



DIFFERENT

**User Reaction and Efficient Differentiation
of Charges and Tolls**

DELIVERABLE D11.1 SYNTHESIS AND CONCLUSIONS

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EXECUTIVE SUMMARY

This Deliverable 11 summarises the main results of the DIFFERENT project.

In the European Union, levels and structures of transport infrastructure charges vary strongly across transport modes and countries. Some degree of convergence exists on the intention to apply the principle of marginal cost pricing in various transport sectors, but, in the presence of unsolved difficulties in funding transport investment and even serious concerns about marginal social cost pricing in several countries, any such convergence is slow. At present, the charging regimes that can be observed are often far from internalising external costs and are rarely based on efficiency principles.

In this situation differentiation of existing charges appears to be a sensible intermediate step. A possible way to increase the efficiency of pricing structures would be to take existing structures as a starting point and try to increase their efficiency by making them more differentiated. This may, however, lead to a number of questions such as: how differentiated should these price structures be in order to lead to efficiency gains, how do users react, what are the effects on equity and revenues, etc. The effects on revenues deserve particular emphasis here because in many countries there are plans to replace the existing system of taxed based infrastructure financing with a system based on user-charges

These questions, with a strong focus on user reactions, were studied both from the theoretical as from the empirical perspective. As far as theory is concerned, DIFFERENT made use of both, the *normative* and the *positive* theory of (transportation) economics. In addition, DIFFERENT made use of behavioural theories, taken from psychology, to study reaction of users to differentiated infrastructure pricing. The normative approach asks how pricing schemes should be structured to lead to a maximum of social welfare. The positive approach takes political realities into account (notably the reflection constraint faced by politicians and regulators, as well as the influence of special interest groups). Both approaches are complementary rather than contradictory. In the theoretical parts of DIFFERENT several hypotheses were developed about the optimal degree of differentiation of infrastructure charges, reflecting both economic approaches as well as the viewpoint of psychology. Using a fact-sheet methodology these hypotheses were then confronted with the empirical facts derived from the case studies carried out within DIFFERENT. Among the many results that emerged from this exercise the most important are (1) that pricing-schemes are rarely implemented in pure textbook forms but rather reflect a compromise between various aspects and approaches, (2) that there is an optimal degree of differentiation beyond which further differentiation is counterproductive, and (3) that a political influence on pricing structures is always discernible and therefore should not be disregarded in the design of pricing-structures.

The many case studies that have been undertaken within DIFFERENT have revealed a multitude of very interesting results. The most important result is probably the general one that pricing is effective, a result which is often denied in transport economics.

To be more precise, this general result should be conceived of as answering two different questions:

- Do price changes have any effect at all on travel behaviour and mode choice? (Under the expression "price change" it is subsumed here also the introduction of a toll, where there was only tax-financing before, e.g. the case of HGV toll in Germany)
- Does differentiation have any effect at all on travel behaviour and mode choice?

The evidence assembled within DIFFERENT shows that the answer to the first question must overwhelmingly be in the affirmative. For the second question the answer is less clear cut. The effects of price differentiation depend very much on the particular mode under investigation and the particular circumstances.

In the following the two questions will be addressed mode by mode.



Effects of Price Changes

Road

With respect to the first question, it can be said that in the case of interurban road transport the evidence shows quite clearly that price changes lead to changes in transport demand. In Germany the introduction of the HGV-toll has led to reactions with respect to route choice, the effective tonnage chosen, and logistics. In Italy modelling work showed substantial effects for the Brenner corridor and also important effects in the Padana region. Due to the different network structure in the two regions, the effects were different, but there can be no doubt that infrastructure pricing had substantial influence on travel behaviour. In Switzerland too the introduction of a toll on HGVs brought quite noticeable effects with it.

As far as urban car transport is concerned, the case studies showed considerable effects in all cases considered (see below) with the notable exception of Rome.

Railways

Unfortunately, the case of railways is very unclear, mainly due to severe data limitations. These data limitations are, of course, a consequence of the regulatory upheaval that the railway sector is currently running through. It can hardly be expected that in the present situation railway operators are very willing to reveal data that from their point of view must be considered as strategic. Probably the most reliable (or rather least unreliable) evidence that was gathered with respect to railways is the evidence on the effects of the so-called "regional factors" in Germany, which are part of the German network operator's (DB Netz) pricing policy. Here the "user reaction", however, is not so much the reaction of train operating companies, but rather the reaction of the public transport authorities which, in Germany, are responsible for putting urban transit services out for tender. The evidence shows that the public transport authorities reacted quite strongly to the introduction of the regional factors by closing lines.

Air

Air transport seems, so far, to belong to the exceptions with respect to effects of pricing. The results obtained in this project only reflect past and recent pricing policies, and in all cases investigated the effects of changes in starting and landing fees on the behaviour of airlines were rather limited. In the case of Hamburg airport the effect of the introduction of noise charges was even non-existent. The London and Gran Canaria case studies showed some effects of starting and landing fees, but these effects were limited. A closer look at the case studies reveals that the cost-share of airport-fees in the total costs of airlines is rather small, and it comes therefore as no surprise that airlines react rather inelastic to these fees. However, this is not to say that differentiation could not work in the future if charges became more substantial, and it would be premature to conclude that pricing in the airport sector is of no relevance for airlines.

Shipping (Ports)

The many case studies on ports show leave no clear picture. However, evidence was found that differentiation aiming at more environmental sound performance or mitigation of risk might be used as a tool within a wider group of tools or policy measures. There is also evidence that differentiation used for mitigating certain risks to improve environmental performance of shipping needs to be considered under a lifecycle approach in order to maintain effective over time. It needs to be assured that the institutional structure is sufficiently effective to react to market and framework changes and has the capability to adjust the differentiation scheme. It also seems to be advisable to discuss if ports are the most effective entity for implementation or if certain differentiation schemes could more effectively dealt with at an institutional level that takes into account the global structure and reach of the shipping sector (e.g. environmental differentiated charges).

Effects of Differentiation

In the following the question of differentiation will be addressed. Still, it can be said already here that there are effects of differentiation, but that the magnitude of these effects depends very much on circumstances.



Road

In interurban road transport the differentiation of the German and Swiss HGV toll according to axle weight and emission classes showed clear effects. In Germany, for instance, a trend towards smaller and cleaner trucks can be observed. In fact, the move to smaller trucks (which are exempt from the toll) has become so pronounced that there is discussion about extending the toll to vehicles under 12t. Similar observations were found in Switzerland.

For urban car traffic, the introduction of the highly differentiated charging scheme in Stockholm led to strong driver reaction; however, since the strongest traffic reductions were found in the hours with the lowest charge, further research is needed to explain this phenomenon. The London scheme at first sight seems not to be differentiated at all, but upon reflection it is clear that the difference between day-times where the charge applies and where it does not apply, amounts to differentiation. The evidence shows, that many car drivers adjust their behaviour accordingly (e.g. by postponing trips into the night-time). Strong effects of differentiation can also be observed in the cases of the HOT Lanes in the USA and in the case of Singapore.

Rail

As already mentioned above, the scarcity of data makes it very difficult to derive clear conclusions in the case of rail. The case of the regional factors in Germany may again deliver the most reliable evidence. The case study showed a clear correlation between differentiation and the behaviour of the public transport authorities. Simulation results based on a German engineering cost calculation model showed that varying the components of a two-part tariff for pricing network access resulted in substantial changes in demand of the freight transport operators.

Air

The Spanish case studies (Madrid Barajas, Gran Canaria) delivered evidence on substantial possible welfare effects of peak-load pricing. The Spanish case studies made also clear, however, that institutional constraints currently prevent these welfare gains from being exploited. The Hamburg case study concerning noise charges showed no effect at all, although this result is closely connected to the special political circumstances that surrounded the introduction of these charges in Hamburg, as is explained in the case study. The case of London has led the conclusion that there is relatively little competition between airports (at least among the London airports). Therefore, price differentiation does currently not seem to be a competitive parameter of airports.

Shipping (Ports)

It was said already, that port-dues amount only to a small share in shipping companies' overall voyage costs, which delivers a somehow similar picture to the results found in the airport case studies. Even though a clear direct impact of differentiation cannot be shown, it should be considered that differentiation, as in the case of environmental differentiated charges in Sweden, has contributed to greater awareness of the environmental challenges in the sector and in combination with other mechanisms has contributed to a shortened period of implementation of emission reducing technology in ships in a geographically limited area. However, the question remains whether the port level is the most adequate level for implementation of measures, which are aimed at delivering towards EU or even global policy goals.



1 INTRODUCTION

1.1 THE COMMON EUROPEAN TRANSPORT POLICY

From the point of view of the Common European Transport Policy, pricing policies in general, and pricing differentiation in particular, have been playing an important role. Over the past 18 years, in fact, from the EC Green Paper "Towards fair and efficient pricing in transport" (EC, 1995), to the recent Directive 2006/38/EC (EC, 2006) amending the Eurovignette Directive 1999/62/EC ON THE CHARGING OF HEAVY GOOD VEHICLES FOR THE USE OF CERTAIN INFRASTRUCTURES, the acknowledgment of the role of pricing differentiation in charging transport activities has become a milestone in the European transport policy.

In 1995, the Green Paper paved the way toward the internalisation of external costs in transport, and, by this way, toward the necessity of differentiating pricing according to the changing transport conditions, e.g. time period, type of road, vehicle technology, etc, whereas the previous discussion of EC pricing policy had emphasised maintenance and operating costs as the key elements to be taken into account in charging practices. The Green Paper also recognised the importance of pricing to reflect external costs and scarcities. The objective underlying the reforms advocated by the Green Paper was that *"Transport policies have in the past focused largely on direct regulation. Whilst rules have brought significant improvements in some areas, they have not been able to unlock the full potential of response options that can be triggered through price signals. Price based policies give citizens and businesses incentives to find solutions to problems. The Union's objective of ensuring sustainable transport requires that prices reflect **underlying scarcities** which would otherwise not be sufficiently taken into account. Decisions made by individuals with respect to their choice of mode, their location and investments are to a large extent based on prices. So prices have to be right in order to get transport right."*¹

Since then on, several EC documents; from the White paper on "Fair payment for infrastructure use", published in 1998 (CE 1998) to the recent mid-term review of the Common Transport Policy outlined in the White Paper "Keep Europe moving" EC (2006) have confirmed the use of pricing as the key driver for capacity allocation, associated to the use of other market-based instruments as transit rights in the environmental sensitive areas and in urban areas. Furthermore, a long stream of RTD research projects have provided valuable insights into the possibility to calculate the external costs of transport and the likely socio-economic impacts².

Concerning the EC documents, it is worthwhile to stress the above mentioned Directive 2006/38/EC, providing a new set of principles for road pricing (now extended to freight transport vehicles above 3.5 tonnes). The preambles of the Directive establish for example the principle that "A fairer system of charging for the use of road infrastructure, **based on the "user pays" principle** and the ability to apply the "polluter pays" principle, for instance through the variation of tolls to take account of the environmental performance of vehicles, is crucial in order to encourage sustainable transport in the Community".

Furthermore, the European Parliament committed the EC to deliver no later than 2 years after the entry into force of the Directive, a generally applicable, transparent, and comprehensible model for the assessment of all external environment-, congestion-, and health-related costs to serve as the basis for future calculations of infrastructure charges. This *in order* to ensure the future application of the polluter pays principle for all modes of transport, providing uniform calculation principles, based on scientifically recognised data, which will clear the way for the internalisation of external costs for all modes of transport.

¹ CE (1995), page i

² A basic but not exhaustive reference must include the following: PETS (1999), UNITE (2000), RECORDIT (2001), IMPRINT-EUROPE (2001), IMPRINT-NET (2005), GRACE (2006)



The related Communication from the European Commission is expected to be delivered in June 2008³ and it is likely to be expected that the pricing differentiation in charging the use of transport infrastructure will be enforced.

1.2 THE DIFFERENT PROJECT

In the European Union, levels and structures of transport infrastructure charges vary strongly across transport modes and countries. Some degree of convergence exists on the intention to apply the principle of marginal cost pricing in various transport sectors, but, in the presence of unsolved difficulties in funding transport investment and even serious concerns about marginal social cost pricing in several countries, any such convergence is slow. As stated in the Terms of Reference, at present, the charging regimes that can be observed are often far from internalising external costs and are rarely based on efficiency principles.

In this situation differentiation of existing charges appears to be a sensible intermediate step. A possible way to increase the efficiency of pricing structures would be to take existing structures as a starting point and try to increase their efficiency by making them more differentiated. This may, however, lead to a number of questions such as: how differentiated should these price structures be in order to lead to efficiency gains, how do users react, what are the effects on equity and revenues, etc. The effects on revenues deserve particular emphasis here because in many countries there are plans to replace the existing system of taxed based infrastructure financing with a system based on user-charges.

A key issue in putting differentiated charges into practice is the need for good understanding of user reactions to differentiated prices. The emphasis of the DIFFERENT project is on learning about user reaction from real-world cases. Hence a range of cases where price differentiation is actually applied will be studied. However, since in some sectors real world cases are scarce or lacking, use will also be made of Stated Preference research. In addition, in some cases, existing models will be used to analyse the effects of price differentiation, in particular, when long-term consequences of pricing structures are to be analysed.

An important dimension is that the infrastructure users who are directly confronted with an infrastructure charge try to pass on at least part of the effect to other actors, notably their customers. The latter's anticipated reaction to such a transfer will determine the infrastructure users' pricing policy as well as their own acceptance of the infrastructure charges. This aspect is of high potential relevance not only for the immediate downward and upward chain of reactions, but, moreover, for the ultimate economic effects of any differentiated charging system.

DIFFERENT, however has also a strong theoretical side. The theoretical inputs into the project mainly come from normative and positive economic theory as well as behavioural theory.

Normative economic theory (in the sense of the modern theory of pricing) is used to identify desirable charging structures from a welfare point of view. This, however, is not done in a "naïve" way, which neglects real-world frictions. Rather, newer models are employed that incorporate such real-world frictions, notably the costs of differentiation on the side of infrastructure operators, their clients (transport firms) and end-users (the indirect users of the infrastructure). Nevertheless, the approach here will still be normative in the sense that benevolent decision makers are assumed that put the normatively desirable charging schemes into practice. In other words, this theoretical part of the project provides answers to the question what type of (realistically) differentiated charging structures *should be* implemented that maximise welfare given certain real-world frictions and restrictions on maximum differentiation.

Positive economic theory complements the normative perspective by relaxing the assumption of benevolent decision-makers and allowing for the influence of all types of interest groups on the price-setting process. Influencing the policy process is also some kind of user reaction. Seen from this perspective, it may well be the case that less differentiated charging systems are more desirable,

³ The methodological study underlying the EC Communication can be downloaded by the DG TREN website http://ec.europa.eu/transport/costs/index_en.htm



because they lend themselves less easily to political manipulation. In other words: positive theory asks the following question: given political circumstances, given selfish motives of decision makers and given the influence of interest groups, what differentiated pricing structures *are the most likely* to be implemented and in how far will they be different from the ones identified by normative theory?

Behavioural theory goes even one step further by taking cognitive factors into account which may lead travellers, and - as has been shown in Switzerland - in some cases also freight operators, to make sub-optimal decisions, either because their ability to process complex pricing information is limited or because of 'irrational' patterns of behaviour.

The potential scope of price differentiation is broad. Some of the most important dimensions for differentiation are:

- Time, for example in the case of congestion or noise nuisance;
- Place, for example depending on congestion level or region;
- Type of infrastructure, to represent differences in quality supplied;
- Type of user and/or type of goods, to capture willingness to pay of clients;
- Type of vehicle and axle loads to take for instance maintenance costs into account.

For each of these dimensions, consequences of higher degrees of charging differentiation are investigated in the project.

Based on the above considerations concerning direct and indirect users, types of effects and dimensions for differentiation, and applied in a coherent way across transport markets, the overall aim of the DIFFERENT project can be summarised as follows:

- To improve understanding of user reactions to differentiated prices;
- To develop a scientifically sound approach to determine efficient differentiation of infrastructure costs based charging schemes and methods to assess their impact on user behaviour;
- To analyse and demonstrate the benefits and effectiveness of differentiated charging and taxation schemes as a means to manage mobility, externalities, equity aspects and to obtain revenues;
- To provide policy recommendations.

DIFFERENT's main objective is to study users' reactions to differentiated pricing. Results on user reaction, however, are not of interest *per se* but are useful only as inputs into the wider policy making process, notably the European Transport Policy (EPT).

The theoretical findings of economic and behavioural theory are of high relevance in this respect. Both approaches contrast within the project the classical "first best" and "second best" solutions to price-differentiation with the outcomes that can be realistically implemented in practice. Economic theory incorporates real-world frictions into the modern economic mainstream-models like the costs of price-differentiation and the selfish interests of policy makers, which make them susceptible to "differentiating" infrastructure prices according to the demands of interest groups. Taking real world frictions like these into account may make it preferable to implement less differentiated pricing schemes than "naïve" economic textbook theory would prescribe. Behavioural theory basically deals with the same question as economic theory, but from the special perspective of psychology. Here the research interest centres around cognitive limitations of the processing of complex pricing-information and the constraints to acting accordingly. The first task of this report will therefore be to summarise these findings in concise form and to draw tentative conclusions from them.

In the second task of the final report, these tentative findings will have to be confronted with the results of the case studies and the modelling work made within the whole project. All of these Work Packages have a strong focus on the estimation of demand and cost elasticities. The estimation of demand and cost elasticities goes hand in hand. The demand for transport is a derived demand. The "price" of transport as seen from the shippers' or users' perspective is therefore its cost. In order to derive hypotheses concerning demand elasticities it is imperative to derive estimates about how price-differentiation in the transport sector affects costs in the transport-using industries.



SYNTHESIS AND CONCLUSIONS

The estimation of demand and cost elasticities is not the only purpose of the case studies, however. The estimation of demand and cost elasticities also serves the ultimate goal, which is to answer the question in how far the pricing-models that seem to be most desirable and practical from the perspective of economic and behavioural approach will achieve certain economic and political ends.

Among the economic goals are cost recovery (or at least deficit reduction) and welfare improvements. Among the political goals are fairness and efficiency, reduction of environmental harm, universal service and others.

The final task in this report will draw the overall policy conclusions and recommendations from the whole project. This will be done with a special eye on the EPT. Of particular interest is the question of cost-recovery which has strong implications for private investment and public policy. The ability to cover infrastructure cost also has consequences for the question of subsidiarity and the federal distribution of the financing of infrastructure building and maintenance. Price differentiation may also have strong consequences for interpersonal and regional equity. It has been shown already in other studies that road-pricing may have important effects on the distribution of economic welfare among travellers. Likewise price-differentiation for interurban roads may not be an optimal policy in poorer regions. Insofar price differentiation also has direct logical connections with the political goal of "universal service". Other important areas that are affected by the results in DIFFERENT are modal shift (private vs. public transport, roads vs. railways, land vs. sea, etc.) and environmental sustainability. It may well be possible, for instance, that differentiated infrastructure prices already go a long way towards a better balance between road and rail (as postulated in the Commission's White book "Time to Decide") and the reduction of the environmental harm caused by transport.



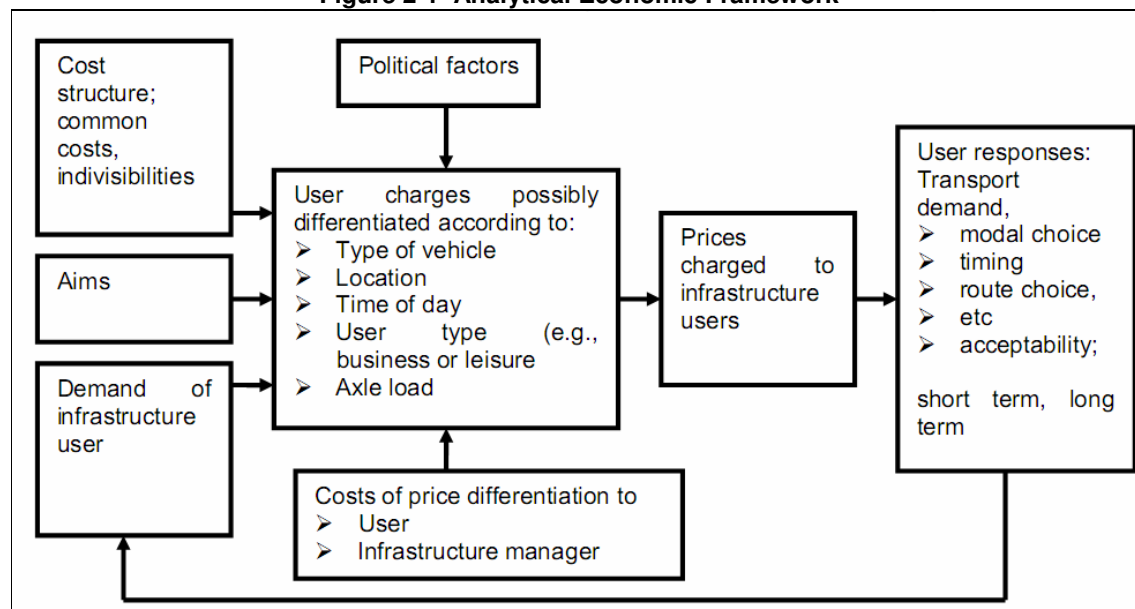
2 THEORETICAL BACKGROUND

2.1 ECONOMIC FACTORS

2.1.1 Introduction

Figure 2-1 provides the analytical framework of the economic factors that playing a decisive role, when infrastructure charges are to be set.

Figure 2-1 Analytical Economic Framework



Source: D.3-1 of the Different Project

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Figure 2-1 illustrates normative arguments explaining differences in price structure. Objectives among infrastructure managers and operators may be different. Also the existence of a certain cost structure of the transport industry (in particular scale economies) has implications for pricing. Demand and demand elasticities of the infrastructure user are also of high relevance for differentiation. But there also other issues that are relevant for user charge differentiation. Policy makers may well affect price setting in transport. This explanatory variable leads to the positive approach, which assumes, that policy makers pursue also privately motivated interests (e.g. re-election). Finally also practical issues are important. For instance, first-best pricing remains a theoretical benchmark because implementation is very costly and possibly too complex to be understood by the infrastructure user.

The effects of price differentiation (i.e. the user responses) may be varied and depend on the type of differentiation and the prices charged to the final user. In between the type of differentiation and the consumers' response we should pay attention to the actual price that is charged to the user. Charges may be passed on to more indirect users (although this may not always be possible, depending on the degree of competition, as is well known from the theory of taxation). For instance, firms confronted with a certain type of road charge will usually apply a mark-up on the price of their products with the consequence that the road toll is indirectly paid by the customer. Similarly, employers may decide to compensate employees for increased commuting costs, which affects their traveling behaviour.

This subsection deals therefore with normative and positive economic aspects with respect to price differentiation.



2.1.2 Normative Theory of Price Differentiation

As already described above, economic theory provides a vast range of constraints to be taken into account when designing price structures. In the following these constraints will be described briefly.

First-Best Pricing in Transport Infrastructure and its Limitations

Following the objective of economic efficiency, the allocation of resources in an economy has to be optimised. An allocation is said to be first-best, if it maximises social welfare subject to technological constraints of production. The optimal result implies that transport services are being provided up to the point where marginal benefit equals the provision cost of the same unit. Prices should therefore equate marginal social cost.

Marginal cost based prices should reflect with respect to differentiation the different levels of marginal costs caused by individuals. Therefore differentiated first-best pricing rules should vary according to several principles, e.g. the technology used, the actual state of the transport vehicle, the distance, time of transport activity, regional considerations, route chosen, etc. Taking all these principles into account simultaneously raises complexity and is counterproductive.

In addition this rule as market equilibrium requires certain conditions: perfect competition, no distortions in other market segments, no externalities, perfect information, and no subsidies or indivisibilities of demand and supply. However, one can easily see that these assumptions will rarely be met in reality. Nevertheless, the result can be utilised as a benchmark for more realistic pricing approaches.

Without regulation, it is very unlikely that the transport market will price at social marginal cost level, so that social welfare will not be maximised. Observable market failures are as follows: economies of scale, indivisibilities, imperfect competition, existence of common and joint costs, externalities, equity concerns, and imperfect information.

Economies of scale arise due to the fact that capital costs are considerably higher than operating and maintenance costs for the infrastructure provider. Further, infrastructure investment can be considered as sunk cost, since it only has a few utilisation alternatives. In the case of economies of scale revenues of marginal cost prices do not cover average cost and it comes to a deficit. The budgetary problem can be solved by Ramsey pricing. Prices then do not deviate too much from efficient pricing. But problems of fairness and possible exploitation of market power may arise, since customers with lower price elasticity of demand have to bear a higher mark-up on marginal cost than customers with high price elasticity of demand. To avoid resistances, some form of average-cost pricing has to be taken into account.

Regarding indivisibilities, capacity can only be increased in relatively large indivisible units due to the fact that additions to physical capacity are often extremely costly. Prices equalling marginal costs in the short run (without capacity extension) may differ from long run costs, when capacity extension costs have to be recovered. Additionally, prices not equalling actual marginal costs will cause inefficient use of capacity.

Existence of scale economies and indivisibilities in the provision of capacity lead to a situation of limited competition, where it is very likely, that a monopoly dominates the market. Although a natural monopoly produces at least average costs there are concerns regarding exploitation of market power, resulting in prices above optimal level. In order to maximise welfare, the government has to intervene either by directly providing the transport service or by regulating prices.

Often transportation firms are multi-product firms which utilise the same production facilities for the production of different services. So many costs can be considered as common or joint costs. The allocation of these costs between products is not always clear and can cause several pricing problems, since determination of marginal costs can then be ambiguous.

It is well known that transport leads to emission of noise, accidents, pollution, and congestion. Because activities of one group (e.g. transport consumers or producers) unintentionally affect the welfare of another group (persons concern of above mentioned effects) without any payment or



compensation being made, externalities arise. Often externalities have negative effects on persons concerned and therefore personal marginal cost lie below social marginal cost. Due to this, the output level is higher than optimal. Externalities have to be internalised by taxes or charges to achieve welfare maximisation.

Finally, equity concerns can arise. Marginal cost pricing lead to a highly differentiated pricing system where no one transport user pays the same price which may be perceived as unfair. For acceptability reasons the resulting pricing scheme is likely to differ from optimal pricing.

Constraints of First-Best Pricing: Second-Best Pricing

Due to above mentioned market imperfections, first-best pricing is of limited practical relevance. Further, the real-world situation including technological, acceptability, institutional, legal, financial, and political constraints force regulators to apply second-best pricing (prices that are available optimally under the constraints applying).

As result of the discussion above economic research has focused on second-best pricing practices. The use of cordons around cities instead of tolling each single road in a network, or the use of step charges instead of smoothly time-varying charges are two examples of second-best pricing. Several models examining effects of second-best pricing with respect to differentiation are available. The Bottleneck model (see Arnott, de Palma and Lindsey, 1990) which examines congestion appearances and the more general TREMOVE modelling framework, which deals with externalities are two examples.

Nonetheless there are several barriers to second-best pricing:

- *Public and political acceptance* for example results from limited perception of congestion charges by car drivers and an apparent inequality of fairness when applying differentiated charges. Politicians therefore avoid implementing such pricing schemes to secure voters' support.
- *Institutional barriers* may arise when more than one regulator is authorised to implement charging systems. Then some form of tax competition is likely to emerge.
- *Technological barriers* may arise if the resulting pricing scheme requires better pricing and monitoring technologies than currently available to properly observe costs.

The following subsections will present the factors affecting price differentiation within the second-best environment.

Transport Demand and Supply

Transport obviously differs from other goods with respect to its characteristics. In most cases transport demand is not really demanded in its own right (see Button, 1993), e.g. people usually have to travel to obtain benefits at the final destination. Additionally, transport demand is not constant over time and certain peak periods can be observed. And although in the long run capacity may also be variable, the fixed capacity in the short run may lead to appearance of congestion.

The market price in a competitive environment is determined by demand and supply and in the equilibrium price will equal the production cost. Applying elementary economics, price will be equated with the marginal cost in the long run. But in case of the transport market this is not likely to happen due to the infrastructure cost structure which is characterised by economies of scale. Therefore monopoly is likely to arise in various degrees.

Objectives of Pricing

There are several motivations for and aims of price differentiation in transport markets.

The first possible aim of pricing is economic efficiency. In the world of *normative economics* governments seek to maximise welfare of all citizens. Therefore in a first-best world, optimal charges equal social marginal costs. Due to the fact that these costs can be very detailed and highly differentiated, first-best pricing needs very much information and can become very complex.



Alternatively, pricing can aim at profit maximisation. While pursuing profitability objectives, it is obvious that the resulting differentiated pricing scheme will differ from that of welfare maximisation.

In contrast to this, publicly owned firms have a stronger focus on cost coverage often for political or fiscal reasons. To do so, a mark-up on marginal costs has to be determined, so that the pricing scheme probably resembles the Ramsey pricing structure.

Taking the issue of environmental sustainability into account, pricing can have the objective of protecting the environment. Pricing measures can be able to cope with transport's environmental effects.

Another objective of pricing measures can be equity. Considering public transport, subsidies to certain groups of society can achieve a basic level of mobility for every member of the society.

Finally, governments can follow macroeconomic policy objectives, focusing mainly on the level of unemployment, the rate of inflation, the balance of payments, and the growth rate of national output (see Stiglitz and Driffill, 2000). Affected by this are investments in transport infrastructure and the pricing of transport services.

Cost Structure

Most of the relevant cost structure elements were already discussed above. However, the presence of scale economies and common costs deserves special attention.

On the supply side, one has to distinguish the provision of transport infrastructure from the transport service. While the latter can be considered as relatively low in operational cost, the former is extremely long-living and fixed cost is very high. That leads to the presence of economies of scale and natural monopolies. When pricing at marginal social cost the problem of deficit is very likely to emerge. Ramsey pricing or multipart tariffs with differentiation elements according to the major cost drivers are often second best solutions in order to take the deficit problem under control.

Common costs are another cost element which may have an impact on differentiation. Since infrastructure companies are often multiproduct firms they use often the same inputs in order to provide different services. For instance start and landing charges of an airport may be differentiated according to the aircraft weight, the landing time, etc. because of the different utilisation of runways.

User Reactions from the Normative Perspective

User reactions to infrastructure charges depend on the specific design of the charging scheme. If for instance cars are charged with a tax, the effects on travel frequency are expected to be less considerable than in the case of a kilometre based charge. Strongly connected with this issue is also the demand elasticity (price sensitivity) of infrastructure users with respect to each pricing measure. As possible user reactions (changes of travel behaviour) the following are identified:

- Trip suppression;
- Changes in schedule of daily activities;
- Choice of different routes;
- Changes in modal split;
- Changes in occupancy rates;
- Spatial choices related to relocation;
- Vehicle ownership;
- Technology choice;
- Changes in destination choice;
- Class choice (for public transport).



In addition, elasticities can be proved to be very useful means, when designing a pricing scheme. However, elasticities should be always seen under the prevailing circumstances. The elasticity of a pricing measure per se does not exist.

In general the following factors affect elasticities:

- Type of price change. Road tolls may for instance have an impact on the route travelled and/or the destination.
- Type of trip and traveller. As an example, trips for commuting purposes are less price elastic than trips for leisure purposes.
- Quality and price of alternative routes, modes and destinations. If alternative routes are supplied at good quality and affordable prices, then price elasticity tends to be higher.
- Time period. In the long run demand elasticity tends also to be higher than in the short run, because users can meet long term decisions taking into account also pricing issues.
- Type of price change.

2.1.3 Positive Economics

Positive Theory of Regulation

Positive economics differs from normative theory for various reasons. For example positive economics takes into account that regulators or policy- or decision-makers maximise social welfare as well as their own private welfare. The resulting policy will therefore deviate from solutions of normative theory, since policy-makers try optimising their own utility which often implies at the same time to satisfy important social groups. The crucial motivation for acting like this is the aim to get elected or re-elected. The groups influencing the decisions of policy-makers are known as special interest groups (SIGs). SIGs try to influence decision-makers and thus interfere with the political process.

The reasons for the existence SIGs' are mainly the powerlessness of a single voter (SIGs' members unite to gain higher voting power) and the aim of controlling politicians (corresponding costs are too high for a single voter but decrease per head with increasing group size). The available measures of SIG's to influence politicians are information supply, campaign contributions, and public promotion of their favoured policy (e.g. via the media).

Through supplying information to the politician a special interest group gains access to the decision-maker. Due to this opportunity the SIG is able to utilise information asymmetry (SIGs can provide more detailed information for the decision-maker) to persuade the politician to realise their favoured policy. An alternative way for achieving the same goal is campaign contributions. Additionally, with this instrument it is also possible to affect the voting behaviour of influenceable voters, who are still undecided. Obviously it is very likely that more than one SIG will emerge to influence political process. Formal studies of the political effects of SIGs have their origin in a study by Friedlaender and Stigler (1962) on the effectiveness of special interest groups' actions. Based on this study several other models were developed in the recent decades.

One of the most important models is the Stigler/Peltzman model (1976) which developed the concept of "regulatory capture", stating that the regulator becomes an instrument of the regulated industry after a while. Reasons for this phenomenon are that on the one hand policy-makers gain votes from supplying regulation and on the other hand regulated firms profit from regulation due to limited competition which induces them to give campaign contributions to politicians. Whereas firms can form small and efficient interest groups, consumers are not well informed about regulatory actions and for them it is harder to establish efficient interest groups, due to high organisation costs. The basic outcome of the Stigler/Peltzman model is that the policy-maker maximises her own utility (taking into account both the support of firms and voters) under the constraint that firm's and voters' welfare (level of profit respectively price level) should be maximised as far as possible. The resulting solution produces a level of price neither at the competitive nor at the monopoly level, but somewhere in between. At this price level, political support is at its maximum.



The model of Becker (1983, 1985) examines the outcome of a political process with more than one SIG involved. The final decision in equilibrium is affected by the political pressure which competing special interest groups are able to exert. This pressure depends on the benefits the members of the group can potentially receive. A critical issue here is the free rider problem, emerging with an increasing number of group members.

Further, Keeler (1984) in his model advanced the theory one step further by combining normative as well as positive features, enhancing the Stigler/Peltzman model by implementing additional information about consumer surplus.

Grossman/Helpman gave this type of theory its modern form by formulating it in terms of modern game theory. They follow Keeler's track by combining normative and positive policy elements and examining political interaction of policy-makers and interest groups. In their models one or more interest groups can affect the policy by campaign contributions. In order to behave optimally SIGs have to estimate the effect of various levels of contribution. The policy-maker's chosen policy has consequences for her future career and her chances to get elected or re-elected. By maximisation of all actors' involved an equilibrium is reached, determining an optimal level of contributions and an optimal policy set.

The general outcome of the mentioned models trying to describe the decision of policy-makers under the influence of special interest groups is a policy which maximises a weighted average of social welfare and individual utility of the decision-maker.

User Reactions from the Positive Perspective

So far, the above mentioned models only consider effects of political interaction of policy-makers and special interest groups with respect to the price level. With respect to infrastructure charges not only the resulting price level of a political process is important, but also the price structure.

In the existing literature very few models deal with the influence of Special Interest Groups on tariff structure. Laffont and Tirole (see Laffont/Tirole, 2000) research the impact of an inclusion of externalities in the Ramsey formula and Laffont (see Laffont, 2000) compared welfare effects of the Smith pricing rule and a two-part tariff, if SIGs alternate in power.

The theoretical work in WP 3 used the main element of the Grossman/ Helpman approach described above, notably that the finally implemented policy will be a weighed average of normative and positive economical elements, and applied it for the case of infrastructure charges. SIGs have different manipulation opportunities with respect to different pricing schemes.

In principle, all existing pricing schemes can be divided into two major groups: cost-based pricing schemes and demand-based pricing schemes.

Beginning with the former group, it has to be noted that SIGs have always the opportunity to manipulate the cost calculation method in favour of the group members by providing adequate information to the decision-maker. Although a huge variety of infrastructure cost calculation methods exists, no generally accepted technique exists.

Therefore, if marginal cost pricing is implemented, social optimal price differentiation can become very difficult. It is likely that special interest groups will try to raise the level of differentiation by adding cost dimensions that work in their favour.

Fully distributed cost pricing can be considered as comparatively resistant to manipulation, although the cost calculation method can still be affected by political interference of SIGs. Due to its foundation on consumer behaviour the method of cost distribution on the basis of output shares, revenue shares, or cost shares is founded on relatively objective data and therefore minor lobbying action is expected. Therefore distortions when implementing one of these three cost distribution methods are relatively low.

The group of demand-based pricing schemes uses demand characteristics like elasticities to efficiently allocate resources.



Ramsey pricing is an example for a pricing scheme directly using demand elasticities to determine prices for different user groups (inverse elasticity rule). In addition to the opportunity to manipulate the cost calculation method (information on marginal cost is still needed) SIGs will try to influence differentiation of the tariff to a higher extent than in the case of fully distributed cost pricing. The reason lies in the fact that different user groups also will pay different charges for the same service due to different demand elasticities. Obviously this tariff structure will be perceived as unfair by the group facing higher charges. Given that the policy-maker still wants to maximise voters' support, she then possibly compensates the disadvantaged group by additional price differentiation. Furthermore, positive externalities can inverse the Ramsey pricing rule. Therefore the respective special interest groups will try to convince decision-makers that certain externalities exist.

Laffont and Tirole (2000) have objected against this type of argument that Ramsey prices do not have to be set by regulators themselves but will automatically be set by the firms involved if the regulator chooses price-cap regulation as regulatory mechanism. The regulator just sets the "right" price cap and the firm will respond by setting Ramsey prices in turn. But this will reduce the influence of SIGs because under this regime it is the firm that decides on pricing, not the regulator or politician.

This argument is certainly right (provided the regulator is indeed able to find the correct weights in the price-cap formula, see Laffont and Tirole loc cit) but it is unrealistic. Transport pricing always involves the political level because the users always form a major part of the voting population. Thus transport prices are always "political prices". Several examples (e.g. the famous case of the M1/M15 and M5 motorways in Hungary) bear this out. Thus, it is unlikely that infrastructure providers can act in a political vacuum.

Very common in transport are highly predictable peak and off-peak periods of demand, a fact utilised in Peak Load pricing. Since off-peak users only have to bear marginal cost in contrast to off-peak users paying marginal cost plus infrastructure capacity cost, SIGs will try to shift financial burdens. Off-peak users will therefore take an attempt to declare marginal cost as infrastructure capacity cost, while on-peak users want to switch capacity costs to marginal cost. It is also possible that tariffs are further differentiated according to vehicle type in order to weaken disadvantages of politically important on-peak user groups.

Non-linear pricing providing multipart tariffs can also be affected by political intervention of special interest groups. Given the fact that fixed cost are represented by the fixed charge component and marginal costs are represented by variable components of the tariff SIGs now try to enhance the welfare of their members through shifting proportions of fixed and variable components of the charge. Additionally, in case of airport landing fees, airlines focus on a higher level of variability of the charges, which is comparable to implementing more differentiation.

2.2 PSYCHOLOGICAL CONSTRAINTS

2.2.1 Introduction

From a psychological point of view, 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. Due to the fact that people do not just react "rationally" to transport infrastructure charging, it is important to understand and predict user reactions towards differentiated pricing to know what processes are behind these reactions. 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 of a pricing system. The organism (O) symbolises the psychological determinants in terms of cognitive, motivational, situational and personal factors and finally the reaction (R) represents mobility or travel behaviour.



2.2.2 Cognitive 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 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.

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 (see Bonsall et al., 2004).

2.2.3 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.

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:

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



- 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;
- 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;
- 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;
- 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.

2.2.4 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 "maximisers" and "satisficers" (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.



2.3 CONCLUSIONS FROM THE THEORETICAL ANALYSIS – FORMULATION OF HYPOTHESIS

The analysis made above has identified the factors that play a decisive role, when designing charging schemes, and therefore are essential for differentiation. Normative economic theory identified three main dimensions which must be taken into account:

- Aims of pricing;
- Cost structure;
- Demand of infrastructure user

In addition, positive theory added the political dimension of pricing. Finally, cognitive factors were contributed by behavioural theory.

Based on these theoretical findings the following (rough) hypotheses are formulated⁴.

Starting with the normative approach, and taking into account aims of pricing it can be concluded that, first, equity consideration will lead decision makers to apply a pricing scheme, in which disadvantaged users are confronted with lower charges compared to other users. Second, efficiency considerations as an objective will automatically lead to marginal cost (or marginal based cost) pricing schemes. If additionally price setting actors aim at cost recovery, then efficiency considerations will lead away from average cost pricing and towards more differentiation. Third, profit maximisation monopolists will adopt pricing structures that reflect the willingness to pay of the sub-groups concerned. As a result the following general hypothesis is formulated:

General hypothesis 1 *The degree of price differentiation adopted by a certain actor depends on factors such as the aims of actors setting the prices (infrastructure managers, transport companies, governments), demand parameters, cost structures and the political context.*

To be more specific, D3.3 formulated the following hypotheses:

H.1 *The higher the weight that price setting actors attach to equity considerations, the more they will be inclined to apply price differentiation where customers that would deserve support from an equity perspective will be confronted with low charges compared with other customers.*

H1.2 *The higher the weight that price setting actors attach to efficiency considerations, the more they will be inclined to apply price differentiation where prices reflect the marginal costs of transport (for example, marginal congestion costs, marginal maintenance costs).*

H1.3 *Consider the case where cost recovery is imposed on price setting actors (for example infrastructure managers). Given the side condition of cost recovery, the higher the weight that price setting actors attach to efficiency considerations, the more they will be inclined to deviate from average cost pricing, implying a move towards differentiated pricing structures.*

H1.4 *Profit maximising monopolists will use price differentiation based on willingness to pay in various sub-markets.*

Taking cost structures into account the following propositions can be stated: First, if the costs of differentiation are extraordinarily high, then price setting agents will adopt simpler pricing schemes that allow a cheaper implementation. Second, scale economies will induce a situation, in which pricing schemes according to the users' willingness to pay will be adopted. The respective hypotheses formulated in D. 3.3 are as follows:

H1.5 *When the costs of price differentiated charging mechanisms are high for the price setting agents, they will choose simple (cheaper) charging mechanisms as second best strategies.*

⁴ For specific and fine differentiated hypotheses see D. 3.1, D.4.1 and D.10.1



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H1.6 *When transport cost structures are characterised by increasing returns to scale monopolistic tendencies will prevail more than in the case where increasing returns to scale are absent.*

The consideration of demand conditions results in the emergence of market structure as a very important constraint on differentiation. More differentiation can be only applied if differences in demand elasticities between the user groups occur.

H1.7 *The more monopolistic power of the price setting agent, the higher the probability that price differentiation will be applied between different user groups.*

Further, as above analysed, pricing schemes in transport have an effect on user reactions. In addition the effectiveness of a pricing measure depends on its degree of differentiation. As a result the following general hypothesis on the consequences of differentiation can be formulated:

General hypothesis 2 *The degree of differentiation of transport prices has an effect on user responses in terms of travel behaviour (for example modal choice, trip generation, temporal choice) resulting in changes in transport flows, the efficiency of the pricing measures and the level of acceptance of the measures.*

Effectiveness of a price measure increases with the level of differentiation, but after a certain level, the effectiveness stabilises or may even decrease due to the various decision making costs users experience due to differentiation (see Figure 2-2). The negative counter effect is stronger in passenger transport compared with freight transport. And it is stronger for frequent users compared with infrequent users. Exemptions to pricing schemes have an adverse effect on their effectiveness, but they enhance acceptance.

In particular the following specific hypotheses are formulated (taken from D. 3.3):

H2.1 *Effectiveness of a price measure increases with the level of differentiation, but after a certain level, the effectiveness stabilises or may even decrease. The negative counter effect is stronger for individuals (e.g. car drivers) paying the charge compared with companies (e.g. rail freight operators). And it is stronger for frequent users compared with infrequent users.*

H2.2 *Exemptions to pricing schedules have an adverse effect on the effectiveness of the price measures.*

H2.3 *When price differentiation takes place in a certain domain (for example time differentiated tolls), the strongest behavioural response takes place within the same domain (change in departure time). Effects in other domains tend to be smaller.*

H2.4 *In the context of efficiency oriented or profit maximising price differentiation, the acceptance of pricing schemes decreases with the level of differentiation. The negative effect on acceptance is stronger in the case of public price setting agents.*

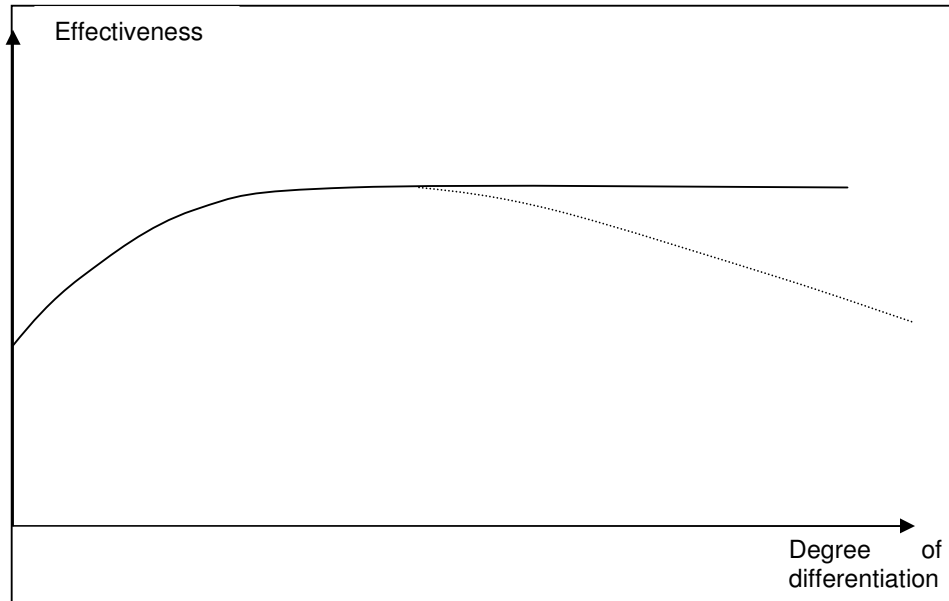
H2.5 *In competitive markets the burden of differentiated transport pricing is passed on from carriers to shippers. This is often not well understood by parties involved, implying an overestimate of the cost increasing effects which hampers acceptance.*

H2.6 *In the case of equity oriented pricing policies, the level of acceptance of pricing schemes increases with the degree of differentiation.*

H2.7 *Exemptions to pricing schedules improve their acceptability.*



Figure 2-2 The Relationship between the Degree of Differentiation and Effectiveness



Turning to the political context of infrastructure charges the positive economic analysis resulted in two basic axioms:

Basic axiom 1 *The setting of Infrastructure-tariffs will always be subjected to a strong political element. The positive theory aspect of setting infrastructure charges is therefore highly relevant. Lobbying activities will be a major explanatory variable for the tariff structure that will finally be implemented.*

Basic axiom 2 *Policy makers will react to lobbying influences and implement a kind of SIG equilibrium (like in the Stigler-Peltzman model or the Grossman/Helpman model described in Del. 3.3). Infrastructure charges which correspond to such an equilibrium may be termed "politically acceptable". In most cases this rules out tariff-structures, which increase the welfare (as compared to the status quo ante) of only one SIG even if total welfare effects should be positive.*

From these axioms the following specific hypotheses can be derived:

H3.1 *The structure of infrastructure charges always reflects the political power of Special Interest Groups (SIGs). A regulatory charging system will only conform to normative pricing principles if this charging system also corresponds to a political SIG-Equilibrium.*

H3.2 *More differentiation makes it easier to reach a SIG-Equilibrium. Therefore, in a tariff setting process with many SIGs, tariffs will tend to become more differentiated (notwithstanding that one or another SIG will lose from the tariff structure).*

- a. *If the implemented pricing scheme is on the basis of marginal costs then attempts at tariff manipulation will take the form of increasing the number of the cost categories that enter into the calculation of the charging system. The observable degree of differentiation with respect to different cost categories will depend on two factors: the question in how far total lobbying expenses for a particular group increase or decrease, and the voting power of the concerned SIGs. The more powerful group will succeed in implementing the charging system that minimises its own expenses.*
- b. *If non-linear pricing is implemented, and if there are many SIGs, then both, the fixed and the variable component of the tariff will tend to become more differentiated.*



H3.3 *Different proposed pricing rules lead to different behaviour of SIGs:*

- a. *An implementation of non-linear pricing will induce the SIGs representing the users of the infrastructure to lobby for a lower fixed component of the tariff and a higher variable component. In doing so, they can shift a larger burden of the capacity risk on the infrastructure owners. The infrastructure owners will do the opposite.*
- b. *Ramsey pricing leads to attempts to manipulate information on elasticities and to bring real or apparent externalities into play. In some cases this may even lead to inverse Ramsey pricing.*
- c. *Taking SIG influence into account, fully distributed cost pricing methods will cause comparatively less welfare distortions than other pricing schemes (see Laffont 2000).*
- d. *If peak load pricing is the intended pricing-policy then SIGs representing the peak-users concentrate their activities on shifting capacity costs to marginal costs (e.g. by producing corresponding studies etc). The SIGs representing off-peak users will do the opposite.*

From psychological point of view and 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 (S-R), and sub-hypotheses, concerning determinants which describe psychological factors that affect behavioural responses on differentiated charges (S-O-R). 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, but which are not included in the hypotheses. As it is not possible to observe all of the described aspects within the DIFFERENT Project, the focus is on those variables which may be the most important ones. Following hypotheses have been formulated:

H4.1 *The differentiation of a pricing scheme and its presentation (framing) affects individuals' behavioural adaptation to the pricing scheme over and above the effect of the price level.*

- a. *There is a point, beyond which, the more differentiated a price structure, the less behavioural adaptation will occur.*
- b. *The modus of payment (e.g. presentation as an incentives or a loss system) has an effect on behavioural adaptation.*

H4.2 *The cognitive elaboration of a pricing scheme, and thus the latter behavioural adaptation is determined (restricted) by capacity limits of human information processing and depends thus, among others, on the degree of differentiation of the scheme.*

- a. *The occurrence of errors in estimating prices will be a positive function of the differentiation of the price structure.*
- b. *Pricing schemes which include differentiation elements which are in line with easy human information processing increase the likelihood of behavioural adaptation according to the schemes.*
- c. *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 (e.g. from public transport).*

H4.3 *The effect of pricing schemes' differentiation on behavioural adaptation to pricing schemes is moderated by motivational factors of individuals.*

- a. *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.*



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- b. An individuals' motivation to adjust behaviour will be a positive function of their personal involvement.
- c. An individuals' degree of engagement will be a positive function of their motivation to adjust behaviour.

H4.4 *The effect of pricing schemes' differentiation on behavioural adaptation to pricing schemes is moderated by objective and subjective situational constraints of individuals as well as by personal characteristics of the individuals.*

- a. 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.
- b. An individuals' engagement with the charges and their motivation to adjust behaviour will depend on their type of personality.
- c. An individuals' motivation to adjust behaviour will be a negative function of their disposable income.
- d. An individuals' ability and motivation to adjust behaviour will be a positive function of their education.

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:

- Does a highly differentiated charging system make people avoid such systems?
- How does age and gender influence the ability and motivation to deal with differentiated pricing systems and how does it affect transport behaviour?

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



3 EMPIRICAL EVIDENCE FROM CASES STUDIES

3.1 SUMMARY OF THE EMPIRICAL RESULTS

3.1.1 Introduction

In the subsection above the theoretical background for price differentiation has been analysed and rough hypotheses have been formulated. The following subsections illustrate all empirical findings of the case studies analysed within DIFFERENT on the one hand and summarise empirical findings with respect to the hypotheses made above on the other. The empirical findings are primarily classified according to transport mode. Furthermore, the findings from economic and psychological research within DIFFERENT will be described.

3.1.1 Empirical Evidence from Economic Perspective

Empirical Evidence from Air Transport Studies

Air transport studies analyse the effects of differentiated airport charges by studying – through different methodological approaches – five case studies based on several European airports (Gran Canaria and Madrid-Barajas, in Spain, the airports in the London area, Hamburg and Ljubljana airports).

Although all of them focus on the problem of airport charges differentiation, the approach is different in each case, depending on the existing situation and data availability. In some cases (Gran Canaria, Madrid and Ljubljana airports) no data was available on the potential reaction of airport users to charge differentiation. Consequently these cases are centred on the consequences as derived from the lack of airport charges differentiation and on recommendations to better allocate the existing capacity. The methodological approach used in the cases of London area airports and Hamburg is different. Their starting point is a situation where airport charges are already differentiated and datasets on their effects are available.

Gran Canaria Airport: A Peak Load Demand Problem

The case study for Gran Canaria airport considers the problem of peaks associated with massive tourist arrivals and departures as determined by tour-operators. Important investment resources are being allocated to the airport because of the peak nature of demand, and without consideration of other alternatives to allocate existing capacity. The demand pattern is a consequence of the tour-operators strategies and imposes very high costs not only to the airport, but to society in general. It is not only that the use of airport capacity and facilities is exacerbated, but also the island accommodation and transport capacity.

In this sense, the aim of this case study is to analyse and quantify the costs imposed on society as a result of the peak-load demand and to explore alternative airport pricing schemes in order to induce a more efficient utilisation of airport capacity.

The case study has been divided into four parts:

- Demand analysis.
- Review of previous relevant work in the literature.
- Identification and quantification of external costs associated to peak periods borne by private and public agents at the airport and by economic agents located outside the airport but directly related to tourism.
- Analysis of available alternatives in order to reach a more efficient capacity allocation.

A total of around € 1 million per month (see Table 3-1) is being borne by economic agents either at or outside the airport as a result of the peak-load demand, and quite probably also induced by the current airport pricing policy that does not differentiate according to traffic conditions. Hotels and apartments



establishments are the greater in number, and also the biggest costs bearers. They are followed by passengers, who experience the lowest time quality when doing the check in previously to departures.

Table 3-1 The Costs of a Non-Differentiated Airport Pricing Policy

Agents	Monthly cost	Annual cost	Percentage
Passengers: Check in area	191,001	2,292,012	19.3
Passengers: Security system	20,530	246,360	2.1
Passengers: Arrivals	29,993	359,914	3.0
Total passengers	241,524	2,898,288	24.4
Hotels	446,967	5,360,364	45.1
Airport services providers	164,753	1,977,036	16.7
Buses	136,818	1,641,816	13.8
Total other agents	748,538	8,979,216	75.6
TOTAL COSTS	990,062	11,877,504	100.0

This analysis adds value to the existing literature on the peak-load problem at least in three aspects: (i) it concentrates on a particular airport, though the methodology used could be easily transferable to other airports with similar inefficiencies; (ii) it should be able to contribute to the cost-benefit analysis of pricing policies at airports and other utilities and (iii) it illustrates a situation in which decisions on charges or the allocation of slots, and on infrastructure investments are taken at different instances, giving rise to inefficiencies that would have not appeared if both responsibilities were resting at the same institution.

Madrid Barajas Airport: Differentiation by Type of Terminal

Madrid-Barajas is the main gateway of the Spanish airport system. During 2006 more than 45 million passengers travelled through this airport. At the beginning of 2006 it opened new facilities -- the new Terminal 4 -- that left the airport with four passengers' terminal buildings and four runways, and a design capacity that duplicated the existing one. After this expansion Madrid-Barajas can process a maximum of 80 million passengers per year.

The Madrid Barajas airport case study concentrates on how the actual level and structure of airport charges can have an influence on competition between airlines when these can choose among different terminals, therefore emphasising the scope of price differentiation by type of terminal. In this case, the initial allocation of slots at the new facilities was subject to great controversy among Spanish airlines, though finally Iberia and its partners of the Oneworld alliance, ended operating from the new Terminal 4, whilst its main national competitor, Spanair, and its partners of Star alliance, were allocated at the old facilities. One of the main consequences of such allocation is quite probably a reduction in the level of competition among airlines.

Terminal 4 is not easily linked with the old terminals. At the moment there is a free bus service, but the whole journey, including waiting times at bus stops may take around half an hour. A passenger in transit should add the time needed to collect his luggage and exit the terminal in case of interconnection of flights. As a result the combination of flights from the passengers' point of view has become more troublesome than in the past, when all the airlines were closely situated.

The case study is divided in three main parts:

- Analysis of demand.
- Review of relevant cases and literature.
- Analysis of alternative pricing mechanisms through development of theoretical welfare models.



The theoretical model shows, in general, that if airlines are allocated to separate terminals, the lack of competition in transfer flights significantly affects the ticket prices of the whole network, the competition between airlines is reduced, the ticket prices are higher and the consumer surplus and the social welfare are lower. Only in some routes and under certain conditions on the market size, the ticket prices may be lower.

London Area Airports: Peak Pricing and Airport Choice

In the economics literature there is an ongoing discussion about airport competition. Do airports compete? If so, do they compete for passengers or airlines? Low-cost airlines play an important role in the discussion on airport competition. Airlines like Ryanair prefer smaller regional airports over the established hubs because these airports are cheaper and offer lower turn-around times. Such airport-airline combinations offer competition to the 'established' airport-airline combinations (e.g. British Airways – London Heathrow). Even though British Airways may offer more low-fare tickets than some low-cost airlines, the airport tax may make the journey more expensive than a trip with a low-cost airline from a regional airport. In this study the passenger sensitivity to the total ticket price (including taxes) is determined, and the cross-price elasticity of demand, that is, the effect of a price change of e.g. Ryanair from Gatwick on the probability that British Airways from London Heathrow is chosen is also calculated.

In this research the price elasticity of market share for different passenger types in European markets originating in the London area is calculated. The underlying reasons are twofold. Firstly, price differentiation to maximise revenues, or manage passenger flows through congested airports is possible only if passengers respond to price changes (i.e. demand is elastic). Secondly, it is a common conjecture that the emergence of low-cost carriers led to fierce competition between airlines, and in some cases airports. This research addresses the question of how market shares change when the total price of a trip changes. The analysis is based on the total price (i.e. airline fare plus airport taxes), because passengers respond to this price. Estimating separate elasticity coefficients for airport taxes and airline fares is not feasible, since the airport tax may be constant across a large number of respondents and alternatives, which creates numerical difficulties. Different models for leisure and business travellers are estimated, as it is a common finding in the literature that these passengers have a different willingness-to-pay, and thus a different price elasticity of demand.

To determine the passenger sensitivity to fares and frequency a nested logit model is used. In the survey data a traveller has indicated to fly to a specific destination. From the OAG-files, the alternatives (departure airport and airline combinations) available to that traveller are identified. The model assumes that the traveller chooses an alternative from all available alternatives. Note that in practice some alternatives may be ignored because the traveller is not aware of the alternative or because the traveller does not consider some alternatives as relevant.

The conclusions from this research are that: i) cross-elasticities of demand between airports are relatively low, indicating that there is little competition within markets; ii) there is little evidence that price elasticities for business travellers are lower (in absolute value) than price elasticities for leisure travellers; and iii) a likely effect of price differentiation is that passengers switch destinations or modes, rather than switch between peak and off-peak, or switch airport to reach the same destination.

Hamburg Airport: The Introduction of a Noise Charge

Hamburg airport was one of the first airports in Germany to be privatised by selling a big part of its shares. It was the first German airport imposing price cap regulation and one of the first differentiating its charges according to noise emissions. The development of traffic figures in Hamburg shows that restructuring the charging regime was an important step for the airport. However, regarding differentiation there are no considerable effects recognisable. In addition, the proportions of the two-part tariff became more variable after the reorganisation. This enables users (especially legacy carriers) to concentrate on their plans of expanding service frequency (a charge payable per passenger favours the use of smaller aircrafts). Econometric work showed that the differentiated noise charge in Hamburg airport has no effect on aircraft choice. In addition noise level did not decline considerably after the introduction of the pricing scheme. The long run noise decline is caused rather from the expected and natural tendency of the carriers to replace older aircrafts with new ones, a fact



which correlates with considerable fuel savings. The empirical findings combined with all heuristic findings provide safe evidences to argue, that the introduction of noise charges at Hamburg airport did not induce carriers to use less noisy aircrafts.

Given that the introduction of differentiated noise charges at Hamburg airport had no detectable effects it might be asked why these charges were introduced in the first place. From the viewpoint of normative economic theory there seems to be little reason. From the viewpoint of the positive theory of regulation, however, the introduction can be explained as a symbolic reaction to the pressure of environmental groups and inhabitants of the adjacent suburbs of Hamburg. The noise charges which were finally implemented can be regarded as a kind of political compromise. The policy makers were in favour of it; the users could live with it because at the same time they could achieve the introduction of their favoured price level and price structure; the airport could improve its environmental image and finally the environmental organisations were not really content with it, but they found the principles of the new charging scheme better than the old ones. Consequently the reasons for the current price structure are better explained within the framework of the positive theory of regulation than within normative theory.

Ljubljana Airport: Demand Peaks

The aim of this case study is the analysis of existing differentiated charges at “Jože Pučnik” Airport in Ljubljana, Slovenia and the identification of possible additional differentiation of Airport charges in order to optimise traffic demand and to redistribute it outside the peak traffic periods. In order to find the optimal solution the case study deals with the following topics:

- Traffic demand analysis
- Identification of congestion periods – potential for differentiated charges
- Existing airport charging scheme analysis
- Demand elasticity and its impact on traffic demand
- Conclusions and suggestions.

Original and current data is used for the analysis of passenger demand and aircraft movements. Some assumptions were made concerning actual load factor per specific air company or airline and actual landing charges for individual air transport companies. The Airport management considers this information confidential. The assumptions for the topics within the “confidential data” area were made in collaboration with Airport officials, so it may be concluded that the average conclusions correspond closely to the reality. This holds good also for demand elasticity coefficients to be found in the scientific literature for other EU regions, which are assumed to be valid also for Slovenia.

Although it is an airport with a moderate level of demand, the existing and anticipated growth of travel demand calls for the introduction of additional, congestion dependent differentiated charging schemes. Besides several projects aiming to increase the capacity of the Ljubljana Airport facilities, the differentiated airport user charges are to be seriously considered in order to reallocate the existing demand pattern and to provide a more efficient utilisation of airport capacity. Differentiated pricing schemes could be rational and efficient responses to such challenges. This case study provides a thorough analysis of transport demand at the Ljubljana Airport and has identified peak periods during the time of a day, a day in a week and a season in the year. A preliminary analysis of price elasticity of demand also indicates that by introduction of differentiated congestion pricing schemes, charter and low-cost carriers would be more affected.

Empirical Evidence from Shipping Studies

Port of Hamburg

The analysis of the tariff structure for the port of Hamburg shows a clear differentiation in terms of ship types, traffic regions and ship size.

The differentiation by ship type among other things depicts the consideration of different accident risks. Therefore, oil tankers pay the highest charge per 100 GT. The risk presented in the case of an



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accident is further reflected by the differentiation of double hull tankers, tankers with segregated ballast water tanks with the regular tankers paying the highest charge.

Ships operating in regional traffics, North Sea and Baltic Sea pay a reduced level of port dues. This is part of the strategy and political mandate to strengthen the port of Hamburg as a regional hub port, as it is expected that this measure makes the port more attractive as a port of call for feeder services. Further, regional feeder services call at higher frequencies and thus the lower port dues are offset by a higher frequency of calls (more charging opportunities).

Additionally, port dues per 100 GT are higher for bigger ships, eliminating incentives to economies of scale in relation to the transport unit.

Charges within the terminal are based on individual agreements with the shipping lines and are established under competitive market conditions. The competitive market conditions are created through inter-terminal competition and interport competition. Thus the port sector in this case is not different from any other industry.

Port of Gothenburg

The fees charged to ship operators in Sweden can be broken down into fairways and pilotage dues levied by the port authority, and port dues.

Fairway dues are based on the vessel's gross tonnage and they are differentiated according to the type of vessels and their sulphur and nitrogen oxide emissions. Pilotage dues are based on the size of the ship, computed on the basis of gross tonnage and distance piloted. Mainly for safety reasons, pilotage dues are kept fairly low by international comparison.

Port companies and port authorities charge fees for the services they provide, dues for fairway infrastructure use inside the port area. Customers pay dues according to commercial agreements covering both fees and dues. Each port company has a stipulated tariff which is usually not used because charges are negotiated as such the application of published differentiation can be questioned.

The port of Gothenburg differentiates ship types for port dues. As in the case of Hamburg tankers are charged the highest fees per GT. This fee even increases if ships do not have segregated ballast water tanks. Port dues for cruise ships are the only that decline with increasing size of the vessel (over 20 000 GT). This might be related to an additional port charge for each passenger.

The Port of Gothenburg has further introduced environmentally differentiated charges based on the level of emissions and ship type. In order to analyse the impact on the actual port dues under different conditions the impact on the basis port dues have been calculated for different ship types. The full implementation of high environmental standards delivers the greatest benefits for all ship sizes and can reach around 6% for a passenger vessel or ferry. In day to day operations with a high call frequency this level of savings is perceived to deliver a substantial savings. However, the actual benefit for oil tankers for complying with environmental standards decreases with ship size. At the same time cruise ships in terms receive the highest benefit when using ships >20 000 GT.

The SMA introduced fairway dues for passenger vessels of 1.80 SEK/GRT. Interestingly this reduction is not offset by higher charges for other ship types. The main argument is the positive development of ship traffic, which in the view of the SMA seems to be sufficient to provide continued revenue neutrality. The new system also introduces environmental differentiated charges for cruise ships, which were not included in the previous system. SMA's argument to keep the fairway dues as low as 0.5 SEK/GRT originates from a study conducted by the organisation that came to the result that such a level of charges would not discourage cruise ships from calling in Swedish ports. In order to not create unwanted user responses in terms of route changes or unfair competitive conditions for different cruise lay-outs, a single charge alone, levied in the first Swedish port of call was introduced. For cruises in which more than 90% of passenger replacement occurs in Swedish ports, no dues are charged. The reasons to not to fully include cruise vessels in the environmental differentiation system is based on the fact that the use of low sulphur bunker oil in all circumstances must be viewed as far too low for meaningful measures to be taken considering the low dues level. As regards the cleaning



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of nitrogen oxides, it has emerged that measures aimed at reducing these can be expected, and have been implemented in certain cases, and thus a decrease in fairway dues are included in the system.

Port of Valencia

Objectives of the Spanish port authority, among others, include the reduction of transport costs in ports and the promotion of competitive port tariffs by applying correcting coefficients and establishing benefits and underscore the national ports' strategy. In the Spanish perspective port dues should respond to the general interest of co-modality and the auto sufficiency of the port system. This means that the revenues generated in ports should cover the operational, financial and fiscal costs and depreciation of goods and installations also allowing realising new investments and the devolution of the port companies. This basic layout principally determines the existing differentiation in port charges, although it is unclear if this differentiation and the application of discounts is reflected in the negotiated tariffs, which are general practice.

The application of similar differentiation measures over a wider geographic area, in this case Spain, in general contributes to the transparency and comparability of port dues. However, the real competitiveness in environments where port dues are negotiated seems questionable. The port of Valencia in its official tariffs provides strong incentives for frequent use and special interest is given to SSS and ferry services which receive stronger discounts than other ship types. These ideas are in line with the policy of the Commission and as such seem of high strategic nature. This refers to special treatment (incentives of SSS) and incentives for compliance with quality standards.

Assuming that these discounts are even brought forward in the negotiated charges with shipping lines, might imply high costs for the port authority, if especially highly discounted traffics grow. As such it is not clear if a national differentiation scheme can suffice to at least create revenue neutrality for the port authority.

Port of Amsterdam

Port authorities charge the terminal operators in two ways: through sale, rent or leasehold of land, and quay fees.

The Amsterdam port authority uses a differentiation of lease rates to attract specific companies for specific sites. This is done by using a land price model. Every year the city council determines a list of base prices. The actual land price for a specific site is then determined by the base price and by taking a series of factors into account. These factors concern both the specifics of the site (e.g. quality or location of the site) as well as of the company that wants to lease it (e.g. branch or specific activities). Because of this method, companies may pay different amounts for the same site. Leases are adjusted yearly according to inflation.

The port of Amsterdam charges quay fees to the terminal operator. The charge is payable by the metre of quay. The price is differentiated by the water depth at the quay and the type of the quay (e.g. bank or wall). The port authority charges this fee for maintenance of the infrastructure. The charge is independent from the level of use. Generally quay fees are passed on to the ship operator in the handling charges.

In difference to other countries the general structure of port charges is decided at national level in the Netherlands. The port of Amsterdam in this case has the freedom to determine the level and differentiation within the given structure for its charges, dues and fees.

The Port of Amsterdam gives two options of calculation of port dues: based only on GT or based on GT and cargo transferred in the port. This reflects the economic principle of an optional tariff composed of a linear component and a two part tariff. However, it needs to be kept in mind that this is the theoretic approach, since it is known that customers often negotiate special prices, especially, when it comes to frequent and long term customers. Further differentiation elements play rather a minor role.

Most quays are part of a terminal and therefore leased with it. In these cases a quay fee is paid by the terminal operator to the port authority (see previous section). In that case, quay dues are included in



handling costs. Only when a ship uses communal quays, the port authority charges directly the ship-owner. The Amsterdam system is more complicated and depends on the size of the ship (GT), the duration of the use of the quay, and the specific use.

Port of Duisburg

The port's infrastructure charges are differentiated in the "Hafengeld", which are the ship related port dues and the "Ufergeld" which is related to the volume of cargo moved across the quay. Therefore the main charging principle is a two part tariff. The existing price differentiation has developed historically and focuses on cost recovery and market requirements. In this regard the competitive position towards other transport modes plays a significant role.

Additionally, the actual charge of port dues is then differentiated by the length of stay and activity of the ship in order to keep berth occupancy low. Further differentiation is given to the type of activity. Ships that are not performing loading or unloading operations are charged differently to ships moving cargo across the quay. Ships that are not performing cargo movements are charged relatively higher prices in order to encourage port activity. Especially loading and unloading activities create further revenue in terms of wharfage.

The wharfage charges are differentiated by product classes. The differentiation by product classes is related to the average value of the product and thus the price elasticity.

A key difference to other ports is the nature of traded products in the port and a significant volume of port operations is based on long term commitments. In specific cases these agreements have a length of 20 to 25 years.

Duisport is not anticipating introducing further differentiation of charges. The company argues that there is no scope for further differentiation. In relation to strategic differentiation the main question is who would cover revenue gaps from strategic, e.g. environmental differentiation since the port is working on a cost recovery strategy.

Shetland Islands - Port of Sullom Voe

Shetland Island Council in charge of the setting of port charges in the port of Sullom Voe has changed the structure of port charges in such manner that they work towards consolidated port charges for tankers. The consolidated charge is made up by the shipping dues, mooring charge, pilotage charge and B&L charges. The only differentiation applied is between ships with segregated and non-segregated ballast tanks. A further differentiation is related to the type of port infrastructure used for operation. The port authority applies lower charges to ship to ship transfers

The strategy is to make port charges as transparent and simple as possible. However, in the case of Sullom Voe it has to be kept in mind that the port only serves one customer, a consortium of oil companies. Nevertheless, the port is in competition with other ports for oil storage for such reason the port authority stated the importance to have a competitive port charge. The efforts to reduce the complexity of port charges can be seen as a response to port throughput development. The port of Sullom Voe is highly dependent on the oil industry in the North Sea.

Shetland Islands - Port of Lerwick

The port of Lerwick is operated as a trust port. Differentiation from the perspective of the trust port has to be seen as a continuous process which evolves out of market requirements or reaction to certain market demands. The changing needs of port users, fishing, oil, ferries and tourism industry and the Shetland community represent a diversified set of demands.

Differentiation of charges is not much different to structures found in other ports. The port authority also stated that charges are negotiable and that all published figures are maximum figures.

Differentiation in the case of the port of Lerwick is not seen as a tool, but as a result of the market evolution and a response to the strategic goal of profit making. The positive development of revenues from port dues hints that the existing differentiation is aimed towards profit maximisation, but has a high sensitivity to its economic impact on the Shetland Islands. The port operator at the same time is



well aware of the wider impacts of the port on the islands' economy and thus stated that the general level of dues will be considered and continuously reviewed in this context. As a Trust Port, the Authority reinvests profits into the maintenance and development of the harbour to ensure the varied requirements of customers continue to be met.

The port of Lerwick is a good example to underscore the question in how far private operators can be obliged to use a specific differentiation scheme. This is especially true for ports operating under private sector principles (e.g. trust ports) and ports which serve very specific and or isolated hinterlands, like the ports in Shetland.

Cross Forth Ferry Passenger Survey

Differentiation schemes in ferry passenger services follow a different pattern. Napier University's Transport Research Institute ran an online survey parallel to the Hovercraft trial across the Forth in Scotland asking people about their perception of the service, their preferred travel options and their preferred pricing scheme for such a service.⁵ The ferry passenger survey revealed:

- Users are looking for reliability and easy memorable schedules.
- Integration with other transport modes, in terms of interchange and ticketing is a key factor.
- Users are willing to pay premium prices for high quality services.
- Users are looking for differentiated pricing schemes that serve their individual needs.
- Parking facilities are a key factor in the determination to use a ferry service.
- If services are perceived as high quality, users present a significant willingness to pay premium prices as well.

Users expressed the need for integrated ticketing. Respondents in the survey saw integrated ticketing as a key factor to attractiveness of a transport service. Integrated ticketing for them also included the wish for parking charges to be either free or part of the fare. These findings revealed that parking might as well be an important part of infrastructure charging and that differentiated charging for parking can create significant user responses in terms of attractiveness and thus usage of a transport service.

Ferry services play an integral role in many city regions, where they are integrated as part of the local and regional public transport system. It has been found that the integration of ferries in intermodal passenger transport chains in terms of ticketing integration has been recognised as key element in ferry transport as part of a public transport scheme. In cases such as Hamburg the transport mode and the user choices do not matter in terms of price differentiation and the costs of operation and use of port infrastructure are weighted against the participation of the ferry services in the transport network in terms of reach, frequency and number of people transported. All losses are potentially covered by the public sector operator.

Differentiation for the user is embedded in the overall goals and strategy of the local transport authority. In the case of Hamburg the overall strategy is defined by seamless transportation and to maximise the percentage of people using time and seasonal tickets.

Results showed that frequency, speed and quality are main drivers for commuters and tourists to use the by-sea transport option. Analysis of the operations also showed the positive environmental performance of the hovercraft in comparison to car and rail travel. Users also stated that there is a clear need to integrate transport pricing between different modes, which underlines the argument to move away from unimodal thinking patterns and shift towards integrated travel. The survey also showed that users wish for innovation.

⁵ The results presented are based on 291 completed online questionnaires received over a 3 week period.



Empirical Evidence from Railway Studies

Infrastructure charging in the rail sector is a relatively new phenomenon. It became necessary due to the separation of rail infrastructure from operations and, consequently, the need to charge operators for the use of infrastructure. The earliest introduction was in Sweden in the late 1980s and, in the subsequent decade, infrastructure charging regimes have been introduced throughout most of the rest of the European Union. Despite efforts by the European commission to promote a harmonised approach to charging throughout Europe, a range of different kinds of regime have been introduced in different member states. These different charging regimes are often a result of different industrial structures within the different member states, as well as different priorities being placed on different member state railways. This situation raises questions as to whether this diversity of approach introduces distortions into the European rail market, to what extent any such distortions might be significant and whether there is a path towards a more harmonised, less distortionary, set of charges. Our efforts to understand the impacts of infrastructure charges fit within these broader research and policy questions.

The impacts that infrastructure charges would have might be expected to include usage of rail infrastructure, adaptation of rail supply and prices to the end-user and other adaptations to rail operations and supply. Moreover, the scale and form of impact might be expected to alter over time, as some aspects of train operations are more difficult to change in the short run than others. For example, it is relatively easy to increase or decrease the length of a particular train at short notice, but it is very difficult to alter the design of rolling stock in anything other than the medium or long term.

However, whilst infrastructure charges are a potential influence on these variables, other cost elements for train operators (staffing costs, train operating costs etc) and demand elements (demand reactivity to price levels, to quality of service, willingness to pay, etc) would also be expected to be important influences on the market. Furthermore, the rail market is also likely to be affected by a host of contextual factors, including the competitive and regulatory framework (monopoly or oligopoly, type of regulation) and levels of car ownership and economic growth.

In our case studies, it has been able to gather information about the main input studied, i.e. infrastructure charge categories and levels. But in many cases it was difficult to gather even the basic information about precise infrastructure charge quantities (i.e. train-paths, or train-km) bought for each category. And many of the other elements are viewed by train operators as being commercially sensitive; even the price levels are often not precisely observable, due to yield management techniques introduced in preparation for competition in the rail market.

Hence, a systematic analysis of the impact of infrastructure charge differentiation seems an extremely difficult prospect at this point. Disentangling the impact of charges from the impacts of all of the other significant influences on the rail market, amidst a diversity of charging regimes and contexts, with a limited supply of detailed data, would appear to be highly problematic.

The rail market is comprised of many different sub-markets, and there are potentially different scales of impacts in different sub-markets. In actuality, it appears to be the case that, in many situations, operators have relatively limited scope to adapt their supply policy and their tariffs in response to infrastructure charges. For instance, where services are franchised, e.g. as is the case with regional passenger services in Germany and with nearly all passenger services in Britain, services are quite closely defined by the terms of those franchises. Hence, there is limited scope for operator response to infrastructure charges during the life of the franchise. However, charges may serve to influence the terms of franchises, either through franchising authorities examining the implications of the charges for the services they wish to specify or through the terms of the franchise bids submitted by competing operators. This mechanism for response, being contained within the planning process, is very difficult indeed to tap into.

In some situations, there may be no reaction at all on the part of train operators, due to mechanisms of compensation being in place. For instance, again where services are franchised it is common (and reasonable) for the terms of that franchise to require operators to be compensated by the franchising authority for any changes in infrastructure charges during the course of the franchise. Again, it may be possible to tap into the impacts as they relate to the franchising authority, but this would again be expected to be problematic.



Nevertheless, whilst reactions may be difficult to analyse and, in certain situations, relatively limited in scale, our interviews did uncover which sorts of parameters have been affected. Main reactions observed were in relation to:

- Design and choice of rolling stock;
- Suppression of unnecessary path reservations when reservation charges were introduced in France;
- Increased use of high capacity rolling stock when peak-hour differentiation was introduced in France (still, as mentioned above, other factors did influence this evolution).

There was some interesting discussion of the share of train operating costs comprised of infrastructure charge-payments. The outcome is that the scale and form of reaction to infrastructure charges is likely to depend crucially on these cost shares. The cost shares for the use of infrastructure vary markedly across the interviewees in different countries. In general, the share of infrastructure charge costs as a proportion of train operating costs was reported to range between 10% and 30%. However, in Sweden the cost share was estimated at approximately 5%, whilst in Germany some operators estimated it to be as high as 60%.

France

The creation of an independent infrastructure manager, RFF, in 1997, was accompanied by a legal framework which allowed a relatively high level of differentiation. A good number of these possibilities for differentiation have been progressively implemented, especially from 2002.

A major part of RFF's revenues comes from the high speed train (HST) lines. Charges for these tracks are relatively high compared with freight and low-traffic passenger. The low charging level of the latter are understood as the expression of the political objective to favour railways in intermodal competition, and to maintain a territorial balance. The specific charges defined for successive new high speed lines may now raise the question of the global coherence of the tariffs, even within the HST markets.

In order to compare current infrastructure charges with marginal costs, one faces the problem of the low level of knowledge of "correct maintenance costs", since the network has for a long time had insufficient maintenance (corrective actions have been taken for a few years). But the real key difficulty for analysing the question of "optimal ICs" is that the imperfect competition context changes the whole picture (see D7.2).

Some observations for specific markets are given in the following:

- **Low traffic passenger trains:** these trains use low tariff lines and therefore the economic signal given by the infrastructure charge is too weak. This may lead to a vicious circle where RFF has too low revenue on these lines to perform good maintenance or to invest for improving them.
- **The existing TER lines (regional traffic):** according to the decentralisation rules, infrastructure charges are almost neutral and provide no incentives, since the State compensates the regions for any change in the level of infrastructure charges. Therefore a key distinction has to be made between "market driven" passenger markets and "contract driven" ones.

The French incumbent rail operator, SNCF, uses widely yield management techniques (ie high differentiation of prices for the end-user) for non-contracted traffics, mainly for high speed trains. This blurs the picture for comparisons of levels, but also for equity assessment: indeed, high speed users are in average much more well-off than what the SNCF's advertisements on very low prices may lead to think.

The main impacts of differentiation that were observed are the following:

- The creation of track reservation charges has led to the cancellation by SNCF of numerous facultative paths that were blocked "just in case they might be used" : therefore additional capacity has become available;



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- The creation of peak-time path charges has increased the incentive for SNCF to develop the use of higher capacity high speed train elements during the last years (multiple and double deck units). Indeed, French infrastructure charges are up to now indifferent to the number of passengers per train.

Still, the observations of impacts were difficult to make and essentially qualitative, because of the dramatic lack of data: all precise data are accessible only to SNCF, only some aggregated data is available. This makes it almost impossible to regulate correctly the rail market, and to develop studies and researches.

Germany

One main element within the track access charging system in Germany are the so called regional factors. This differentiation element refers to a multiplicative surcharge for certain parts of the network (a priori defined). Therefore regional factors can also be seen as a regional differentiation element. DB Netz argues at this point, that due to the low demand in these parts of the network it is impossible to cover operating costs. However, DB Netz considers the possibility to negotiate the value of the regional factor in the case that the operators or public transport authorities purchase higher amounts of tracks. The regional factors are imposed in very low frequented parts of the network and therefore they concern public transport services in the short haul (up to 50 km). Statistical research on user reactions to the regional factors revealed the following:

- Due to the regional factors additional costs are covered out of the so-called regionalisation funds;
- Regional public transport authorities, who were burdened after the introduction of the regional factors proceeded to fare increases, but however they passed only parts of these costs on the passengers;
- On the one hand a relatively high positive correlation between the regional factors and the use of busses were recognisable; and on the other hand a medium but negative correlation between the regional factors and the purchased tracks was recognisable.

Further, with respect to passenger fares, the introduction of a kind of yield management led to a strong opposition by media, passenger organisations and several politicians. This opposition was translated to decreasing passenger figures, a fact which forced DB to withdraw several elements of the new fare system.

Evidence about fare elasticities show, that passenger demand reacts relatively inelastic to fare increases. Besides, despite the old data set, travel demand seems to be more elastic with respect to the travel time than with respect to fares. Finally despite the higher degree of differentiation of the new DB fare structure and the opposition by the media and passenger organisations passenger demand for rail services remained relatively constant or decreased slightly, a fact which strengthens the assumption of an elasticity less than one (as widely known from theory, travel demand is a derived demand).

Freight transport was studied on the basis of engineering cost data and an isoelastic demand function. This was necessary because of the specific legislation for track assignment in Germany. Track wishes for passenger services are privileged and get priority compared to track wishes for freight transport. The analysis showed that the higher differentiated track access charging system of 1998 (TPS 98) provided better incentives for freight operators to demand a higher number of tracks.

Sweden

The aim of the railway charges in Sweden is to enable the management of the transport of passengers and freight on the railways in the most socio-economic way as possible.

According to the Railway Act, all railway undertakings that use the infrastructure shall pay a fee that is equivalent to the cost that is incurred as a direct consequence of the operation of railway vehicles. The fee shall correspond to the short-term socio-economic marginal costs.

Included among the socio-economic costs are those costs that affect players other than the railway undertakings and traffic organisers. These include the costs incurred for maintaining and keeping the



infrastructure open to traffic, but also the type of costs that affect society in general, for example in the form of emissions into the atmosphere from diesel-operated traffic, noise from traffic and the increased risk of accidents as a result of growing traffic volumes. Also included among the marginal cost-based charges are the extra fees that are allowed to be levied for the utilisation of congested infrastructure.

In addition to the marginal cost-based charges, infrastructure managers are allowed under certain conditions to bill for special charges and fees. These are of two types:

- Fees to help cover the fixed costs of the infrastructure. The fees shall be commensurate with a socio-economically effective use of the railways. This means that they shall not be so high that those market segments which can pay at least the marginal cost-based fees are prevented from using the infrastructure (Chapter 7, § 4 of the Railway Act).
- Fees that are charged for infrastructure that has been built in the form of special projects with financing conditions and other conditions which involve demands to the effect that the fees should cover either the whole or part of the costs for operation, maintenance and capital costs for the facilities. Unlike the case in Alternative a), the fees may be set higher than is commensurate with a socio-economically effective use of the railways (Chapter 7, § 5 of the Railway Act)

In order to promote the development of new rail traffic or the use of significantly under-utilised lines, the Railway Act permits the application of time-restricted discounts subject to certain conditions. Either the whole or part of the fee for the use of infrastructure may be charged even in those cases where the capacity is not utilised.

Fees for services that are provided in connection with use of the infrastructure shall be non-discriminatory. If the party that has such services is alone in providing them, the fees shall be calculated on the basis of the cost of providing them and on the basis of the actual benefit the purchaser of the service requests (cost price).

The set of charges is looked upon as sensible due to the fact that the charges are low (compared to the level of other European countries). The operators have difficulties of expressing clear statements of behaviour, given the scenario of increased charge levels or changes in charge structure. Concerning the passenger market this is also “biased” by the fact that subsidies probably will cover for some of the increase.

According to the approximate infrastructure charge proportion of train operating costs, estimated to 4-5%, a fair percentage increase (or decrease) of this proportion will not be that significant for the operator. Though, there is a level of charge where the competition with road and sea will be perceptible, but not so much for the time being. Fairness is emphasised as an important prerequisite concerning both the level in itself and for the changes of user charges put on rail, road and sea.

Empirical Evidence from Motorway Studies

The Swiss HVF Scheme

The Swiss scheme for charging HGV has been analysed with special reference to impacts of fee differentiation with regard to the emission category on haulage companies. The case study is developed through a desk analysis based on existing statistical figures and a survey among stakeholders: shipping companies, haulage companies, companies of branches with high transport intensity, rail transport operators, road transport associations, truck dealers.

The road freight transport sector is characterised by strong competition. In such an environment, incentives set by differentiated charges have a large impact on the behaviour of the “target group”. Cost reducing measures must be exploited in order to preserve competitiveness. In the Swiss case, such cost reducing measures could be observed in purchase and investment decisions as well as in decisions concerning the use of vehicles. The impact on the latter is probably the strongest effect of Heavy Vehicle Fee (HVF) differentiation.

The HVF differentiation – as is the HVF itself – is a bigger challenge for small haulage companies than for larger ones. In an environment of strong competition the haulage companies will not be able to



fully pass the cost increase caused by new charging regimes on to the shippers. Small companies will have more difficulties to compensate this development with productivity gains.

The Swiss case study illustrates the relevance of the interplay between a charging regime and the regulation framework in the same policy field. The regulations concerning the emission standards for new vehicles partly dominated the incentives set by the HVF differentiation. An integrated policy strategy should consider both fields of state intervention in a co-ordinated way. Because a differentiated charge leaves more flexibility for efficient adjustment than regulation (e.g. fixed standards), one could argue that the charge differentiation in favour of less polluting vehicles should more clearly precede regulations than in the case of the Swiss HVF.

The impact of charge differentiation does not only depend on the incentives set by the charge but also on other factors (e.g. cost differences, financing restrictions). This fact increases the inefficiency problem, if the spread of the differentiation is not related to the ecological performance of the vehicles but set in political negotiations. Countries leading the way in introducing differentiated user charges may affect neighbouring countries.

The German HVF scheme

After almost 30 years of discussion Germany abandoned the Eurovignette and proceeded to a satellite based HGV toll system. The main reason is to be found in the increasing deficits of motorway infrastructure, since in Germany (as a transit country) HGV transport demand is growing over proportionally to other sectors. The German HGV fee is mainly a fully distributed cost charge and is differentiated according to the number of axles and emission standards.

Analysis of data published before and after the introduction of the German Heavy Goods Vehicle (HGV) charging scheme reveals the effects of the tolling system on revenues, load factor of the vehicles, composition of the fleet, route diversion and modal shift. The main results are the following:

- The German HVF scheme is the first step in the direction of user infrastructure financing in Germany. It can be concluded that not all toll aims have been achieved.
- Revenues are raised according to plan; environmental aims are only partly achieved with a long-term trend of a decreasing number of no-load trips and the increased use of environmentally friendly vehicles.
- Success concerning other aims, such as modal shift, is not recognisable at all. As a consequence of such reactions, some politicians and lobbyists, but also scientists, call for an extension of tolls to the secondary road network and second to extend toll to all vehicles over 3.5t.
- In addition, there are phenomena of toll avoidance as well as user reactions in direction of using vehicles under 12t.
- HGV overall transport demand seems to be inelastic in the German case.
- The introduction of the German HGV fee was possible because several important interest groups (like the truckers) advocated it, whilst no important special interest group objected it. The use of revenues (total infrastructure and not only motorway infrastructure with precise in advance arranged percentage for railways, motorways and waterways) shows clearly, that the HGV fee is the outcome of a process which bears many compromises and therefore corresponds to a political equilibrium in the sense of the positive theory of regulation.

Road Haulage Survey on Tolls Differentiation

The survey was organised according a two-steps procedure (firstly a main group of operators contacted and interviewed by phone, secondly a sample of 17 operators, 9 from Poland and 8 from Italy, contacted by e-mail), was focused especially on 'structural' and behavioural reactions to road freight tolls differentiation. The sample, small but well matched, included multimodal operators and third party logistic providers, which brought in a broader perspective on real alternatives to road freight transport in the shorter and in the longer term, as well as large and small companies and single hauliers (owner-driver), the latter being the ones with tight cost constraints. Unfortunately, it was extremely difficult to get feedback from the contacted single hauliers and this category is therefore



under-represented in the final results. On the whole, due to the difficulties in data collection, the survey results, even if interesting, are not much generalisable. However, they can be summarised as follows:

- Tolls are not considered by the operators as the main problem or aspect of freight road transport, compared to road congestion and road quality (maintenance); this is probably due to the fact that road tolls account for less than 10% of the total production costs.
- The extension of toll differentiation on other corridors or on a whole road network could have relevant effects in terms of vehicle class and emissions (fleet renewal), which are also the actions that operators are willing to adopt (probably due to the fact that they are also required to renew fleets for other reasons, for instance operation costs).
- Differentiation based on time of day/night could have positive effects both on corridors and whole networks; nevertheless, it could have some problems in terms of acceptability from transport operators, as well as from the general population (even though local population was not involved in the survey). Major problems of acceptability are expected also in the case of differentiation by period of the year.
- The extension of toll differentiation to whole networks seems to be more effective than the introduction of the same policy on selected European corridors. Effects of further extensions of toll differentiation can be expected in the long term, with smaller or less relevant effects in the short term.

Analysis of Current Charging Schemes for Road Passenger Transport

This desk work is related to two case studies of real applications of differentiated charging on motorways. The first one is the case of France, where applications of toll charge modulation to spread returning weekend and returning holiday motorways traffic exist since 1992. United States HOT lines are the second case, which refers to High Occupancy Vehicle (HOV) lanes that allow charged access to Single Occupancy Vehicles (SOVs) according to dynamic schemes.

Surcharging for congestion costs has been introduced in France on the A1 (Paris-Lille) motorway in weekends since 1992 (it is still going on) and experimented 12 years ago on the major links with the South (A10/A11, A5/A6) at the time of important movements for the summer holidays. These toll modulations were focused on light vehicle peak flows. Tolls on an urban section near Marseille are also differentiated according to day/night hours. Unfortunately, there are very few data available to assess the reaction of these modulation schemes.

The tolls on the UK's M6 Toll road were originally set in the light of evidence from models and market research. Data from the first six months of operation showed higher than anticipated usage by passenger traffic. The toll operators concluded that passenger traffic was willing to pay more to use the toll road (to avoid a notoriously congested stretch of the parallel M6 Motorway) and so raised the toll by 50%. This appears to be an example of toll differentiation being adjusted to reflect the demand response - presumably with the objective of maximising income.

US HOT Lanes

Although the concept of HOT lanes can vary between applications, the general idea is of a High Occupancy Vehicle (HOV) lane that allow access to Single Occupancy Vehicles (SOVs) in return for a toll. There are currently 7 HOT lane schemes in the U.S. with a further 25 schemes under consideration.

HOT lanes were put forward as a "solution" to the under-use of HOV lanes which was evident in the 1990s; the idea being that some of the spare capacity to be "purchased" by traffic which would not normally have access to the HOV lane. HOT lanes thus offer general traffic managed access to dedicated lanes on payment of a fee. Most HOT lanes employ electronic payment systems to collect the tolls.

Time-differentiated pricing is used to encourage drivers to switch from the busiest periods to those that are less busy. In most cases this is achieved by a pre-published schedule of prices which will apply at specified times on specified days but, for example in the case of the San Diego I-15 HOT lane, the



actual charges will be lower than the published schedule if local traffic conditions justify it. The published schedules can be quite complex (for example, the SR-91 price schedule is different on each day of the week and the scheduled price may change up to 16 different times in the course of a single day). In exceptional circumstances the pre-defined levels may be over-ridden and a much higher charge imposed but all schemes adhere to the principle that drivers are informed of the prevailing price before they have to commit themselves to use the HOT lane (and that, even if the price increases while they are using the lane, they will not be charged at a higher rate than that which was in force when they entered the lane).

Although the objectives of individual HOT lane applications may vary, most aim to reduce congestion while maintaining, or increasing, overall flow. Some aim to reduce journey times, not only for traffic using the tolled lane, but also for traffic continuing to use the un-tolled lanes. Most schemes offer an assurance that prices will be set at levels designed to achieve these objectives and that prices will not be higher than is necessary deemed necessary to achieve a given level of service.

The published price schedules are determined in the light of observed variations in demand and network performance at different times of day and on different days of the week. This, together with assumptions about demand elasticities, capacities and speed-flow relationships, allows ideal charges to be identified for different periods. Experience gained during the early months of implementation allows these initial estimates to be refined to reflect local conditions. Deviations from the published schedules may be triggered by real-time data showing the level of flow or congestion to be outside the expected range (e.g. if the flow is much lower than expected, a reduction in price may be triggered).

A considerable amount of evidence is now available on the performance of HOT lanes. The literature includes numerous examples of the achievement of reductions in congestion, increases in average speeds and increases in total flow. The environmental impacts have generally been less positive because the increases in speed and flow have tended to outweigh the reduced fuel consumption and emissions attributable to reductions in the amount of stop-start traffic. Most schemes have yielded revenues in excess of costs – although the set-up costs appear hard to justify unless there is a significant congestion problem to be solved and some spare capacity available.

Almost all schemes have had to overcome a degree of local opposition but, with the help of publicity and outreach effort, most appear to have achieved lasting support from the local population. Although the cost of using a HOT lane can vary considerably and, in some schemes, cannot be predicted for certain before commencing the journey, the resulting unpredictability has not surfaced as a significant concern for individual motorists. It seems that, provided that motorists are informed, via variable message signs, of the charge they might incur before they commit to using the HOT lane, and provided that they still have the option of using the free lanes, the potential variation in charges is not a major concern.

To summarise, it seems that HOT lanes have, in most cases, managed to improve the utilisation of road capacity, yield revenue and provide a superior level of service for those prepared to pay for it. The most successful schemes appear also to have reduced overall levels of delay and other externalities. HOT lanes thus offer an example of price differentiation (by time day and level of congestion) which can achieve effective yield management and an overall increase in social welfare.

Using Transport Models to Test Differentiated Road Charges

Evidence presented here is taken from new modelling work and from a synthesis of earlier model-based studies in the UK.

The main NEW modelling application consists of the simulation of several differentiation scenarios using the Brenner TEN-T corridor model. This model was originally identified as the reference tool for the modelling exercises in the work packages WP8 and WP9 and a significant part of the activities was devoted to its update and revision. In order to widen the modelling analysis simulating tolls differentiation in a diverse context, the Padana region motorway model was then added. In the Padana region supply and demand conditions are quite different from the Brenner corridor: instead of a major route mainly used by crossing traffic and with limited problems of capacity, a complex and often congested network where local traffic is prevailing. For the sake of comparability, similar



approach and similar differentiation schemes have been followed as far as possible in the two modelling applications, even though they have diverse demand segmentations.

- *The Brenner TEN-T Corridor model* The Brenner corridor is one of the main gates for trans-Alpine traffic for both passenger and freight. Thus, a significant amount of crossing demand (with a substantial proportion of long distance HGV traffic) contributes to the traffic on the tolled motorway connecting Verona to Innsbruck and beyond. At the same time, especially in the Italian part, the road corridor is also used for (relatively) short-distance trips. Along the whole corridor, a national road runs parallel to the motorway and can be considered as an alternative route (of course especially for local trips). A major railway is also available on the corridor and a new rail tunnel is planned within the TENs projects.
- *The Padana Region Motorway model* The Padana Region study area comprehends Lombardia, Emilia Romagna and Veneto regions and its motorway network includes : A4 Milano–Venezia, A1 Milano–Bologna, A22 Brennero–Modena, A21 Piacenza–Brescia and A13 Padova–Bologna. The region is densely populated and the motorways road network is also used for local trips within the study area. The model deals with freight and passenger traffic and includes also the network of national roads developed beside the motorway network.

Testing different toll schemes on the Brenner corridor and in the Padana region leads to some interesting results. In particular, the following points seem to be relevant:

- The impacts of the differentiation schemes are not the same in the Brenner model and in the Padana region model. This suggests that the context of application of the tolling scheme is very relevant.
- In the Brenner corridor, where congestion is limited and a large share of traffic consists of heavy trucks crossing the whole study area, the impact of differentiation schemes on the level of services and the environment is low. At the same time, the motorway operator is able to increase revenues even significantly. In the Padana region, where a more complex and congested network exists and demand includes many more local trips, level of services can be improved but the revenues of the network operator are less certain and require that also part of the road network (in addition to motorways) is tolled, which is politically challenging.
- Both models suggest that a trade-off between objectives does exist: improving levels of service can reduce motorway operators revenues while higher revenues can well be produced without gains for the road users.
- Even when travel times can be reduced in non negligible amounts, like in the Padana region, the rise of charges and, as a consequence, of total costs for travellers exceeds the benefits. In the Brenner context, scenarios oriented towards the minimisation of time spent can come up with benefits exceeding costs only if discounts are used, which might be undesirable from the motorway operator perspective.
- It seems impossible to reduce significantly emissions using differentiation tolls. If more polluting vehicles are overcharged they just shift on road and more elaborated schemes are able to produce only limited savings of pollution in the Brenner corridor, while in the Padana region even such a small result is not visible.
- Since in the Brenner corridor travel times cannot be improved, the only significant benefit from the social point of view can spring from a proper use of the revenues of the motorway operator, e.g. for developing alternative modes or boosting the renewal of the fleet.
- Toll schemes that provide for high charges on pollutant vehicles lead to remarkable, positive results from the network operator perspective. However, if such a policy ensures remarkable gains in the short term, changes in the fleet structure could imply, in the long term, significant losses for the network operator. Instead, discounting tolls for “cleaner” vehicles seems a good strategy to minimise undesired effects on future earnings.

A number of model-based studies have been conducted in the UK, they include some modest early studies and some much larger studies under the umbrella of the Department for Transport's Multimodal Studies programme and National Road Charging Feasibility Study. The results of these studies suggest that appropriate differentiation of charges on motorways might provide an effective means by which to (i) reduce the diversion to local roads caused by introduction of charges on



motorways and (ii) influence route choice with the objective of minimising delay or marginal social costs. Particularly effective differentiation schemes identified by the UK modelling work were:

- Differentiation by time of day (to reflect different degrees of congestion);
- Differentiation by type of vehicle (to reflect their different environmental externalities);
- Differentiation by type of motorway (to reflect their different roles in the overall network – e.g. for strategic traffic or to relieve congestion on other roads); and
- Differentiation by type of traffic (strategic or local).

Evidence from calibrated demand models also suggested that drivers would be willing to pay much higher tolls during congested periods if, by so doing, they could achieve near free-flow traffic conditions.

Empirical Evidence from Urban Studies

London

The London congestion charge (one of the most discussed issues in the public but also among researchers) is a prime example for a multi-aim charging scheme in urban areas. The aims of the London congestion charge were the following:

- To reduce of traffic congestion;
- To achieve radical improvements to bus services across London;
- To improve travel time reliability for car users;
- To enable a more reliable distribution of goods and services for London.

The structure of the charge is a flat rate (initially £ 5.00 per day and later £ 8.00 per day) and varies between day and night. In addition, the existence of several exemptions (Chargeable are in particular cars, vans and lorries, not chargeable are licensed taxis, buses and coaches, and all two-wheelers) and discounts suggest that a certain degree of differentiation exists.

Initially a dramatic effect of original introduction occurred (reduction of 14% of all traffic and 33% of cars). However, when the level of the charge was increased from £5.00 to £8.00 in 2005, the effect was very small with a 3% reduction of all vehicles and 3% of cars. Similarly, the number of bus passenger increased from 77,000 to 106,000 from 2002 to 2003, while the 2005 price increase had no detectable impact.

Besides, there was shift in departure times from the charged to the non-charged periods: a small shift to earlier starts in the morning and a larger shift to later departures in the evening.

The traffic reduction initially also led to a substantial reduction in congestion, in the range of 30% in 2003 and 2004 compared with 2002. Since then congestion increased again to nearly old levels. As a reason Transport for London gives the effect of traffic management measures that reduce road space in favour of cyclists and pedestrians and increased levels of roadwork. Still it is possible that after the shock of the introduction car users return again to their old travelling habits.

The economic impact of the congestion disputed: Transport for London claims a positive impact on jobs, business turnover and profits, while the Chamber of Commerce claims that the charge had a negative impact on retailers.

Effect of exemptions: Substantial shift from chargeable to non-chargeable vehicles with 30% reduction of the former from 2002 to 2006 and 16% increase of the latter.



Singapore's Electronic Road pricing Scheme (ERP)

Road pricing is an important component of Singapore's overall transport strategy along with high import duty on cars, a high annual vehicle registration fee and improvements to public transport. The origin of ERP can be traced to the 1975 Area Licensing Scheme (ALS), a manual permit scheme operating in the most congested parts of the central business district (the "restricted zone"). In 1995, the ALS was replaced by the Road Pricing Scheme (RPS) which covered the major expressways as well as the original restricted zone. In 1998 the Electronic Road Pricing (ERP) scheme, based on the use of smart card technology to support a pay-as-you-use principle, replaced the manual schemes for the restricted zone and the expressways and, a year later, ERP was extended to arterial roads beyond the restricted zone. The ERP employs stored value cash cards in in-vehicle units (IUs) from which cash is deducted each time the vehicle passes an ERP gantry. The communication is via dedicated short range radio.

The main objective of the ERP is to make motorists more aware of the true cost of driving, thereby optimising road usage and reducing congestion. Other aims are to provide better journey times for those users paying the charge and to encourage use of public transport, car pooling, alternative routes and alternative times of travel. The objective of the ALS scheme was to reduce commuting trips by private cars into the restricted zone but in 1989 this was redefined to include improving travel speeds on the road network.

The ERP operating hours for the restricted zone are Mondays to Fridays 7:30 to 19:00, and for the expressways and outer ring road areas are Mondays to Fridays 7:30 to 9:30. The ERP differentiates charges according to vehicle type, time of day and location of the gantry. Charges for passenger cars, taxis and light goods vehicles vary between S\$0.50 and S\$3, charges for motorcycles vary between S\$0.25 and S\$1.50, charges for heavy goods vehicles and light buses vary between S\$0.75 and S\$4.50, and charges for very heavy goods vehicles and big buses vary between S\$1 and S\$6. Since 2003, the transition from one time period to another has been smoothed by a graduated tariff. The charge rates are regularly reviewed and are intended to maximise road usage subject to achieving target speeds (45-65 km/h on the expressway and 20-30 km/h on arterial roads). An appropriate charge is calculated on the basis of observed demand, known capacity, speed flow curves and elasticities and, if this is deemed politically acceptable, will then be imposed (factors such as the effect of traffic diverting to other roads is also considered when deciding the final charge).

Although initial revenues for ERP were disappointing (due to a combination of lower average charges, fewer than expected multiple entry trips and the 1998 regional recession), the annual gross revenues are now around \$ 80 million giving an operating profit of around \$ 60 million. The scheme has resulted in a significant reduction in traffic in the central area during the scheme operating hours, and to an increase of about 20% in average speeds. A major reason for the decrease in traffic seems to be associated with a reduction in multiple entry trips.

ERP was introduced with considerable publicity and guidance to users (e.g. all vehicle owners were sent brochures explaining how ERP worked and the differences between ERP and ALS/RPS). Awareness of ERP was raised by adverts in the print media and television and there was a test phase that allowed motorists to test their IUs and experience the ERP charging process. Considerable effort was made to reassure people about lack of privacy was not a serious issue. A survey found 75% of respondents felt it was fair to charge vehicles for congestion, and over 60% agreed with congestion management measures other than vehicle ownership taxes. This is despite the fact that exemptions no longer apply for taxis, motorcycles or goods vehicles and no discount is provided for residents.

Stockholm

Although the congestion tax has been introduced in Stockholm as a permanent feature in August 2007, only little data is available from this and the case study had to be based on the trial carried out in the first half of the year 2006.

The introduction of the trial scheme led to traffic reductions of up to 35% on some arterials and the average reduction of traffic crossing all cordons was 22% during the charging period, and by 19% for the 24-hour day. Overall, and for all modes, it is estimated that 110,000 trips per day 'disappear', i.e. are diverted from the city centre or no longer take place at all. It is possible, however, that not all of



these reductions are due to the congestion charge, since one study found a general trend of decrease in travel between 2004 and 2006. In contrast to Trondheim and London, there was very little, if any, shift in traffic to non-charging hours; some of the data even indicates a decrease in traffic for all hours of the day.

The traffic reduction also reduced congestion significantly. During the morning peak, for traffic travelling into the city, congestion was reduced by around 30% and the respective travel times by around 20%. For outbound traffic, congestion was much smaller in the first place, but the tax could reduce this further by 40% and the travel times by around 20%, which means in effect that traffic was flowing quite freely.

Within the charging period, the lowest traffic reductions are found in the morning during the main peak and the post-peak shoulder. The general assumption for explaining this phenomenon is that commuters as well as business travellers, who may be on the way to their first appointment during this time, have the lowest elasticities.

However, both in the morning and in the afternoon, the traffic reduction is larger in the pre-peak shoulder with the € 1.50 charge than in the main peak with the € 2.00 charge and, furthermore, the biggest reductions overall occur during the first charging period in the morning and the last in the afternoon, when the charge is only € 1.00. Neither the Swedish reports nor any of the work carried out within the DIFFERENT project can shed any light on this finding, and this is therefore an area that deserves further research and investigations.

A dedicated study (Transek 2006) had investigated the equity effects of the Stockholm trial. The study concluded that “statistically, one is ... ‘hardest hit’ by the congestion tax if one is a well-to-do, gainfully employed male living in a household with two adults and children in the inner city or in Lidingö⁶”. Households with higher incomes pay the highest tax and also have the highest benefit from travel time reductions, but the tax payments far outweigh the travel time advantage, resulting in the highest net loss for the households with the highest disposable income. For business and commercial travel the picture is different: although their travel time gains are slightly lower than for personal travel, they pay, as a group, substantially less congestion tax, so that on balance they already directly benefit from the introduction of the congestion charge before any use of revenue is taken into account. Unsurprisingly, if the revenues were to be used to reduce income tax, low income earners would gain least since they only pay relatively little income tax in the first place, while they would gain most, if the revenues were used to reduce public transport fares.

The possible impact of the congestion tax on trade had been investigated through a number of surveys. It was found that, if the congestion tax had any overall impact on the retail sector in the city, it would be only very minor; and similarly, no clear or major impact could be found for a range of other trade sectors.

A cost-benefit analysis was carried out as part of the evaluation. The two largest figures in there by far are the congestion tax itself, which costs the car drivers € 76.3 million per annum, but shows in positive terms as public sector revenue, and the savings of € 52.3 million annually from the reduction in car and bus travel times caused by the congestion tax. Adding to that the time savings, which are due to the improvements made to the public transport system in autumn 2005, the total benefits from time savings are € 68 million. Against this stand the costs of the initial system set-up and the on-going operation and maintenance. On that basis it was estimated that the permanent system would produce a net benefit of € 42 million per annum.

The figures available so far from the permanent scheme show that the results from the trial, as far as traffic reductions and other headline figures are concerned, were very close indeed to those figures that so far emerged from the permanent scheme. Therefore the trial has to be considered a resounding success both in terms of predicting the effect of the congestion tax as well as in terms of persuading the Stockholm residents to vote for it in the public referendum.

⁶ Lidingö is an island outside the charging zone that is only accessible from the outside world through crossing the zone.



Edinburgh

The Edinburgh charging scheme was aborted following a resounding rejection by the public in a referendum, but extensive modelling had been carried out over the years with two different models. The results from the two sets of these, which were potentially of most interest to DIFFERENT, because they compared different charging schemes without different accompanying investment packages, were analysed.

From the first set of model runs, it was found that one of the key effects of any of the investigated charging schemes was the shift from car travel to public transport use. The modal shift increased with the level of charges, but the relationship between the charging level and the modal shift was not linear and the marginal effect of charge increases on modal shift decreased more and more the higher the charge became. Overall, and at least in this modelling exercise, there is no impact from any differentiation of charges on traffic reduction, neither by number of cordons nor by differentiation over the day; all differences in impact on traffic volumes can be simply explained by the overall charging level. The analysis of the economic impact also confirms the non-linearity of the impact of higher charges: a "spatial differentiation" of charges is overall more effective than a mere increase in the level of charges at one particular cordon, i.e. 'catching' more people in the cordons has a stronger effect than charging fewer drivers more money.

From the second modelling exercise it is unfortunately not possible to draw any general conclusions. Differences in traffic reductions between different schemes are largely due to the simple question of whether the charging is operating at any cordon during the time period considered, without any obvious further effects of differentiation by time of day.

Trondheim

The cordon charge introduced in 1991 led to a reduction of 10% in traffic crossing the cordon during both the high and low charged periods. However, this was offset by increases of 8 to 9% in the evening and on weekends, so that, overall there was no notable traffic reduction. It should be noted that this happened during an economic recession period with zero annual general growth in traffic. The main effect was a shift in departure times with only a 1 percentage point traffic increase in the early morning before charging hours and a 3 percentage point increase at evenings after charging hours for home to work trips, but a 13 percentage point increase for work to home and 19 percentage point for home to shopping trips in the evening after the charging hours. Overall, it was very visible how drivers delayed their cordon crossing in the evening to avoid charge.

Concerning the relationship between charging level and traffic reduction it was found that during the highest charge in the morning peak there was only a 4 percentage point reduction for home to work and home to shopping trips, while the main reductions occurred during the low charge period from 10:00 to 17:00 with -13 percentage point for work to home and -15 percentage point for home to shopping trips.

The introduction of the spatially more differentiated zonal scheme in 1998 had only minimal impact on overall traffic levels as well as on modal split for those trips that were uncharged before and charged after 1998, while the initial scheme had decreased the car share for trips across the cordon by around 6 percentage point, and this is the first indication that the initial introduction of a charging scheme has stronger impacts than later modifications.

The main effect of the introduction of the zonal system was, as in 1992, a time shift. While the general increase in mode share of cars between 1992 and 2001 for non-charged vehicles was 6 percentage point and for those charged after, but not before, was 5 percentage point, it was only 1 percentage point in the highest charged morning peak, 6 percentage point during the lower charged mid-day and afternoon, 13 percentage point during the evening and night, and 21 percentage point during the weekend, which is again a clear indication that higher charged time periods by no means automatically lead to the highest traffic reductions.

When the charge was discontinued in 2005, traffic levels inbound across three typical toll stations increased at the rate of 3.8% overall and 11.5% during (previous) charging hours. The overall increase was in line with the general traffic growth in the area. Traffic impacts were in many ways



mirror images of the impacts when charging was introduced. Changes in departure times and route choices were the most visible responses to the annulment of charging by car drivers.

Model runs show that the average generalised cost per car trip in the city for weekdays decreased by 22% from 2005 to 2006, as a result of the annulment of tolls. The elasticity value with respect to kilometres travelled was estimated to -0.32.

The introduction of the charge led to a very small short term-loss in city centre trading, while in the long-term there was still overall growth albeit with some loss in market share. However, the cessation of charge did not, at least not in the short-term, lead to any up-turn in trade.

Opinion polls on the attitudes to the Trondheim toll ring indicated decreased opposition after implementation. In April 1991, six months prior to the implementation date, about 70% of the respondents objected to the toll ring. In December 1991, two months after implementation, the negative share had dropped to below 50%. During the summer of 1992 the mood was such that slightly more people were positive (37%) than negative (35%). However, as time went by, the negative share increased and the positive share decreased until a peak in October 2003, when four times more were negative than positive. The very low support in 2003 is related to negative publicity and discussions at that time about the immediate introduction of five new charge stations close to the city centre. A strong indication of the importance of information is that when respondents were reminded about what type of projects the revenues from charging were financing, the support increased considerably. When respondents in 2005 were asked about their attitudes to urban tolling, taking into account the use of revenues, the negative share decreased from 47% to 38%, and the positive share increased from 19% to 30%. What is perhaps more surprising, is the delight with which respondents in 2006 responded to the same question, when asked about their attitude to having had urban tolling in Trondheim. The negative share now dwindled to 27% and the positive share increased to 48%.

The story of Trondheim's toll ring is a story of twisting and turning political preferences and compromises, and corresponding adjustments of the scheme design. Thus, a major planning challenge has been to secure sufficient agreement on the toll ring through more than a decade of numerous minor decisions. All the City Council debates concerning scheme design and adjustments, revenue disposal and road projects, have provided opportunities for the opponents to contest the toll ring principle and the Trondheim Package. The planners' abilities to gain continuing support rest on an understanding of the political climate, close co-operation with leading politicians, and responsiveness to public involvement claims.

The Spitsmijden Experiment

The Dutch Spitsmijden⁷ project was set up to study the feasibility of a reward scheme to encourage commuters not to drive during the morning rush-hour.

The reward trial comprised a behavioural analysis, technical and organisational implementation, welfare optimisation and traffic simulation. The trial was carried out by a public-private partnership comprising universities, private companies and public institutions. The geographical focus was on the heavily congested Dutch A12 motorway link from Zoetermeer towards The Hague. An experiment involving 340 regular rush-hour commuters was conducted in order to obtain revealed preference observations for a behavioural analysis. This was complemented by several surveys (including a stated preference survey), which extended the scope of the dataset.

Participants for the trial were selected among frequent car commuters identified using license plate observations collected by automated cameras. Participation to the trial was voluntary.

All participants received a reward for each time they avoided the peak traffic periods (7:30 till 9:30) over a ten week period (September through December 2006). This was established by comparing the number of times that the participant did not drive during peak traffic to how often they had driven during morning traffic before the experiment. They avoided peak traffic by either driving at another time or by using alternative means of transport (such as public transportation, carpooling, or working

⁷ 'Spitsmijden' can be roughly translated as 'avoiding rush hour'.



from home). As a reward, the participants could choose between money and a 'Yeti' smartphone. The monetary reward was more popular: 232 participants chose to receive money compared to 108 who found the Yeti more interesting. Different levels of the monetary reward were tested for, ranging from € 3 to € 7 per day.

Various technologies were used for the automated registrations. Electronic vehicle identification was used for registration and enforcement. Other technologies, such as cameras with number plate recognition and GPS position logs were also used.

The number of peak car commutes was on average reduced by 50% under the impact of the reward schemes, with the higher reward levels corresponding to somewhat larger decreases. The participants generally substitute off-peak car travel for the original peak commutes. The remainder of the behavioural shift was mainly towards working at home (hence cancelling the trip) and to a smaller degree to travelling by public transport or by bike. It must however be noted that in the particular setting of the experiment the public transport alternative was substandard due to a major infrastructure overhaul.

The focus of the behavioural analysis was the choice process where commuters select a travel alternative from a wide choice set comprising different modes, different departure times as well as the choice not to travel at all. Special attention was paid to how the participants trade off travel time for rescheduling effort and how this is influenced by the reward offered.

The behavioural analysis led to the establishment of a number of parameters (including value of time and schedule delay). These were fed into simulation models that had been developed as part of the project. One model is based on economic welfare theory and was used to determine the optimal reward level. The second model is a dynamic traffic model that allowed the simulation of different reward levels and an assessment of the global impact of the corresponding reward schemes.

At the time of writing extended scientific research is still ongoing and more results will become available in due time. These will focus both on advanced behavioural analyses as well as extending the traffic simulation and welfare optimisation modelling frameworks described above.

Rome

The Rome city centre charge aims generally at the achievement of a sustainable development by shifting the modal split from private car use to public transport in the city centre of Rome. Already having a flat-fare charging system for limited traffic zones, the effects of a new charging system consisting of a daytime and a night time (subdivided into summer and winter scheme) scheme are being analysed.

The simulation of the daytime scheme (from 6:30 to 18:00) takes into account different charge levels for cars, mopeds, and motorcycles as well as the public transport supply. Only selected groups of car drivers are allowed to access the limited traffic zone. Additionally, seven scenarios based on the current situation are built up by varying the charging situation and public transport supply to analyse particular effects separately.

The night time scheme (from 6:00 to 23:00) differs completely from the daytime one: The access to certain areas is completely free, causing a large set of car drivers only crossing the area. Furthermore, in the evening hours demand is shifting from systematic trips to trips for recreational or shopping reasons. Therefore in the simulation of the night time scheme a new demand model has been calibrated. Because demand is also significantly varying between summer and winter periods the simulation model is subdivided. Variations in the level of charges for cars and public transport supply are used to build up five summer scenarios and four winter scenarios.

The daytime scheme model used is a multiclass, multimodal, elastic demand, network equilibrium model where choice of individuals is decomposed according to the classical four step approach (questions of trip, destination, mode, and route). Therefore, the demand model is a mode and route choice model (mode: multinomial logit model; route: multinomial logit model for car and moped, sequential logit model for transit mode). The night time scheme model is based on multinomial logit models.



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The simulation results can be used to evaluate the elasticities of different trip options when applying a per trip pricing scheme to cars entering the limited traffic zone (€ 1 to 6).

Elasticities in the daytime scheme are very low, where non-systematic users behave even less elastic than systematic users. Arguments for that result can be seen in the lack of mode alternatives, so that the modal split does not change for any price change.

Moped users react almost inelastic for each car price, i.e. car drivers do not shift to the moped mode. Public transport demand is most elastic for systematic users of the limited traffic zone. Concerning summer night schemes, the share of public transport is the highest for both work and shopping trips. Additionally, work trips show lower elasticities for all considered alternatives in comparison to shopping trips.

The moped share is highest for recreational trips, followed by public transport. The elasticities for recreational trips are the lowest for all alternatives considered.

Crossing trips have high car elasticities and relatively high values of cross elasticities. Car users prefer destination change, departure delay or route change.

Results from the winter night scheme show an increase of moped and public transport trips to the cost of car trips when the car charge increases, but there are no observable effects on destination change and departure delay. Car elasticities increase strongly when car charges increase. The results for crossing trips can also be applied in the case of winter night trips.

During daytime, users strongly favour cars. This result does not change for increasing car charges. In night summer models the reason for a trip determines elasticity values and user behaviour. Shopping trips have the highest elasticity, followed by work trips. Least elastic behaviour is observed for recreational trips.

Winter model results show a strong reduction of car use due to a shift to moped or public transport when raising car prices.

Milan

Milan, introduced since the beginning of 2008 the so-called 'Ecopass', a pollution charge for vehicles entering the city centre. Besides, a modal shift in favour of public transport, as well as release of congestion are also aims of the charging scheme. The charge is mainly differentiated according to pollution classes. Notwithstanding the recent character of the measure preliminary results are available. In the first month, the traffic reduction during charging hours was 26% in the charging zone and 12.5% outside; and, as in the Trondheim and London, there is a very small increase in traffic in the morning before charging starts, but a clear peak in the evening after the end of charging. In February and March traffic reduction was significantly lower (14% in the charging zone and 8% outside).

In addition, (as from normative theory already formulated) a shift in car ownership occurred. The share of passenger cars with for emission class 3 (€ 2/d) among all cars went in February down from 14% to 9% and for class 4 (€ 5/d) from 25% to 11%. For Light Duty Vehicles numbers the share of class 4 went down from 51% to 38% and for class 5 (€ 10/d) from 20% to 15%. At the same time, the share of low emitting cars increased accordingly.

To a certain extend the effectiveness of the scheme with respect to the environmental goals (air quality) could also be recognised. Air quality improved initially, but weather conditions could explain the largest part of the reduction of pollution, since in March the improvement in the charging area was not better than outside.

With respect to the third goal, public transport also benefited as well with an increase of 9% in underground passengers and an increase in surface commercial speed, initially as high as 11% but soon reduced to a 4% gain.



Taking all these effects into account, it can be safely stated, that the differentiated 'Ecopass' charge in Milan induced the desired reactions from car drivers and therefore is additional evidence that price differentiation can be a useful tool in road pricing schemes.

Transport Modelling for City Tolls

Based on the Edinburgh network, a conceptual model has been used to investigate the comparative benefits of various charging schemes with different degrees of differentiation as well as to explore the importance of correct estimates of elasticities for the outcome of these comparisons.

Two of the schemes modelled were primarily for benchmarking purposes: a system of MSC tolls applied across the whole network, and a Uniform scheme (at a common rate per km across the whole network) intended to act as a proxy for a fuel duty increase. Other schemes modelled were cordon-based, distance-based and area-based, plus some motorway-based schemes. Totally a set of eleven schemes was modelled, each of which corresponded at a number of different charging levels.

With respect to the effects of the different pricing measures, modelling work revealed that MSC based tolls result in a substantial reduction of total network delay. Additionally, the "benefit" (as measured by the sum of the reductions in the cost of total delay and externalities compared with the no-toll alternative), was the highest.

Similar results to the first-best MSC based tolls scheme were also derived by the application of a simple uniform tariff scheme. The main reason for this is the spatial nature of the charging scheme. It seems that since the total toll revenue is kept fixed, MSC based tolls and uniform tolls result in very similar user reactions.

Direct comparisons of area-based and distance-based schemes indicate that, whilst they give similar reductions in demand, the area-based scheme gives a much greater reduction in total delay, whilst the distance-based scheme gives a much greater reduction in vehicle-kilometres in the relevant regions. In each case, the pure cordon scheme gives a rough compromise between the distance-based and area-based equivalent, but with a somewhat smaller reduction in demand. An important distinction between the area-based and distance-based schemes is that, in the latter, drivers will seek to re-route to minimise the charge they incur, which can induce a considerable increase in vehicle-kilometres.

Besides, the results for the specific network modelled show that the size of the area covered by the scheme play the major role with respect to the effects. The reason is that a wider area corresponds with a higher number of drivers who would have to pay the charge; This result can safely be formulated also for other networks.

Whilst the results described here were obtained assuming a value for elasticity of $e = 0.3$, a further series of tests were conducted assuming different values for e . The sample results from these further tests confirm that, whilst the numerical value of measures such as total delay obviously depend on the value of e , the broad nature of the results, and the relative ranking of schemes, is not significantly affected by this. Therefore, it appears safe to say that generally the precise estimate of elasticities is much less crucial for the comparison between different schemes than for the estimate of their effects in absolute terms.

Empirical Evidence from Intermodal Chains

Cost Comparison of Intermodal and Road Freight Haulages on Selected European Routes

Desk research done within work on D10.1 proved that price is a major determinant of mode choice decisions within the freight sector, particularly in a competitive market. Thus, it was essential to analyse in details real transport cost on selected European routes. Authors compared road transport, as the most frequently used, and intermodal haulages, as widely promoted by the European Commission. Intermodal scenario was defined as a road-rail scenario because most European countries have a well developed railway infrastructure (inland waterways are not so ubiquitous, sea transport is not relevant to land-locked countries). There is also another aspect in favour of detailed analyses of intermodal transport using mainly railways, which is the fact that in most European countries railway infrastructure is very well developed and easily accessible for the majority of



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European regions. Furthermore, many big companies have their headquarters inside the continent, where only railway and air transport may be an alternative to road transport. Although potentially relevant, air transport was not taken into account in the simulations due to the high costs that would have been incurred.

Therefore, to calculate real transport cost and compare prices of road and intermodal haulages simulation model was created. The cost model assumes that, on the main part of the route, the loads are transported by rail or/and sea to assigned consolidation/deconsolidation points. The trains shuttle between points of origin and destination. The points may be used by any company. Road vehicles are used to transport goods to the consolidation points and for the final distribution of loads.

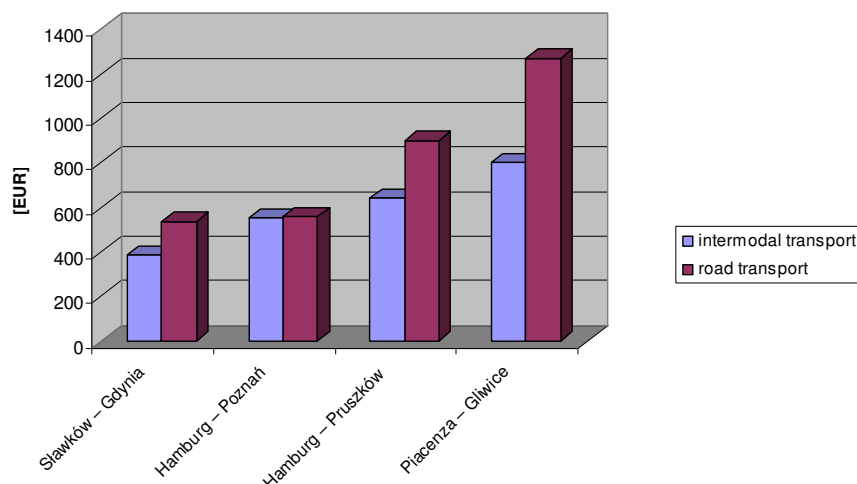


Figure 3-1 Comparison of 40-foot Container Transport Costs on Selected Routes

The comparison shows that in some parts of the Europe an intermodal solution is cheaper than road haulage. According to executed simulation, intermodal haulages are attractive for companies on medium and long routes (e.g. from 500 km). Moreover, calculations assumed 30% transport operator's margin. Therefore, the price of intermodal haulages might be even cheaper, if all actors involved in transport processes agreed on new terms. However, this statement depends on many local constraints, cannot be generalised and should be verified in different EU regions.

Multimodal Passenger Transport System

The hypotheses, created in D10.1 were examined using a combination of evidence from previous studies, new modelling work, and logical deduction. The new model is a simple elasticity-driven spreadsheet which predicts the usage of individual modes and combination modes by a representative population of travellers under different pricing scenarios. The scenarios explore the impact of charges which were differentiated in terms of mode, time period and trip length. The analysis begins by examining the effect of charges based on marginal social costs but is extended to explore the effect of:

- Revising the charges to allow for changed conditions caused by introduction of charges based on base year conditions.
- Investing the revenues pro rata to demand or exclusively to favour environmentally sustainable modes.
- Exempting environmentally sustainable modes from all charges.
- Abolishing all pre-existing taxes and subsidies.
- Allowing for any revision to prices associated with changes in the per-unit costs of providing transport services.

The case studies and evidence referred to in the analysis include:



- River and coastal ferry services in Hamburg, London, The Three-cities conurbation and in Scotland.
- The London, Stockholm and Singapore road user charging schemes.
- The abortive attempts at pricing reform by Deutsche Bahn and SNCF.
- Pricing Policy in the UK Bus industry and the low cost airline industry.
- The UK's National Road Pricing Feasibility Study.
- New evidence on travellers' response to complex pricing structures.

3.1.3 Empirical Evidence from the Psychological Perspective

Case Study: AKTA Road Pricing Experiment

The AKTA road pricing experiment was the Danish part of the EU project PROGRESS⁸, where road pricing was examined by various approaches in 8 European cities (AKTA, 2005; Nielsen & Sørensen, 2007). 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 pricing schemes with different levels of charging. The three different pricing systems implemented in AKTA varied in their time differentiation, spatial differentiation and payment mode.

Analyses done within the DIFFERENT – project used subsets of GPS – data (travel behaviour) and questionnaire data (acceptance, stated behavioural adaptation) to investigate the impact of differentiated pricing on public acceptability and travel behaviour.

The results show that the participants successfully 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. However, the AKTA road pricing experiment provides no convincing evidence that there is an impact of differentiated pricing over and above the effect of pricing as such. Further, 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. Particularly concerning relationship between route choice and acceptability, it was found that participants who were positive towards different types of road user charges chose the cheapest route whereas participants that were negative did not. The AKTA study moreover 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.

Case Study: Edinburgh Demonstration Trial

The Edinburgh case study considered the moderating impact of users' attitudes and habits on their behavioural adaptations towards differentiated charging. The objective of the Edinburgh technology demonstration trial was to demonstrate the viability of the proposed congestion charging approach. During the trial, volunteers were asked to simulate the purchase of licences whenever travelling through one of the demonstration sites by car during the day. Accompanying the demonstration trial, participants were asked for their opinions and experiences on congestion charging by interviews at different time points.

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. Results from the case study emphasise that situational aspects have an impact on the amount of behavioural adaptation. These results, together with those on motivational aspects imply that, if road charges are to evoke behavioural changes it is necessary

⁸ <http://www.progress-project.org/>



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.

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.

Case Study: Newcastle Survey on Attitudes and Responses to Road Charges

The main aim of the Newcastle survey (designed specifically for the DIFFERENT - project) was to explore the factors affecting public perception of the complexity and effectiveness of differentiated road charging schemes and their behavioural responses to them.

The picture which emerges is of a population who consider congestion to be a relatively minor problem, who are sceptical about the effectiveness of road charges and unconvinced of the need for 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).

The results suggest 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 include a per-mile element are perceived as more complex. Thus it was found evidence that the degree of complexity perceived is influenced not only by the amount of differentiation but also by the nature of that differentiation.

Moreover the case study provide evidence to suggest that, over and above the degree of differentiation, the presentation of pricing schemes may influence users' attitudes and responses. The results indicate 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.

Also considerable evidence is found on the effect of motivational factors on users' responses towards pricing. Results 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). Moreover the results similarly show a correlation between the perceived fairness of road charging and anticipated ease in making an accurate estimate of charges. Considering the effects of users' socio-demographic characteristics on attitudes and responses, the results show 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. Further older respondents were less likely to expect to increase their overall trip numbers in response to such charges. 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. Moreover there was a positive relationship between having professional qualification and expecting to change travel patterns or change the timing of journeys in response to the introduction of charges. The 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 was significant negative.

In terms of situational aspects the results show 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.



Case Study: GRACE / DfT Questionnaire Survey

The GRACE questionnaire survey was intended to help in the specification and calibration of models of drivers' response to complex charging regimes. The idea behind the questionnaire 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 results suggest 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). This provides evidence that behavioural responses are affected by the perceived complexity of the scheme. Moreover the case study suggest that people are prepared to put more effort into consideration of alternative mobility behaviour if prices are easier to predict and 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. Thus people's preparedness to engage with pricing structures may be influenced by their perception of the effort required and the likely potential saving.

The results also indicate that the stated likelihood of future behavioural adaptation is strongly conditioned by the respondent's opinion on their ability to respond. There was also a 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". As already mentioned above, situational aspects have a strong impact on the amount of behavioural adaptation. Results on perceived situational constraints, together with those on motivational aspects suggest that, if road charges are to evoke behavioural changes it is necessary that individuals should perceive that they have opportunities to respond. The introduction of road charges without users perceiving any behavioural control might lead to contrary effects like reactance (adverse motivational state) or resistance to road charges.

Considering the effects of users' socio-demographic characteristics on attitudes and responses, the picture which emerges is that the age of driver 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. Moreover woman were more likely to state they would choose a new route, share the driving or stop travelling altogether but less likely to change 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.

Experiments: Laboratory Experiments Regarding User Response towards Charges

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. In experiments 1 and 2 the complexity of a road pricing scheme was varied on two dimensions (spatial and temporal) from simple to very complex (five steps). These experiments provide an indication that there is a relationship between participants' acceptability (approval) of road pricing and their responses to differentiated prices. To investigate this more in detail and to obtain causal evidence, a third experiment was conducted where it was tried to manipulate the acceptability of urban road pricing (via an introduction text about procedural fairness in implementing and about costs or benefits of road pricing). This second factor contains also five steps (four treatment groups, one control group). Within all three experiments the main dependent variables are delay (latency time) and error rate in price estimation but also subjective rating concerning perceived certainty about estimates and perceived easiness to understand.

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. 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. 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. The first two experiments provide an indication 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). To investigate this more in detail, a third experiment was conducted where it was tried to manipulate the acceptability of urban road pricing (low vs. high). This experiment did show 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). 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. 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.

Another interesting finding was 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.

Case Study: Interviews with Road Hauliers / Freight Operators

Two interview surveys focus on freight operators' / road hauliers' perception and attitudes towards differentiated transport charges and several aspects of differentiation. Data from these surveys were merged to get a more reasonable sample size. Analyses 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.

Results show that acceptability towards differentiation elements is particularly strongly correlated to the likelihood of future behavioural changes in medium terms as well in long terms. These findings underline that positive attitudes towards differentiated prices are also in means of freight sector essentially relevant for prospective success and effectiveness of pricing measures. Further, variables which sought aspects of direct handling with differentiated toll charges by operators (e.g. understandability, engagement to deal with schemes) do not contribute to prediction of stated likelihood of behavioural changes considerably. That might suggest that the understandability of charging schemes respectively the engagement to deal with them is less important for freight operators regarding their behavioural adaptations than for individual car users or transport passengers. A further fact supports this assumption additionally: vast majority of respondents state that they have special staff that calculate and evaluate road toll expenditures. So, cognitive burden by differentiated pricing schemes do not play the role than for single individuals and is identified as 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 freight operator sector affect behaviour rather in the long run than immediately.

Further findings suggest that diverse elements of differentiation differ regarding statements of acceptability by respondents. Thereby, differentiation according emission or vehicle class seems to be



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more acceptable than other differentiation elements. Differentiation in terms of geographical aspects (e.g. mountainous or sensitive areas) or time aspects (period of year / week / day) are rather less acceptable to road freight operators than other elements. It is noticeable that differentiation element rated more acceptable advert to changes at vehicle side whereas less acceptable rated differentiation elements advert rather to concrete behavioural changes. One possible explanation of this effect might be that freight operators perceive more control to respond towards vehicle side based price differentiation than to a price differentiation which affects directly the execution and which is more outside perceived behavioural control.

Case Study: Hovercraft Trial, Kirkcaldy to Portobello

Cross Forth passenger ferry 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.

Analyses used online 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.

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. 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.

Further results 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

Case Study: User Reactions towards Yield Management in the Long-Distance Rail Passenger Sector

The main objective of the case study was to investigate the user reactions towards differentiated fares and prices in the rail passenger long-distance sector and to identify reasons for the low acceptability of yield management. 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. In order to implement yield management 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. 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).



Reactance is an intense adverse motivational state and leads to attempts to restore one's behavioural freedom by direct and indirect way. 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. This theory was 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. Therefore a questionnaire study was conducted to explore the attitude of respondents 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 and to measure psychological reactance.

The results from the case study confirm the existence of high reactance towards yield management in the long-distance sector. The picture which emerged was that rail passengers perceive the new fare system in the long-distance sector (underlying yield management) as restriction of their perceived behavioural freedom and thus they reacted with psychological reactance. Respondents stated that they have problems with the advanced purchase requirements and rebooking and cancellation fees and they more prefer the old pricing scheme.

Moreover the findings provide evidences that psychological reactance towards yield management is caused by the characteristics of the system. It was found that the advanced purchase requirements and the rebooking and cancellation fees, contribute most to the development of reactance. Furthermore psychological reactance increases if the respondents evaluate the old pricing scheme positively and if they describe themselves as price sensitive, but uninterested customer.

Finally, the results suggest that situational factors such as travel frequency and personal factors affect the response towards yield management. It was shown indirectly that frequent travellers will react more strongly towards restrictions of behavioural freedom caused by yield management than less frequent travellers. It emerged that BahnCard holders have more problems with the advanced purchase requirements and rather prefer the old scheme. Because of the fact that this group of persons more often travel by the Deutsche Bahn, it is assumed that frequent travellers show more reactance towards yield management.

3.2 CONCLUSIONS FROM THE EMPIRICAL RESULTS: ECONOMICS

The overview of the case studies provided above indicates a large degree of heterogeneity across the cases. Given that most cases concern non-experimental real world implementations, this does not come as a surprise.

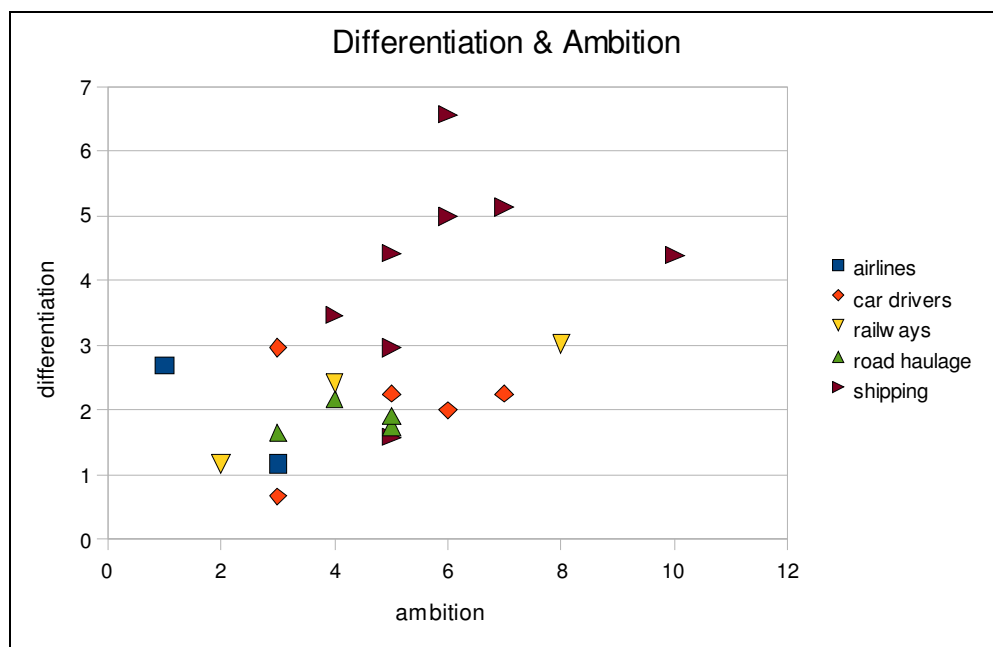
All case studies focus on infrastructure price differentiation. In order to draw some safe conclusions WP 3 introduced and discussed an indicator that captures the degree of differentiation of a pricing scheme and allows to compare it to other schemes.

The indicator has two parts. Concerning the first part of the indicator, the empirical analysis showed that the goals of cost coverage, efficiency, and environmental goals are the ones most often adopted. In detail, the degree of ambition, i.e. the case's number of objectives, varies from case to case.

Concerning the second part of the indicator, the dimensions of price differentiation, four dimensions of price differentiation have been frequently observed: type of vehicle, type of user, size of vehicle, and time. From the actual numbers of each case's differentiation dimensions and corresponding price level, the degree of differentiation has been derived.

Bringing together the number of goals and the degree of differentiation, it is clearly observable that there exists a positive correlation between the two measurements. The higher the number of goals, the higher the differentiation of a tariff (see Figure 3-2). This confirms the intuition that each objective has to be considered when designing a differentiated tariff.

Figure 3-2 Degree of Differentiation vs. Number of Goals (Ambition)



Source: Del. 3.3 of the DIFFERENT project

The involved actor in designing the tariff is in most cases a semi-public firm or the public sector. In the majority of cases, the involved actor uses literature reviews and stakeholder interviews to decide on the design of the tariff. Only a minority uses models. Implemented tariffs mainly induce user reactions concerning route or (air)port choice, but also effects on choice of mode, vehicle type, and destination were frequently observed. Charge payers are freight and passenger companies, car drivers and others, but never the government. The actual effect of the tariff is for most cases on environment. Although efficiency is highly important with respect to objectives, in the most cases, this goal is not treated often in the tariff studies.

Finally, in the case studies there seems to be a duality between pricing scheme objectives and the analytical evaluation of the impact of the differentiated scheme.

Based on the theoretical framework provided in chapter 2, two general hypotheses were formulated. In a subsequent step this led to more specific hypotheses. In Table XX the results of analysis with respect to the hypotheses are presented. A first general hypothesis describes the factors that inspire price setting actors to adopt a certain degree of differentiation. A number of specific hypotheses were formulated to operationalise this relationship. In the analysis (see D.3.3) only a limited number of the specific hypotheses could be confirmed, whereas for the other hypotheses no clear picture was obtained or in one case even the reverse was revealed.

A second general hypothesis relates the degree of differentiation to user responses. The outcome of the analysis is clearer here. For three out of seven hypotheses the postulated relationship could be identified in the data set, especially with respect to the effectiveness vs. the (optimal) degree of differentiation as well as user reactions vs. the dimensions along which price differentiation occurs. For the remaining hypotheses either sufficient data was lacking or difficulties in measuring were identified. With respect to the latter problem it has to be noted that the theoretical concept of exemptions is somewhat difficult to capture in real world schemes, where large reductions sometimes are a substitute for exemptions. Moreover, pricing schemes without exemptions seem not to exist in reality, making it difficult to test for the impact of exemptions in our cross case analysis.



Empirical data shows that the political factor plays an important role for tariff implementation and therefore forms a crucial constraint. Furthermore, additionally it is observable that a higher degree of regulation leads to a higher importance of the political dimension. This is valid for all transport modes and all countries. Hence, basic axiom 1 is in line with the empirical data provided from the fact sheets.

The setting of Infrastructure-tariff will always be subjected to a strong political element. The positive theory aspect of setting infrastructure charges is therefore highly relevant. Lobbying activities will be a major explanatory variable for the tariff structure that will finally be implemented.

In WP 3 the notion of politically accepted tariffs was coined. A politically accepted tariff is one which corresponds to a game-theoretic equilibrium between interest groups. The case studies show that politically accepted charges can be found in all transport modes. In the majority of cases the finally implemented charge is accepted, in the sense that there are currently no activities to reverse the tariff. This shows that a kind of SIG equilibrium is reached. So, basic axiom 2 conforms also with the empirical data.

Policy makers will react to lobbying influences and implement a kind of SIG equilibrium (like in the Stigler-Peltzman model or the Grossman/Helpman model described above). Infrastructure charges which correspond to such equilibrium may be termed "politically acceptable". In most cases this rules out tariff-structures, which increase the welfare (as compared to the status quo ante) of only one SIG even if total welfare effects should be positive.

Although lobbying is likely to create welfare losses, most tariffs from the empirical analysis are classified as efficient. In those cases where the efficiency goal is missed lobbying is the main reason. Lobbying was clearly recognisable in most cases and in all transport modes as well as all countries of the EU.

The group which profits most from a tariff structure is the group of infrastructure users rather than the infrastructure providers. An explanation can be existence of well organised special interest groups lobbying for infrastructure users. Surprisingly, the infrastructure companies do not seem to be able to establish their favoured tariff.

Often the political power of the favoured SIG was not clearly observable. However, only the minority of cases showed medium powered SIGs. More often were either low powered or high powered special interest groups.

Analysing the resulting degree of differentiation, it can be concluded that the lobby activities itself and the particular power of SIGs involved have effects on the final tariff structure. In cases with some medium powered special interest groups the resulting degree of differentiation was highest. That can be interpreted as compromise between equally powered special interest groups. Especially weak or strong SIGs involved lead to a less differentiated tariff structure (see Figure 3-3). Using this information, some of the hypothesis listed in Table XX can be confirmed.



SYNTHESIS AND CONCLUSIONS

	Hypothesis	Confirmation	Comments
H1.1	The higher the weight that price setting actors attach to equity considerations, the more they will be inclined to apply price differentiation where customers that would deserve support from an equity perspective will be confronted with low charges compared with other customers.	Yes	Qualitative analysis
H1.2	The higher the weight that price setting actors attach to efficiency considerations, the more they will be inclined to apply price differentiation where prices reflect the marginal costs of transport (for example, marginal congestion costs, marginal maintenance costs).	No	Data gives no clear picture.
H1.3	Consider the case where cost recovery is imposed on price setting actors (for example infrastructure managers). Given the side condition of cost recovery, the higher the weight that price setting actors attach to efficiency considerations, the more they will be inclined to deviate from average cost pricing, implying a move towards differentiated pricing structures.	No	Data gives no clear picture.
H1.4	Profit maximising monopolists will use price differentiation based on willingness to pay in various sub-markets.	No	Data gives no clear picture.
H1.5	When the costs of price differentiated charging mechanisms are high for the price setting agents, they will choose simple (cheaper) charging mechanisms as second best strategies.	Yes	
H1.6	When transport cost structures are characterised by increasing returns to scale monopolistic tendencies will prevail more than in the case where increasing returns to scale are absent.	No	No comparison possibilities.
H1.7	The degree of charge differentiation is larger when the variation in willingness to pay, and in the price elasticity of demand is larger among subgroups of consumers.	No	No sufficient data.
H1.8	The more monopolistic power of the price setting agent, the higher the probability that price differentiation will be applied between different user groups.	No	No clear evidence for confirmation.
H2.1	Effectiveness of a price measure increases with the level of differentiation, but after a certain level, the effectiveness stabilises or may even decrease. The negative counter effect is stronger for individuals (e.g. car drivers) paying the charge compared with companies (e.g. rail freight operators). And it is stronger for frequent users compared with infrequent users.	Yes	
H2.2	Exemptions to pricing schedules have an adverse effect on the effectiveness of the price measures	No	Limited data availability.
H2.3	When price differentiation takes place in a certain domain (for example time differentiated tolls), the strongest behavioural response takes place within the same domain (change in departure time). Effects in other domains tend to be smaller.	No	Limited data availability.

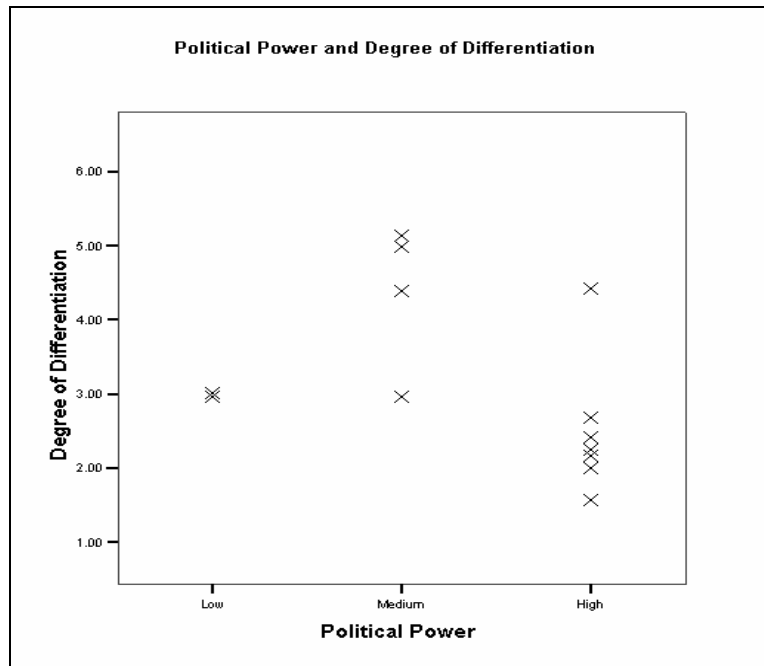
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SYNTHESIS AND CONCLUSIONS

	c. Taking SIG influence into account, fully distributed cost pricing methods will cause comparatively less welfare distortions than other pricing schemes (see Laffont 2000).	No	Not possible due to the nature of many case studies.
	d. If peak load pricing is the intended pricing policy then SIGs representing the peak users concentrate their activities on shifting capacity costs to marginal costs (by producing corresponding studies etc.). The SIGs representing off-peak users will do the opposite.	No	Not possible with the given Data.

Figure 3-3 Political Power and Degree of Differentiation



Source: Del. 3.3 of the DIFFERENT project

The hypotheses presented are based on the theoretical framework presented in chapter 2 and are rather plausible with respect to within case variation in differentiation. However, a cross comparison of wildly customised cases is less straightforward. Not only come cases in a myriad of flavours, each one with its own quirks and particularities, making any subset of real world cases to be a showcase of heterogeneity rather than a laboratory for hypothesis testing. But even if we leave beside cosmetic issues and focus on the essentials, there seem to be a number of key variables that are difficult to control. This problem consists in the difficulty to capture these variables in a generic way.

3.3 CONCLUSIONS FROM THE EMPIRICAL RESULTS: PSYCHOLOGY

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. Based on the results from case studies and experiments, following conclusions are deduced:

- If the **degree of differentiation** increases, **inaccurateness and time to respond (latency time) in examination of pricing schemes** 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 dimension of differentiation is perceived differently difficult by users**. A higher likelihood of perceived difficulty is given by the following conditions of charge differentiation:
 - the charge varies non-linearly (e.g. if price is a non-linearly increasing function of speed);
 - the charge varies unpredictably (e.g. with price as a function of current congestion);
 - differentiation dimensions are not clearly observable (e.g. with price based on current emissions);
 - charges 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);



- the pricing scheme is based on spatial divisions which may not be widely known (e.g. with cordons or zone boundaries which do not follow well-known boundaries);
 - charges 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).
- **Users' experiences** of any dimension of differentiation **reduce the effect of complexity in that dimension**. Price differentiation which builds on already existing cognitive structures (e.g. from public transport sector) and mental maps of users are advantageous. It must therefore be recognised that cognitive structures and mental maps could differ with the user's 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 as simple as possible.
- Motivational factors, particularly acceptance, affect user's perception of pricing schemes and user responses towards differentiated prices. 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. People who accept infrastructure charges have fewer problems to deal with differentiated pricing schemes than people who do not support.
- 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 cognitive effort to deal with them is high, it will become more likely that individuals continue to travel as before.
- The effect of 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.
- The degree to which acceptance influences user response is moderated by people's perception of the availability of internal and external resources to respond (perceived behavioural control⁹, see Ajzen, 1991). Particularly, the perception of situational opportunities (external resources) which enables them to respond to pricing schemes seems to play an important role.
- Lack of perceived behavioural control over response to pricing schemes, and scheme characteristics that restrict people's perceived freedom of action, might lead to an intense adverse motivational state and to attempts to restore behavioural freedom (psychological reactance, Miron & Brehm, 2006), and eventually, to 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 often allocated to special organisational structures of companies. Concerning responses towards differentiated charges, transaction costs in terms of cognitive effort are less essential.
- The knowledge about transferability of results from one transport mode to another so far is limited. The findings suggest that the way people react to pricing schemes strongly depend on people's perception of unique characteristics of specific transport modes. (E.g. the business success of the transfer of yield management principles from the air sector to the rail road sector in Germany within the introduction of a new fare system of the Deutsche Bahn (DB) in 2002 failed to appear and the introduction met with substantial opposition from the public and passenger

⁹ *Perceived behavioural control* (Ajzen, 1991) is the degree to which an individual believes that the behaviour is under his or her control. Thereby, lack of perceived behavioural control depends on two factors: on the one hand it is possible for a person to perceive external barriers (lack of external resources), on the other hand a person might perceive lack confidence in his/her ability to carry out the behaviour (lack of internal resources, self-efficacy).



associations.) So, cross sectional transfer of charging scheme principles and thus the transfer of expectations in behavioural changes seems not to be adequate if unique characteristics and specific perception of users on (specific) transport mode are not taken into consideration.

It has to be acknowledged that conclusions and generalisation of findings are limited, among others, by methodological issues. The majority of studies are characterised by correlative design and, strictly speaking, do not allow causal relationships to be inferred. Further, some case studies were not specifically designed to allow examination of the effect of differentiation degree on user responses 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 sector are clearly underrepresented and partly marked by small sample sizes. These case studies however provide interesting results and further research activities would be useful to broaden and enlarge insights into user responses towards differentiated pricing.



4 CONCLUSIONS AND RECOMMENDATIONS

4.1 GENERAL CONCLUSIONS

4.1.1 The Contribution of the DIFFERENT Project to Differentiated Charging

Within this subsection the insights from DIFFERENT to the pricing approach will be analysed.

From a practical point of view, the review of pricing differentiation practices shows that, despite the different transport modes, among the determinants and the related measures for the implementation of pricing policies, the market characteristics are important. More specifically:

- When the existence of natural monopolies is manifest, e.g. in the interurban road (motorways), rail network, airports and ports, the basic precondition for the adoption of pricing reforms is the institution of an independent authority, able to regulate the access to the network of third parties and new entrants (competition for the market). This recommendation is also supported from the results of the positive theory of regulation;
- When liberalisation and privatisation processes have determined the presence of private operators and or concessionaires, a legislative context ensuring competition and non collusive behaviour may be required (competition in the market).

On top of that, an equal important role must be assigned to **acceptability issues** and the adoption at national level of the EC principles for pricing reforms, e.g. non-discrimination, transparency and consultation. This conclusion can be drawn from the DIFFERENT case studies; i.e. in Rome, Trondheim, London and Stockholm, for which the existence of fair implementation of pricing schemes, e.g. campaign awareness, compensation, equity consideration, etc. has been proved as a basic precondition (a part the presence of technical requirements).

From a theoretical point of view, DIFFERENT has shown the state-of-the-art of existing body of economic theory on charge differentiation, behavioural strategies of adaptation to differentiated charges, and modelling approaches for simulating the reaction (transport demand) to price differentiation.

The following conclusions can be drawn:

Economic theory provides a complex picture. On the one hand, an analytical stream of economic theory suggests the optimal framework (the normative approach) for transport charges differentiation. It is reached pursuing economic efficiency, a concept derived from welfare economics, according to which transport charges (prices) should equate with marginal social costs in order to obtain the maximal social welfare. This implies that the price of transport services should be provided up to the point where the benefit for the marginal unit is equated with the costs of providing that unit (the so-called first-best rule).

On the other hand, a complementary stream of analysis questions the practical application of the concept of marginal cost in transport, due to technological, institutional and political reasons, opening the way for deviations from the first-best pricing rules, i.e. towards second-best pricing approaches. This means a move from a normative approach (how transport charges should be in order to ensure welfare maximisation) towards a positive approach (how transport charges actually are in order to take account of several constraints).

In terms of impacts on charge differentiations practice, it can be said that following the normative approach a highly degree of charge differentiation is required, i.e. the charges should vary taking account simultaneously of several dimensions (variability of vehicle technology, time of travel, place of driving, driving style, etc). Conversely, a less differentiated structure of charges, reducing its intrinsic complexity, can be suggested following a positive approach.



The adoption of a less differentiated charge structure also emerges from the **behavioural theory**, according to which there are cognitive limitations that restrict the degree of complexity that people can deal with and thus the degree of differentiation possible. However, the behavioural theory also stresses the importance of motivational factors in accepting differentiated charges. Thus even if transport users are able to understand a complex 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 without a certain degree of acceptability.

The contributions provided by the behavioural theory approach assume that there is one point where more differentiation of charges does not lead to more users' adaptation, because people do not understand the system anymore. Thus, when looking at user's reaction of differentiated pricing, it seems reasonable to consider the question of people's acceptability together with their ability to respond to the price signals.

Summing up, the DIFFERENT project provided a general framework for identifying the preconditions for a fair and efficient implementation of pricing differentiation in transport, both theoretically and from a practical point of view.

In such a context, the methodological approach for the identification of a common framework focuses on the most important determinants for a fair implementation of pricing reforms, suggesting a short list of measures able to address these determinants, which may need to be integrated by other initiatives, depending on the particular situation in a given European country.

The relevant determinants, common to the overall countries, distinguish structural factors (the basic legislation and the institutional arrangements), technological factors (the infrastructure of pricing) and behavioural and political aspects (the acceptability of the pricing reforms).

4.2 CONCLUSIONS AND RECOMMENDATIONS REGARDING ELASTICITIES

4.2.1 Airports

Many different services and activities are carried out at airports nowadays. These activities are usually grouped into *airside* and *landside*, and the fare structure of the airport tends to mimic this grouping. Consequently, when talking about differentiation of charges at airports the whole set of charges susceptible of being differentiated and the criteria applied in this regard has to be taken under consideration. For instance, when airports decide to deal with the noise problem through a pricing mechanism they may opt for the creation of a new charge (noise charge), for the differentiation of the landing charge based on this criterion or for introducing surcharges on the landing charge when noise is perceived as most annoying (i.e. night periods).

The degree of airport charges differentiation in Europe has been already presented in Deliverable 2.1 of this project. It was shown that the main differentiation criteria were:

- Aircraft weight
- Period of the day (e.g. day, night)
- Flight type (e.g. national or international)
- Traffic condition (peak/off peak)
- Aircraft noise
- Aircraft emission levels (pollutants)

Speaking in economic terms the main element of the tariff structure in the airport sector is a two-part tariff. Within the DIFFERENT project several cases of airport charges differentiation were analysed. Taking into account that in some instances the differentiation was already in place whilst in others was not, the methodological approach in each airport case study was necessarily different.



Perhaps the most important overall conclusion has to do with the effectiveness of market mechanisms in inducing a change in airlines' behaviour. The basic argument is as follows: **the weight of airport charges on the whole costs structure of air carriers is minor, hence any modification in the level or even the structure of charges will cause only a small reaction on the airlines' side, if there is any reaction at all.** This "low elasticity" argument appears to be confirmed at least in one of the case studies presented (Hamburg Airport), whilst in some others there might be caveats in this concern.

Two important policy questions may be answered using the results of the analysis in the case of the London airports: do low-cost airlines operating from a secondary airport compete with full-service airlines serving a main airport in a multiple airport region, and do the estimated demand elasticities imply that price differentiation will be successful? The results show that the cross-elasticities of demand are rather low; there **seems to be only a small effect of price change at one airport on the market share at another airport.** This may indicate that competition is not as strong as expected, but one should realise that we look at the elasticity at the market-level. A price change in a market may well lead passengers to change their destination. This effect cannot be captured within our model due to data limitations (such data are simply not available). The same can be said for price differentiation. Changing prices to spread demand in a certain market over time or over different airports operated by the same airport operator may lead to the situation where passengers decide to change their destination. From the airport operator's perspective, this may not be a big issue, but for an airline it may be problematic. Another finding is that **the direct price elasticity of demand varies only little between business and leisure travellers**, contrary to what was expected from the literature. One would expect that business travellers fly during peak hours, and are relatively inelastic. But because of the capacity constraints at London airports, airlines may operate on the elastic part of the demand curve during peak hours, even though the demand function for business travellers may be steeper for business travellers when compared to leisure travellers.

4.2.2 Ports

Ports are operating under different environments and organisational structures. However, the port sector is neither standardised nor homogenous in regard to ownership, organisation, competitive framework and administration. Furthermore, ports vary in size, functions and geographical reach of hinterlands. Therefore pricing strategies vary as well, whereas the basic scaling factors used for price differentiation are somehow similar. In this respect the operational scheme of a port, whether it is operated by a public body, concessioned (i.e. landlord scheme) or fully private operation, has a significant impact on the charges levied by the different bodies. This also means that ports are subject to different degrees of regulation and supervision.

The shipping market can very generally be split in general cargo, container, and dry and liquid bulk markets each using different ship types.

A key distinction has to be made for ferries. This transport vehicle is capable of carrying passengers, accompanied cars and freight vehicles (accompanied or unaccompanied) at the same time. This makes the ferry rather unique amongst transport modes because of its combined large freight and passenger carrying capability. In the case of road and rail, freight and passenger transport demand tends to conflict, whereas on a ferry they function in a complementary way.

Many ports provide services to a number of these markets and thus the ship type used in each market is the most evident differentiation criteria, since the transported products also have different price elasticities, depending on the overall value of the product.

In many cases the structure of port infrastructure charges¹⁰ is clearly defined for the public domain, but **port charges are actually a matter of negotiation, especially for large customers.** This poses a significant challenge in analysing the effectiveness of differentiation in the shipping sector and implies the question in how far the existing differentiation schemes are brought forward in real market application. In this context the author of D6.2 assumes that the concept of differentiation is in some

¹⁰ This does only include charges made directly to the ship and does not include terminal handling charges.



respect applied and reflected in the actual contracts. But one should be aware that the effectiveness of differentiation might be questioned in this context.

In the general context of published charging schemes, the following dimensions of differentiation prevail:

- Ship type
- Type of traffic
- Frequency
- Location
- Compliance with standards (e.g. environmental standards).

Main findings throughout the project in relation to elasticities of user response on differentiation of port infrastructure charges depend on the type of traffic:

- Traditionally, experts agree that demand for port services is relatively inelastic with respect to port prices in overseas container shipping.
- The variation in the role of port costs for different shipping sectors and markets in the overall transport costs means that elasticities vary as well. Port infrastructure costs weigh the highest in overall port costs in Feeder services and intra European RoRo.
- In the ferry sector, for short distance and passenger ferries in public transport networks usually different approaches can be found to infrastructure charging. The most common are flat rate charging over a specific period of time.

4.2.3 Railways

First of all, in rail transport, the main obstacle for implementing differentiation, but also, before this, for analysing and testing effects of differentiation, is the lack of pertinent data. Access to sufficient data would be the preliminary step in any initiative concerning differentiation.

No general straightforward conclusion on the desirability of differentiation can be drawn. Indeed, from the theoretical point of view, making non differentiated infrastructure charges come closer to optimal infrastructure charging levels could be much more worth than trying to differentiate finely around the initial infrastructure charges levels if those levels are far from the optimal ones. A recommendation would be to get an idea of where “optimal” infrastructure charges levels would be relatively to actual infrastructure charges, how spread-out actual and optimal infrastructure charges would be, and how sensitive the welfare would be to infrastructure charges variations. Theory and some modelling tools could be developed for this.

Data relative to elasticities is very scarce and unreliable, whereas elasticity is a major source of sensitivity in the results of differentiation. And for freight, where traffic generators are quite concentrated, and where, often, one generator represents by himself one sub-market, since the demand is mainly industry-driven and not driven by transport prices, the concept of elasticity is less relevant, and decisions are rather of the type “all or nothing”.

The recommendation is therefore **to gather more knowledge on operators and end users’ sensitivity to infrastructure charges, qualitatively and through elasticity estimations.**

4.2.4 Urban Studies

Within chapter 3 the overall traffic reduction through charging in urban areas was shown. This subsection draws conclusions with respect to elasticities. Elasticity estimates are available from Trondheim, London, Singapore and, most extensively from Rome, but they vary widely:

- For Trondheim, with an increase of 22% in generalised costs, the estimate of the arc elasticity is - 0.32;



- For Singapore, the change in generalised cost is not known, but estimates for the CBD range from 0 to -0.42 and for the expressways from -0.16 to -0.44, which means that the medium values are in a similar range to Trondheim;

Furthermore, these values lie in a range that is generally assumed to be fairly typical. However,

- For London, where the generalised costs with the introduction of the £ 5.00 charge increased by 23.5 %, i.e. similar to Trondheim, the estimated elasticity is -1.3 according to independent research. Transport for London put the figure even higher at -1.6, but both values are unusually high;
- On the other hand, the response to the increase in the level of charge from £ 5.00 to £ 8.00 was extremely inelastic: a price rise of 60% only led to a reduction in chargeable vehicles by 5%. Part of this can be explained by the fact that, at the same time, the fleet scheme became more attractive, and many drivers avoided the top charge by joining a fleet scheme. However, this can only be one contributor to the apparently inelastic user reaction.

Overall for London, there was undoubtedly a very large difference in the effects of the initial scheme introduction and the increase in price.

In Rome, there were also substantial differences between elasticities, here between daytime and night time schemes and between different user groups. The aggregate elasticity for car drivers at a charge of € 6 per trip cover a wide range:

- -0.02 for occasional users in the daytime;
- -0.07 for regular users in the daytime;
- -0.18 for recreational trips in the summer nights;
- -0.46 for work trip in the summer nights;
- -1.4 for all trip purposes in the winter nights;
- -2.0 for shopping in the summer nights;
- -2.0 for crossing in the winter nights; and
- -7.0 for crossing trips in the summer nights.

This is not only a remarkable range, but also contains some surprising details, in particular the low elasticity for recreational trips, which is a mere third of that for work trips at the same time.

The differences between all of the above figures for the four cities mean that **extensive further research is needed** to obtain a clearer picture about user reaction to road pricing per se and, even more so, to differentiated charges.

However, the work carried out in DIFFERENT with the conceptual model indicates that, while the **assumptions on elasticities are crucial for the estimation of the absolute benefits of any scheme, they are much less crucial for the comparison of alternative schemes.**

4.3 CONCLUSIONS AND RECOMMENDATIONS REGARDING USER REACTIONS

4.3.1 Airports

In any situation the major recommendation is **to consider every particular case with care, thinking about all possibilities that may trigger a reaction on the airlines side.** The Gran Canaria Airport case study illustrates this issue. During the preparation of this case study it was stated many times that airlines were not sensitive to changes on airport charges. Nevertheless airline representatives stated that they are willing to move operations between peak and off peak days as far as they remain within the same hourly interval when they are compensated through lower airport charges. This initial response could be considered as evidence of demand sensitiveness at least on the airlines side.



The peak-load problem is usually mitigated through peak-load pricing, which would imply pricing at short-run social marginal cost. However, although peak-load pricing is an efficient mechanism from a theoretical point of view, sometimes it may be difficult to be implemented because of the following reasons: (i) it might be difficult to calculate the short-run marginal cost in an accurate manner, (ii) the existence of grandfather rights or institutional barriers and (iii) a low elasticity of demand between peak and off-peak periods. If the peak-load pricing can not be implemented for any of these reasons, other alternative policies may be considered, such as restricting the number of slots to be granted to the airlines during the peak days. However, the growing importance of low costs carriers in air transport markets, the possibility to extend the differentiated policy to other airport charges as those of handling operations, or even more important, the difficulty to fund huge airport investments based on peak capacity needs, are among the counter arguments to bear also in mind when implementing a new pricing policy aimed to redistribute demand.

Additionally, it has been shown that peaks are dynamic, and for the case of airports in the Canaries, they appeared to be dynamic in time but also in space. Such a finding suggests that in order to design a new pricing policy the necessity rises to take into account the whole network of airports within the Canary Islands, as they are operated by the same institution and as the several destinations within the Archipelago seem to be close substitutes. In this concern, any pricing policy aimed to redistribute the peaks would have to be flexible enough to react to subsequent changes of demand. A situation in which airports announce new prices with few weeks or even days in advance would be much desirable as it would contribute to a more efficient utilisation of the airport capacity.

The case study of Ljubljana Airport illustrates also the problem of congestion at peak periods. Although it is an airport with a moderate level of demand, the existing and anticipated growth of travel demand calls for introduction of additional, congestion depending differentiated charging system. Besides several projects aiming to increase the capacity of the Ljubljana Airport facilities, the differentiated airport user charges are to be seriously considered in order to reallocate the existing demand pattern and to provide more efficient utilisation of airport capacity. Differentiated pricing schemes could be rational and efficient responses to such challenges. This case study provides a thorough analysis of transport demand at the Ljubljana Airport and has identified peak periods during the time of a day, a day in a week and a season in the year. A preliminary analysis of price elasticity of demand also indicates that by introduction of differentiated congestion pricing schemes, charter and low-cost carriers would be more affected.

4.3.2 Railways

Interest of differentiation in rail depends primarily on the orders of magnitude of its potential impacts for operators (sensitivity to variations in infrastructure charge level for sub-markets).

In cases of imperfect competition –a frequent situation in the transport field- and on the ground of pure welfare calculations, the optimal tariff is highly dependent on the specificities of the situation: the level of the cost of public funds, the nature of competition (Cournot, Bertrand, etc.), the specification of the demand functions. And generally speaking our knowledge in these fields is often poor. This point advocates for more research on the field of imperfect competition, especially in the following fields: data on costs, prices and elasticities, nature of competition.

The research field of imperfect competition in rail markets seems to be quite important in order to explore more precisely these important issues and have a better understanding of what the final indirect impacts of infrastructure charging are, once interactions between competitors and demand converge to an equilibrium. Trying to open and explore this “black box” of interactions would be highly desirable, since the very basic representations such as perfect competition assumptions present some important biases. A simple generic formulation for representing some interactions has been used in D7.2, but there may be other tractable representations.

The German research showed clearly that regional differentiation led to multiple user reactions. One part of the additional costs (caused by the regional factors) was passed to the end passengers. In addition public transport authorities started thinking about the use of busses instead of trains (statistically confirmed) and finally some other parts of the additional costs were captured by the



founding scheme of public transport in Germany. A major conclusion therefore is that **regional differentiation is inadequate if the goal is to change the modal split in favour of the railways.**

4.3.3 Urban Studies

The main user reactions identifiable in urban studies are the following:

- Change of travel time;
- Change of vehicle ownership.

With regard to the timing of trips, there was one clear common finding for Trondheim and London since there was a small shift in departure times towards **a very small increase in traffic in the early morning before charging starts, but a clear peak in the evening after the end of charging**, deriving from drivers who delay their departure, presumably mainly from work, until after the end of the charging period.

In contrast, while there were also some very small traffic peaks just before and just after the charging period in Stockholm, overall, here there was no shift to non-charging hours of any substance, and, according to some of the data, traffic volumes even went down outside the charging hours.

With regard to change of vehicle ownership, in the case of London, the effect on different types of vehicles stems from the **exemptions given to licensed taxis, buses and coaches, and all two-wheelers. Their number within the congestion charging zone increased** between 2002 and 2006 by 16%, while the number of chargeable vehicles, i.e. cars, vans and lorries decreased by 30%.

In Milan, the vehicles with the lowest emission classes were also exempt, but furthermore there were different levels of charges for the different levels of classes with higher emissions. What was very noticeable as a result of this charge was the **strong shift from higher to lower emitting cars**. The share of passenger cars with for emission class 3 among all cars went down from 15% to 9%, for class 4 from 22% to 11% and for the highest emission class 5, where the charge is € 10 per day, from 0.4% to 0. For Light Duty Vehicles numbers the share of class 4 went down from 49% to 39% and for class 5 from 22% to 15%. At the same time, the share of low emitting cars increased accordingly.

4.3.4 Motorways

From the experiences and analyses discussed in this part of research, the main conclusions concerning inter-urban road charges can be summarised as follows:

Differentiation of road tolls is effective. Its application induces perceptible changes in demand behaviour. There may be a particular role for tolls which are higher during periods of heavy congestion, – particularly if drivers who pay these higher tolls can be guaranteed a high level of service. Inter-urban road tolls differentiation is generally accepted and perceived as a fair measure. In the shorter term, the impact is generally low: some re-routing can be expected and the road haulage sector is encouraged to improve efficiency. Mode shift on non-road alternatives is quite unlikely especially for freight.

In the longer term, emission-based charge differentiation is expected to lead to an accelerated fleet renewal. Some evidence of this is already available for freight. If tolls are progressively adapted to the new fleet structure, in order to keep the incentive alive, the cost for the freight sector could become significant and transferred on the haulage rates. If the differentiation scheme is not adapted, its effect is doomed to disappear and also revenues would shrink significantly. A consequence of the previous items is that inter-urban charge differentiation seems not an effective policy for environmental purposes in the short term, as any expected impact has only a poor positive correlation or even a negative correlation with lower transport emissions. Most likely, a similar conclusion holds for safety as well. Differentiation schemes can be designed with different objectives, but a trade-off between alternative targets most likely exists: e.g. the most preferable scheme for the motorway operator in case of project financing may well be not the best scheme for improving the level of service of the network. The specific context of application does matter. In non-congested corridors charge differentiation can raise money, but there is little room for social benefits, which can be achieved only



if constraints are placed on the use of revenues. Instead, in congested areas the level of service of the road network can be improved, but this generally implies the charging of ordinary roads, which is politically challenging.

From the conclusions above the following recommendations arise:

- Set **carefully** the objectives of intra-urban charging differentiation, both in the **short terms and in the long term**, since diverse objectives may need diverse differentiation schemes.
- Consideration should be given to greater use of **time-varying tolls** following the model of the US HOT lanes and the results of the Spitsmijden experiment.
- When designing a differentiation scheme, take into account **network effects**: appraising the impact of differentiated tolls according to a simple incentive-response mechanism measured on a single aggregated demand curve can be misleading.
- As a further specification of the previous item, if a differentiation scheme is applied with the “neutral” objective of internalising external costs, **it should be applied extensively in order to avoid undesired effects**. For instance, charging only more polluting trucks only on motorway can give rise to more traffic on ordinary roads and therefore larger environmental damages.
- Consider that a differentiation schemes may require a **different model of road management**. For instance, using road charging differentiations to improve the level of service of a network may require a network concessionaire rather than a motorway concessionaire.
- Consider that a differentiation scheme does not necessarily give rise to social benefits in terms of saved travel time or reduced emissions and therefore **constraints on the use of the revenues could be needed**.

4.3.5 Ports

Port charges have a high level of differentiation. The historic development shows that perceived inequalities from users in the system have been eliminated through differentiation. Many price structures and differentiation have evolved historically as a response to user respectively market pressure. Pressures originate from ports competing in regions with similar hinterlands areas, or where ports compete over transshipment markets. Additionally, ports might have to react to demands from shipping lines, especially if a particular shipping company has a significant market share of traffic in a port. In other words the currently implemented tariff structure at ports is a conglomerate of market pressures on the one hand and the positive theoretical framework described in section 2 on the other. Port infrastructure charges are only one part of overall port costs and do not necessarily create user responses. Thus, the overall effectiveness of a differentiation scheme as a stand alone economic tool needs to be evaluated. As a result user reaction to specific price differentiation schemes in ports is not measurable, because users calculate costs in terms of overall voyage costs. In specific cases costs for whole logistics chains are laid out for the decision making process. In addition, very often port dues are negotiable and therefore differentiation becomes a black box. It is not clear if differentiation schemes are applied and reflected in negotiated prices, therefore, in many cases tariff structures can not be judged in terms of efficiency. However, in the last years has been noticed a shift of tariff structures towards environmental motivated differentiation. In many cases differentiated charges at ports reflect the risk situation for certain vessel types. E.g. by charging more to ships that pose higher risks to a port, such as tankers. If differentiation is used to mitigate risk, the following needs to be kept in mind:

- By charging higher port dues to a specific ship group, the respective shipping operator can react in two ways: by reallocating their services to other ports, which does not reduce the overall risk; or by replacing the current ship with a ship with higher quality standards and in return a lower risk level. Under a holistic approach, the former is not a desirable option, because it just shifts risk geographically and does not reduce the risk at all. Therefore, the elasticity of the user to higher charges and the potential reaction is important to take into account. Furthermore, such differentiation is a discriminatory approach and should be accompanied by incentives to influence the user towards reducing the overall risk level, in this case the introduction of a higher standard ship, to make it effective.



- Differentiation to mitigate risks (e.g. oil spills) should not be introduced in a single port, but in a wider geographical area context, in order to avoid the mere reallocation and, thus, the geographical shift of the risk. Even in a competitive environment, mitigation of risks should be dealt with in cooperative manner and in a joint effort of the ports in a specific region. In this case it seems advantageous to have an objective mediating body or organisation that drives such an approach.

4.4 CONCLUSIONS AND RECOMMENDATIONS REGARDING REGULATORY FACTORS

4.4.1 Airports

Differentiation of airport charges by type of terminal is pretty much a new development that has been fostered by the high growth of low costs carriers. Even the European Commission recommends that different terminals with different characteristics should be subject to different airport charges (Proposal for a Directive of the European Parliament and of the Council on Airport Charges, article 8). In order to better understand the main insights of such a type of differentiation a theoretical model for the case of Madrid Barajas airport, which at the beginning of 2006 opened new facilities expanding its capacity substantially, has been developed. Iberia and the Oneworld group were allocated to the new facilities while Spanair (main Iberia competitor in the domestic market) and the Star Alliance remained at the old terminals. Airport charges are the same irrespectively of type of terminal. Our theoretical model shows, in general, that if airlines are allocated to separate terminals, the lack of competition in transfer flights significantly affects the ticket prices of the whole network, the competition between airlines is reduced, the ticket prices are higher and the consumer surplus and the social welfare are lower. Only in some routes and under certain conditions on the market size, the ticket prices may be lower.

The allocation of airlines to terminals should promote the competition between airlines, and be non-discriminatory. Here it has to be pointed out that the adverse network effects of allocating airlines to different terminals may be mitigated by using a differentiated scheme for airport charges or even if terminals were well connected, and shifts from one terminal to the other were not too costly in terms of time for transfer passengers (which is clearly not the case of Madrid/Barajas airport). All these considerations should be carefully taken into account when constructing new facilities at airports and deciding the reallocation of airlines to such new facilities.

4.4.2 Railways

From the theoretical point of view, operators that have different operating costs should bear different infrastructure charges. Besides the equity concerns, competition rules in EU do not allow this. Simulations made by WP7 indicate that the welfare gains could well be negligible, anyway.

Very often there are **little competitive forces in the railway markets**, in which in many cases a **vertically integrated firm is the major market player**. This raises the question of the optimal regulation (although this concern was not part of the DIFFERENT research). In Germany for instance the new regulatory body (Bundesnetzagentur) thinks of introducing regulatory practices similar to the practices of the telecommunications sector.

In addition, **a comparative look at the US American railroads** could prove to be very useful. Analysing the reasons of the success of the US American railway sector could give some interesting hints with huge regulatory impact.

4.5 CONCLUSIONS AND RECOMMENDATIONS REGARDING INSTITUTIONAL FACTORS

The conclusions with respect to institutional factors rise mainly from economic theory. Positive economic theory showed that special interest groups intervene in the political process in order to derive utility for their members. In this respect (as in D. 3.3 shown) it is very likely that apart from regulation special interest groups will try to affect the tariff structure. In other words the degree of differentiation of a charging scheme will finally also reflect the balance of the political power. In almost



all studies the political dimension was recognised as a very important factor affecting the final implemented charging scheme. As already in D.3.3 shown, in the case that only one but powerful SIG exists, the degree of differentiation decreases. In contrary, if the balance of the political power is distributed among more competing SIGs, the degree of differentiation tends to increase. That is, the regulator will take into account the interests of all major SIGs and implement a kind of political equilibrium that incorporates both, social and SIG welfare. So far the theoretical framework is clear. Taking into account overall welfare it has to be stated that in most cases the equilibrium described above leads to welfare losses¹¹. The reasons for this are very simple: First, lobbying is very costly for SIGs. Second, a higher differentiated charge, can lead to welfare losses, if exemptions from pricing scheme take place. Take for instance a time based differentiated road pricing scheme (peak-load pricing) in which commuters are exempted. Such a pricing scheme can never achieve the goal often formulated for peak load pricing, notably the better utilisation of the existing capacity.

Turning to the current situation, analysis in D.3.3 demonstrated that in most cases users are the favoured groups in almost all transport modes, rather than infrastructure operators. Certainly the reason of this development lies upon the degree of privatisation of infrastructure companies. Laffont and Tirole (see Laffont and Tirole 2000) stressed with this respect the simple opinion that a privatised infrastructure operator will maximise revenues by implementing respective pricing strategies. In this case all that the regulator needs to do is to regulate the price level (i.e by using price caps). However, the possibility of privatisation of public utilities is evaluated heterogeneously within the different EU countries. Great Britain for instance is a country, which traditionally pioneers privatisation. In contrary, the privatisation of Deutsche Bahn for instance has been discussed very controversially among all participating actors in Germany. Taking into account that this solution will not be applicable for all European countries, it is necessary to search for further solutions, which could mitigate the problem described above. One possibility has been pointed out very often by many transport economists and in several research projects (although these recommendations do not result out of positive theoretical considerations). This possibility deals with **the establishment of independent regulatory authorities**. Infrastructure companies are regulated in European countries inhomogeneously. In some countries the regulatory body is an independent authority which in most cases takes advice from industry experts (e.g. AENA for Spanish airports). In some other countries regulation occurs mainly in the respective ministries (e.g. airport regulation in Germany). It is apparent, that the last one makes it easier for user groups to intervene in the political process and achieve the favoured tariff structure. However, still the use of such authorities does not guarantee a regulatory regime free of SIG intervention. As already in literature shown, there are still possibilities for SIGs to manipulate the regulatory authority (bureaucracy theory). Notwithstanding this eventuality, the establishment of independent regulatory authorities enhances transparency and therefore could take (at least) some of the problems coming out of lobbying activities under control.

4.6 CONCLUSIONS AND RECOMMENDATIONS REGARDING WELFARE EFFECTS AND GENERAL POLITICAL EFFECTS

4.6.1 Car drivers

The benefits of differentiation must be set against the costs of achieving it. From the theoretical point of view the bottleneck congestion model presented in D. 3.3 showed clearly that roughly half of the first-best welfare effects of a time differentiated charge can be obtained in the simplest setting with just two levels. In addition, the evidence from modelling work suggests that the majority of the welfare benefits achievable from road charges can be gained through a relatively simple system with minimal differentiation. The majority of the welfare benefit comes from reductions in congestion and this can be substantially achieved simply by charging only at peak times in urban areas. More sophisticated charging regimes with differentiated charges reflecting the amount of congestion at different types of day and on different links will achieve greater reductions in congestion but, if they require expensive technology or databases, may not be worthwhile. Differentiation by type of vehicle is, by contrast, relatively cheap to achieve and is thus easier to justify.

¹¹ There are also cases thinkable in which SIG activities can lead to welfare gains. For a deeper analysis in this issue see Grossman/Helpman (2000).



Although welfare effects are in most studies not explicitly treated, urban case studies give enough evidence for formulating the following recommendations

Although it has not been proven by detailed modelling, it appears unlikely that a scheme designed to maintain free-flow on the motorways or maximise revenue for the motorway manager would simultaneously minimise congestion and other externalities within the urban area. Thus, at risk of stating the obvious, in order to maximise overall benefits, a degree of prioritisation or compromise is required between potentially conflicting objectives of different stakeholders. In doing so, the following principles should be born in mind:

- **The “best” solution** would allow charges to be differentiated according to the characteristics of individual links and the amount of traffic wanting to use them at any given point in time. This implies a degree of differentiation which, while technically achievable, may be **more complex** than people can cope with.
- As a **second best approach**, the different roles and characteristics of different types of road may make it wholly appropriate **to introduce different charges on different types of road** – with higher charges on congested urban roads than on parallel motorways.
- Equally, a considerable proportion of the theoretically achievable benefit can be obtained by introducing **time-varying tolls**. Considerable benefit can be gained simply with a peak / off-peak differentiation but greater benefit is achievable (in the case of limited access links at least) from a dynamic variation as applied in some of the US HOT lanes. The Spitsmijden experiment confirms these benefits also for Europe.

Generally seems likely that overall benefits (defined as minimisation of delay, accidents and other externalities while maximising the benefits to society and the economy) might be maximised by combining a charge on the urban roads with charges designed to give a degree of protection to traffic using motorways and other strategic links. The urban charge might be levied on traffic crossing specified cordons or using roads within a specified area while the strategic-link-protection charge might involve specific charges for using motorway access or egress links or dynamic charges just sufficient to preserve free flow conditions.

4.6.2 Railways

Infrastructure charges should ideally be differentiated according to the drivers of the costs, in line with efficiency objective and the short term marginal cost principle, and also according to the demand in line with fund raising concerns and the Ramsey-Boiteux type of pricing principle.

In order to follow the drivers of cost, infrastructure charges should be differentiated according to the weight of the train, to the speed, to the age of the track (older tracks generate more maintenance costs than new ones) and maintenance programmes of the track, and to the traffic level (in order to cope with congestion and scarcity costs). These items are not linked to the occupancy of the train.

According to the fund raising objective, the marginal cost principle should be amended to take into account the willingness to pay of the operators; this willingness to pay is linked to the occupancy of the train and to the willingness to pay of each of the customers (passengers or freight) of the operators. In this line, infrastructure charges should be differentiated according to the speed of the train (linked to the willingness to pay of each customer) and to the number of customers (number of passengers and tons of freight). Although it is not possible to observe this parameter, from the theoretical point of view, differentiation according to the operator's price levels and/or revenues for each type of train should be taken into account.

How to progress in the implementation of these principles starting from the present situation in most European countries, where infrastructure charges are per train*km, with some modulation by time and by type of train?

A first possibility would be to index infrastructure charges on the age of the track and the speed of the train (to account for both the increased damages and for the increased WTP of the final customers). But policies of “cadencement” (standard and regular tracks with reference speed) lead not necessarily



to increase infrastructure charge with train speed, but rather depending on the difference between desired speed and reference speed.

A second possibility would be to modulate the infrastructure charges according to the occupancy level of the train. To measure the number of passengers or the number of tons can be difficult; a proxy would be the number of wagons, with an increase of infrastructure charges for the double-deck ones. The balance between the train term and the occupancy term would be a means to fine-tune the balance between the number of trains and the occupancy of them and appears as a means to cope with congestion. A recommendation would be to develop more research on this special field of interest.

A third possibility would be, in line with the objective of fund raising, to implement some form of yield management in infrastructure charges; for instance to propose discounts for advance reservations or for large reservations. Still, whenever the incumbent is still holding an enormous market share, would this measure be revenue increasing for the IM, and also compatible with competition rules ?

A fourth possibility, in line with the efficiency objective when there is no price regulation, would be to reduce the infrastructure charge in situations of market power.

A last possibility would be to implement a non-additive charging system in order to take into account the fact that often the willingness to pay of the longer relations are smaller than the willingness to pay of the shorter ones due to competition with other modes; a charging system based on the couples origin-destinations of the relations served by the train would theoretically cope with this difficulty, assuming data can be obtained.

Whatever the type of differentiation that may be implemented, the main problem will remain the availability of relevant and precise data. This issue has already been analysed above.

4.7 CONCLUSIONS AND RECOMMENDATIONS REGARDING OTHER ECONOMIC FACTORS

4.7.1 Urban Studies

Further economic effects are identified mainly in urban studies. In most cases these effects deal with the following:

- Impact of charges on the local economy;
- Impact of charges on public transport;
- Further impact of congestion pricing.

Results with regard to the impact of urban road user charging on the local economy are available from Trondheim, London and Stockholm.

In Trondheim there was a very small short term-loss in city centre trading, but in the longer term there was still overall growth, even if the city lost some market share to out of town trading. However, since this was a general trend in many European cities, it is not clear whether all of this was due to the road pricing scheme. Furthermore, following the cessation of the charge there was, at least in the short term no up-turn in city centre trade.

The effects in London are disputed. Transport for London claims that the congestion charge had a positive impact on jobs, business turnover and profits, while Chamber of Commerce claims a negative impact on retailers.

During the Stockholm trial, no visible effect on trading or other business activity could be found and it remains to be seen whether there will be any long-term effect from the permanent scheme.

But overall it appears that urban road user charging has little or no impact on the local economy.



With regard to the impact of charges on public transport there is data available from Trondheim, London, Milan and Stockholm that shows the increase in public transport usage after the introduction of the charge.

In Trondheim there are no absolute figures, but the mode share of public transport increased for trips that would have been affected by the initial charge from 23% to 27%; for the trips that were only affected by the later introduction of the zonal system these figures were 6% and 16% respectively, although it needs to be noted that these were based on a very small sample size.

In London, the number of bus passenger increased from 77,000 to 106,000 from 2002 to 2003, but it is not possible to distinguish how much of this was the direct effect of the charge and how much was due to the improved provision in public transport. As for traffic reduction, the 2005 price increase had no detectable impact on public transport use.

In Milan, public transport benefited from the Ecopass with an increase of 9% in underground passengers and an 11% increase in surface commercial speed during the first month of its operation although that went down to 4% in the next month.

In Stockholm, data provided by the public transport operator, allows to account for the effect of the improved public transport provision alone, since a comparison without and with all improvements in place, but before charging started, showed that passenger numbers had increased by 2%. Overall, as a combined effect of PT improvement and the tax, for the whole county the operator reports a 6% increase in PT use with 140,000 more boarding passengers. On the inner city trunk bus routes the increase is also 6%, but on the inner city local bus routes even 14%.

Finally, an important conclusion is given in the analysis made in D 3.3 using the TRMOVE modelling framework. According to these results, congestion pricing can potentially internalise a much larger externality compared to environmental concerns. For CO₂, it seems even unlikely that any welfare gain could result from whatever effort targeted at reducing its emissions.

4.7.2 Car Drivers

If the objective is simply to maximise revenues then differentiation takes on a new role. Generally speaking, it becomes a mechanism for yield management and for targeting special markets. For example:

- By charging higher tolls in exchange for a guaranteed high level of service (as in the US HOT lanes).
- By charging higher tolls to traffic which has little choice but to pay (as may be the case for some bridge tolls, but is generally truer for peak period traffic than for off-peak traffic).
- By offering discounts to users who may be encouraged to increase their usage of the system (as in the *Liber-t Week-End* and *Activ-t* schemes).

It is perhaps also worth noting that, if the objective is to maximise revenues, advantage can be taken of the fact that, faced with a seemingly complex charge in a high, or very low, price domain, users tend to under-respond to the actual charge (i.e. they have a tendency simply to pay up and continue with their previous pattern of behaviour) – thus yielding more revenue than would have been produced if the charge had been readily understood.

4.7.3 Ports

Port devolution has led to a wider spread of port authorities operating under private sector principles (e.g. Port of Hamburg, Port of Amsterdam). In this setting, the implementation of a differentiation scheme that is driven by political interest, either national or at European level, can only be realised, if revenue neutrality can be guaranteed for the charging body.



The differences between long-term and short-term needs have to be taken into account. Normally, only short-run effects and reaction are being considered but certain aspects have an influence in the long-run, which are not measured in the short-run. The level playing field of introduction is a very important issue and needs to be discussed further. The efficient use of capacity of ports needs more elaboration.

In the port sector, strategic port charge differentiation schemes underlie a lifecycle development. For example, the differentiation of port dues to attract higher standard ships using the compliance with the green award as the measure of differentiation makes sense during the start up and expansion phase of this scheme. However, as soon as the scheme comes into maturity, the differentiation effects are declining and the strategic incentive loses its importance. This is for example the case in Sullom Voe, where the differentiation is no longer applied, because all ships fulfil the differentiation criteria of segregated ballast water tanks.

A main problem identified, however, is how to use the revenues or recover costs which are produced by the differentiation scheme. This is only relevant when it comes to externally induced differentiation schemes.

4.7.4 Intermodal Chains

Freight Transport

Transport cost analysis for multimodal chains showed that multimodal solutions may be cheaper on selected sections even by about 30%. However, to create effective connections there must be a number of interested companies that will regularly ship so as to load the train maximally. This raises the problem of coordination among shippers. Therefore, the concept of the EU's Transport Commission concerning establishment of a new profession – freight integrator – whose task would be to coordinate the intermodal chain seems to be justified. Obviously, a possibility of giving financial support to railway carriers in case of not having sufficient weekly loads to transport must be considered.

From the shippers' point of view the price is an important but not the only criterion of transport mode selection. The nature of the transported goods as well as just-in-time production are two additional criteria, which apart from pricing issues also have an impact on modal choice. In road transport, due to strong competitive forces, an increase of infrastructure charges will not always be passed entirely to shippers. However, it does not mean that an increase of transport rates caused by an increase of infrastructure charges will make companies change transport mode. More likely is that shippers will change the transport operator. The importance of infrastructure charges from the logistics' point of view is even smaller. Likewise from the logistics' perspective an increase of infrastructure charges will not cause respective proportional changes of prices for shippers.

The survey carried out for intermodal chains showed that the interviewed companies would be willing to use intermodal transport more frequently if it was cheaper. However, it should be remembered that the companies thought that the current low level of use of intermodal transport results mainly from non-price reasons.

Summing up, bigger differentiation of infrastructure charges will not have a significant influence on the general modal split and usage of intermodal chains. The recommendation rises therefore from this analysis is related to the local circumstances. **Where local circumstances are appropriate, the local authorities should include price differentiation among the measures used to promote the use of multimodal chains.** In addition, it would be more effective for the European transport system to promote co-modality, as a wider concept of intermodality.

Passenger Transport

The main conclusion from the multimodal analysis refers to the potential impact of differentiated infrastructure charges for the use of different transport modes. The introduction of infrastructure charges based on marginal social costs differentiated by mode, trip length and time of day, could have a significant impact on modal shares – particularly if the revenues are invested appropriately. Therefore the degree of differentiation could induce users to change transport modes. In particular, if



policy aims at a shift to environmental sustainable transport modes, intermodal differentiation (with respective revenue use in favour of environmental sustainable modes) could achieve the desired effect but the charge structure would represent a departure from the economic optimum and the result is unlikely to be economically efficient. With this respect, rises the recommendation **to consider very carefully the consequences of any removal of subsidies to public transport** (although such subsidies may, in a strict sense, be economically distortionary, their removal can have serious consequences for environmental sustainability).

4.8 CONCLUSIONS AND RECOMMENDATIONS REGARDING PSYCHOLOGICAL FACTORS

In the interests 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. with price as a non-linearly 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 response to complex pricing signals.** Results show that precisely calculation of prices at least within individual transport sector is unlikely. People prefer rather prediction of prices (by heuristics) which will prove satisfactory at a certain level with regard to necessary cognitive effort 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 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 negative 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.

4.9 OVERALL CONCLUSIONS AND OUTLOOK

4.9.1 Do Prices Have Any Effect?

The most important question to be answered by DIFFERENT is probably the following: Do prices have any effect at all?

To be more precise this question should be split up in two parts:

- Do price changes have any effect at all on travel behaviour and mode choice? (under the expression “price change” it is subsume here also the introduction of a toll, where there was only tax-financing before, e.g. the case of Germany)
- Does differentiation have any effect at all on travel behaviour and mode choice?

The evidence assembled within DIFFERENT shows that the answer to the first question must overwhelmingly be in the affirmative. For the second question the answer is less clear cut. The effects of price differentiation depend very much on the particular mode under investigation and the particular circumstances.

In the following the two questions will be discussed mode by mode.

Effects of Price Changes

Road

With respect to the first question it can be said that in the case of interurban road transport the evidence shows quite clearly that price changes lead to changes in transport demand. In Germany the introduction of the HGV-toll has lead to reactions with respect to route choice, the effective tonnage chosen, and logistics. In Italy modelling work showed substantial effects for the Brenner corridor and also important effects in the Padana region. Due to the different network structure in the two regions, the effects were different but there can be no doubt that infrastructure pricing had substantial influence on travel behaviour. In Switzerland too the introduction of a toll on HGVs brought quite noticeable effects with it.

As far as urban car transport is concerned the case studies showed considerable effects in all cases considered (see below) with the noticeable exception of Rome.

Railways

Unfortunately the case of railways is very unclear, mainly due to severe data limitations. These data limitations are, of course, a consequence of the regulatory upheaval that the railway sector is currently running through. It can hardly be expected that in the present situation railway operators are very willing to reveal data that from their point of view must be considered as strategic. Probably the most reliable (or rather least unreliable) evidence that was gathered with respect to railways is the evidence on the effects of the so-called “regional factors” in Germany, which are part of the German network operator’s (DB Netz) pricing policy. Here the “user reaction”, however, is not so much the reaction of train operating companies but rather the reaction of the public transport authorities which in Germany are responsible for putting out urban transit services for tender. The evidence shows that the public transport authorities reacted quite strongly to the introduction of the regional factors by closing lines.



Air

Air transport seems, so far, to belong to the exceptions with respect to effects of pricing. The results obtained in this project only reflect past and recent pricing policies, and in all cases investigated the effects of changes in starting and landing fees on the behaviour of airlines were rather limited. In the case of Hamburg airport the effect of the introduction of noise charges was even non-existent. The London and Gran Canaria case studies showed some effects of starting and landing fees, but these effects were limited. A closer look at the case studies reveals that the cost-share of airport-fees in the total costs of airlines is rather small, and it comes therefore as no surprise that airlines react rather inelastic to these fees. However, this is not to say that differentiation could not work in the future if charges became more substantial, and it would be premature to conclude that pricing in the airport sector is of no relevance for airlines.

Shipping (Ports)

The many case studies on ports show leave no clear picture. However, evidence was found that differentiation aiming at more environmental sound performance of mitigation of risk might be used as a tool within a wider group of tools or policy measures. There is also evidence that differentiation used for mitigating certain risks to improve environmental performance of shipping needs to be considered under a lifecycle approach in order to maintain effective over time. It needs to be assured that the institutional structure is sufficiently effective to react to market and framework changes and has the capability to adjust the differentiation scheme. It also seems to be advisable to discuss if ports are the most effective entity for implementation or if certain differentiation schemes could more effectively dealt with at an institutional level that takes into account the global structure and reach of the shipping sector (e.g. environmental differentiated charges).

Effects of Differentiation

In the following the question of differentiation will be addressed. Still, it can be said already here that there are effects of differentiation but that the magnitude of these effects depends very much on circumstances.

Road

In interurban road transport the differentiation of the German and Swiss HGV toll according to axle weight and emission classes showed clear effects. In Germany, for instance, a trend towards smaller and cleaner trucks can be observed. In fact, the move to smaller trucks (which are exempt from the toll) has become so pronounced that there is discussion about extending the toll to vehicles under 12t. Similar observations were found in Switzerland.

As far as urban car is concerned noticeable effects of differentiation could be detected in Stockholm. The London scheme at first sight seems not to be differentiated at all. Upon reflection it is clear that the difference between day-times where the charge applies and where it does not apply, amounts to differentiation. The evidence shows, that many car drivers adjust their behaviour accordingly (e.g. by postponing trips into the night-time). Strong effects of differentiation can also be observed in the cases of the HOT Lanes in the USA and in the case of Singapore.

Rail

As already mentioned above the scarcity of data makes it very difficult to derive clear conclusions in the case of rail. The case of the regional factors in Germany may again deliver the most reliable evidence. The case study showed a clear correlation between differentiation and the behaviour of the public transport authorities. Simulation results based on a German engineering model showed that varying the components of a two-part tariff for pricing network access resulted in substantial changes in demand of the freight transport operators.

Air

The Spanish case studies (Madrid Barajas, Gran Canaria) delivered evidence on substantial possible welfare effects of peak-load pricing. The Spanish case studies made also clear, however, that institutional constraints, currently prevent this welfare gains from being exploited. The Hamburg case



study concerning noise charges showed no effect at all. This result, however, is closely connected to the special political circumstances that surrounded the introduction of these charges in Hamburg as is explained in the case study. The case of London has led the conclusion that there is relatively little competition between airports (at least among the London airports). Therefore, price differentiation doesn't seem to be a competitive parameter of airports.

Shipping (Ports)

It was said already, that port-dues amount only to a small share in shipping companies' overall voyage costs, which delivers a somehow similar picture to the results found in the airport case studies. Even though a clear direct impact of differentiation cannot be shown, it should be considered that differentiation as in the case of environmental differentiated charges in Sweden has contributed to greater awareness of the environmental challenges in the sector and in combination with other mechanisms has contributed to a shortened period of implementation of emission reducing technology in ships in a geographically limited area. However, the question remains whether the port level is the most adequate level for implementation of measures, which are aimed at delivering towards EU or even global policy goals.

4.9.2 Outlook on Further Research

DIFFERENT has produced many results but also raised many new questions. It is appropriate to close this final Deliverable 11 by naming a few of these unresolved issues.

From the viewpoint of normative economics it is regrettable that up to now there are only few studies concerning the welfare effects of differentiated pricing schemes. The DIFFERENT case study on the Spanish airports is a notable exception. As far as it is known there are only very few studies on the welfare effects on interurban road-pricing schemes. For instance, there has been no systematic analysis of the German HGV system's welfare effects, despite the wide publicity it has achieved. In other countries too, most of the existing studies of interurban tolling systems concentrate on physical traffic flows, less on welfare benefits. The same holds true for urban tolling systems. There are exceptions, of course, like studies made for Stockholm and London. It would be interesting, however, to have more of these studies for cities of differing size. Proud'homme's provocative "back-of-the-envelope" calculations concerning costs and benefits of the London and Stockholm schemes have at least demonstrated that it is important to go beyond modelling physical traffic flows (as economic theory, of course, postulates). It might very well be the case that there is a "critical size" for cities which must be reached for a tolling system to "pay off" in welfare terms. Preliminary modelling work in Germany seems to confirm this view.

The research in DIFFERENT has made it very clear that the analysis of differentiation can gain a lot by bringing psychology and economics closer together. As far as we can see, there are many unexplored questions in the intersection of psychology and economics. One important issue that comes to mind is the possibility to study the effects of incorporating behavioural models like Herbert Simon's "satisficing behaviour" or others into the study of price-differentiation (instead of the main-stream "utility maximising" paradigm). We firmly believe that a closer and more fundamental collaboration of psychologists and economists can help to shed further light on many questions raised in the behavioural sections of DIFFERENT.

From the viewpoint of positive economic theory too, many new questions have arisen. The case of Hamburg airport, for instance, remains a puzzle. Why did authorities introduce a noise-charging system that had no effect on the airlines' behaviour whatsoever? There remains modelling work to be done (probably based on game theory) to explain this riddle. Another important question that has emerged, is the question why certain users object so strongly to certain pricing-schemes which at first glance seem to be even in their own interest. An example is provided by peak-load pricing of airports which is strongly opposed by airlines. A further important direction of research has been opened by Laffont's insight that simpler pricing-schemes might be better (in welfare terms) than more differentiated schemes because simpler schemes may be less open to political manipulation of special interest groups (even though the more differentiated schemes may be preferable from a normative point of view). DIFFERENT has shown that more research is needed here both on the theoretical as



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on the empirical level. In short, DIFFERENT has confirmed that there is an open research programme which might be entitled “the positive theory of infrastructure pricing”.

Finally, as a very important matter, DIFFERENT has shown that in the case of railways far too little data are available to draw reliable conclusions and recommendations, be it from the normative or the positive viewpoint of economics. In our view the European Commission should seek ways to remedy this deficiency. Serious research and serious policy recommendations must be based on reliable data. This is particularly important in the case of railways because it might be very well the case that price differentiation (especially in the form of yield-management techniques) may be one (or even “the”) key to the long-term survival of railroads as a mode of transportation, notably in freight transportation. According to many observers, the key of the American railroads’ success lies in their ability to price discriminate rather than in the explanations usually offered, like long distances and absence of interoperability problems. Therefore the suggestion here is that the European Commission initiates research on both issues: (1) how to collect data in a way that makes better research possible but which respects the strategic interests of the railway industry and (2) the relevance of price-discrimination for increasing the modal share of railways.



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