9 |
| | Public transport | 26 | 34.0 |
| | Bicycle | 43 | 40.5 |
| | On foot | 7 | 6.6 |
| Ways during leisure via | Motor vehicle | 24 | 22.7 |
| | Public transport | 33 | 31.1 |
| | Bicycle | 46 | 43.4 |
| | On foot | 3 | 2.8 |
| Personal involvement (city center) | Never | 39 | 36.8 |
| | Once a month | 23 | 21.7 |
| | Several times a month | 28 | 26.4 |
| | Weekly | 10 | 9.4 |
| | Daily | 6 | 5.7 |
| Personal involvement (peak hours) | Never | 51 | 48.1 |
| | Once a month | 29 | 27.4 |
| | Several times a month | 19 | 17.9 |
| | Weekly | 4 | 3.8 |
| | Daily | 3 | 2.8 |

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# APPENDIX 7 - DIFFERENTIATED CHARGING SCHEMES LEEDS

| Charging Regime | Charge in pence per mile in specified zone and period: | | | | | | Summary | | |
|---|---|---|---|---|---|---|---|---|---|
| | Blue zone (10 miles) | | Green zone (5 miles) | | Red zone (5 miles) | | Number of zones | Number of time periods | True price (£) |
| | 0700-0800 | 0800-0900 | 0700-0800 | 0800-0900 | 0700-0800 | 0800-0900 | | | |
| | | | | | | | | | |
| 1 | 10 | 10 | 10 | 10 | 10 | 10 | 1 | 1 | 2.00 |
| 2 | 15 | 15 | 20 | 20 | 20 | 20 | 2 | 1 | 3.50 |
| 3 | 5 | 10 | 5 | 10 | 5 | 10 | 1 | 2 | 1.50 |
| 4 | 10 | 15 | 15 | 20 | 15 | 20 | 2 | 2 | 3.00 |
| 5 | 1 | 8 | 8 | 10 | 15 | 20 | 3 | 2 | 1.85 |
| | | | | | | | | | |
| 6 | 5 | 5 | 5 | 5 | 5 | 5 | 1 | 1 | 1.00 |
| 7 | 15 | 15 | 20 | 20 | 20 | 20 | 2 | 1 | 3.50 |
| 8 | 10 | 20 | 10 | 20 | 10 | 20 | 1 | 2 | 3.00 |
| 9 | 5 | 8 | 8 | 10 | 8 | 10 | 2 | 2 | 1.50 |
| 10 | 1 | 8 | 8 | 10 | 15 | 20 | 3 | 2 | 1.85 |

Note that the schemes were described in the simplest manner commensurate with containing sufficient information to define the charge. Thus, where the 0800-0900 charge was the same as that for 0700-0800, the period was defined as 0700-0900; when the same charge applied in the green and red zones, the green zone was defined as a 10 km zone; and when the same charge applied in the blue, green and red zones, the blue zone was defined as a 20 km zone.

# APPENDIX 8 - SAMPLE DESCRIPTION DRESDEN II

| Attribute | Category | n | % |
|---|---|---|---|
| Gender | male | 70 | 46.7 |
| | female | 80 | 53.3 |
| Age | 18 - 20 | 51 | 14.4 |
| | 21 - 25 | 81 | 48.1 |
| | 26 - 30 | 14 | 24.5 |
| | Over 30 | 4 | 13.2 |
| Employment status | Employed | 1 | 0.7 |
| | Self-employed | 1 | 0.7 |
| | Retired/ unemployed | 2 | 1.3 |
| | Student | 145 | 96.7 |
| | missing | 1 | 0.7 |
| Educational background | Hauptschulabschluss | 1 | 0.7 |
| | Real-/Mittelschulabschluss | 1 | 0.7 |
| | Abitur | 138 | 92.0 |
| | Fachhochschulabschluss | 0 | 0 |
| | Universitätsabschluss | 10 | 6.7 |
| Household Income per month | Up to € 500 | 99 | 66.0 |
| | € 500 - € 1.000 | 42 | 28.0 |
| | € 1.001 - € 2.000 | 5 | 3.3 |
| | More than € 2.001 | 2 | 1.3 |
| Travel via | Motor vehicle | 2 | 1.3 |
| | Public transport | 14 | 9.3 |
| | Bicycle | 91 | 60.7 |
| | On foot | 28 | 18.7 |
| Ways during leisure via | Motor vehicle | 17 | 11.3 |
| | Public transport | 35 | 23.3 |
| | Bicycle | 61 | 40.7 |
| | On foot | 43 | 28.7 |
| Personal involvement (city center) | Never | 11 | 7.3 |
| | Once a month | 43 | 28.7 |
| | Several times a month | 47 | 31.3 |
| | Weekly | 42 | 28.0 |
| | Daily | 14 | 9.3 |
| Personal involvement (peak hours) | Never | 4 | 2.7 |
| | Once a month | 56 | 37.3 |
| | Several times a month | 55 | 36.7 |
| | Weekly | 29 | 19.3 |
| | Daily | 8 | 5.3 |