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### Editors

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### CURACAO Project Office

Transport & Travel Research Ltd

Arundel House

6 Portland Square

Bristol BS2 8RR

UNITED KINGDOM

Tel: +44 (0) 117 907 6520

Fax: +44 (0) 117 907 4146

Email: [curacao@ttr-ltd.com](mailto:curacao@ttr-ltd.com)

Web: [www.ttr-ltd.com](http://www.ttr-ltd.com)

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## Table of ACRONYMS

Previous projects that are cited in this report are as follows:

AFFORD – Acceptability of Fiscal and Financial measures and Organisational Requirements for Demand management

DANTE – Designs to Avoid the Need to Travel in Europe

CUPID - Coordinating Urban Pricing Integrated Demonstrations

DESIRE – DESigns for Inter urban Road pricing schemes In Europe

EUROTOLL- EUROpean project for TOLL effects and pricing strategies

EUROPRICE - EUROpean urban road pricing network

FATIMA - Financial Assistance for Transport Integration in Metropolitan Areas

HEATCO - developing Harmonised European Approaches for Transport COsting and project assessment

METEOR - Monitoring and Evaluation of Transport and Energy Oriented Radical strategies for clean urban transport

OPTIMA - Optimisation of Policies for Transport Integration in Metropolitan Areas

REVENUE – REVENUE Use from Transport Pricing

PROGRESS – Pricing Road Use fOr Greater Responsibility, Efficiency and Sustainability in cities

PROPOLIS – Planning and Research Of Policies fOr Land use and transport for Increasing urban Sustianablity

PROSPECTS - PROcedures for recommending optimal Sustainable Planning of European City Transport Systems.

SPECTRUM – Study of Policies regarding Economic instruments Complementing Transport Regulation and the Undertaking of physical Measures

TRANSPLUS – TRANSport Planning Land Use and Sustainability

TRENEN - Models for TRansport ENvironment and ENergy

UNAQ – the CURACAO User Needs Assessment Questionnaire

# 1 INTRODUCTION

The aim of CURAÇAO is to promote and support the fairer and more efficient pricing of road use in urban areas throughout Europe. The project is doing this by working with cities interested in pursuing road pricing to identify the barriers to their doing so, and providing evidence on ways of overcoming those barriers. That evidence is being provided in two forms: through a series of case studies and in an annually updated State of the Art Report, both of which will be disseminated through the project website (<http://www.curacaoproject.eu>) and a series of workshops.

This is the first version of the State of the Art Report, and is based on evidence collated from research and practice over the period to the end of 2006. It addresses a series of issues which were included in the proposal for the project, together with others which were identified in a survey of End User Cities in July 2006. This document is organised around the resulting list of issues thus identified

1. the possible objectives of road pricing schemes (Chapter 2)
2. the ways in which road pricing schemes can be designed to meet those objectives (Chapter 3)
3. the technologies available to support such scheme designs (Chapter 4)
4. techniques for predicting the effects of road pricing schemes (Chapter 5)
5. techniques for appraising/evaluating the effects of road pricing schemes (Chapter 6)
6. specific evidence of impacts on the economy (Chapter 7),
7. the environment (Chapter 8)
8. and equity (Chapter 9)
9. factors affecting the acceptability of road pricing schemes (Chapter 10)
10. the potential transferability of experience from one city to another. (Chapter 11)

Of these, issues 1, 2, 3, 4, 7 and 8 were included in the original proposal; issues 5 and 6 were added later. The specific issue of environmental impacts was only raised in late 2006, and is not addressed in this version of the report. It has also been decided to defer coverage of technologies until the second version of this Report, pending consideration among end user cities of the level of information needed on what is an increasingly complex topic.

Figure 1-1 illustrates the linkages between these ten topics. Determination of objectives is the essential pre-requisite for scheme design, and also forms the basis for subsequent appraisal of alternative schemes. Once schemes have been designed it is possible to predict their effects and hence to appraise their performance against the agreed objectives, and to assess their acceptability. The available technologies will contribute to scheme design, and will also have direct implications for acceptability. Within the overall appraisal, this Report places particular emphasis on environmental, economic and equity impacts, all of which will also affect acceptability. Finally all of these issues will be factors in assessing the transferability of performance and practice from one city to another.

These issues are covered in the order listed above in the next ten sections of the report. While this is generally a logical order in which to consider them, it should be noted that there will be some feedback between them. For example, problems identified at the appraisal stage could justify changes in scheme design, while factors which make a scheme less acceptable could lead to changes either in the scheme design or the underlying objectives. These feedback issues are raised as they arise, and summarised in the concluding section.

Each section is structured around a series of questions which cities might ask, and answers to those questions based on available evidence. End User Cities were asked to comment on an initial list of these questions in November 2006. The resulting list of questions reflects their suggestions and concerns. A few of the issues which they raised then, concerned with legislation, business processes, administration and enforcement are being considered within the separate work package on case studies, since it is anticipated that the evidence will be more practical and city-specific in nature. It may prove appropriate to incorporate these issues into future versions of the State of the Art Report.

Each question is answered based on research and practical evidence available to the study team, and information sources are provided as appropriate. Given the number of consultancy studies into road pricing, it is probable that there will be other relevant evidence of which the study team is unaware.

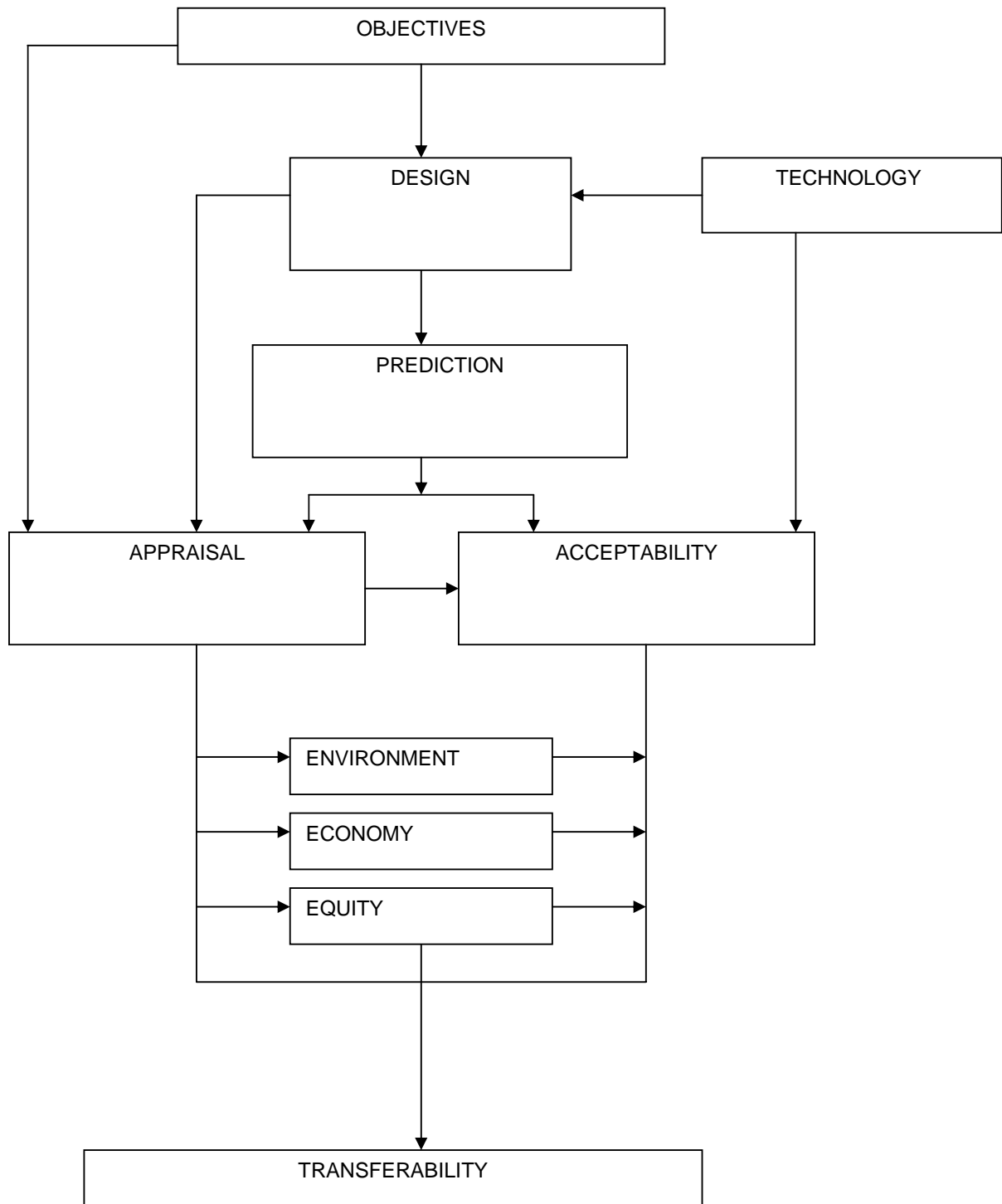
We would very much welcome information on other evidence which could be included in future versions of the Report. We also have a small budget available to commission inputs from outside Europe on experience which might be relevant to European cities, and suggestions for gaps which might be filled in this way would be helpful.

We hope that this first edition of the State of the Art Report will prove helpful to cities considering the introduction of road pricing. We would be grateful for comments, and suggestions for enhancements which might be made in future versions. In particular:

- Are there other issues which we might usefully cover?
- Are there other questions which we should attempt to answer for the issues which we do consider?
- Is there other evidence of which you are aware which could be incorporated?
- Are there particular issues on which you would welcome evidence from outside Europe?

Please send any comments and suggestions to Andrew Koh at the Institute for Transport Studies at the University of Leeds, England: [a.koh@its.leeds.ac.uk](mailto:a.koh@its.leeds.ac.uk).

Figure 1-1 The interactions between issues considered



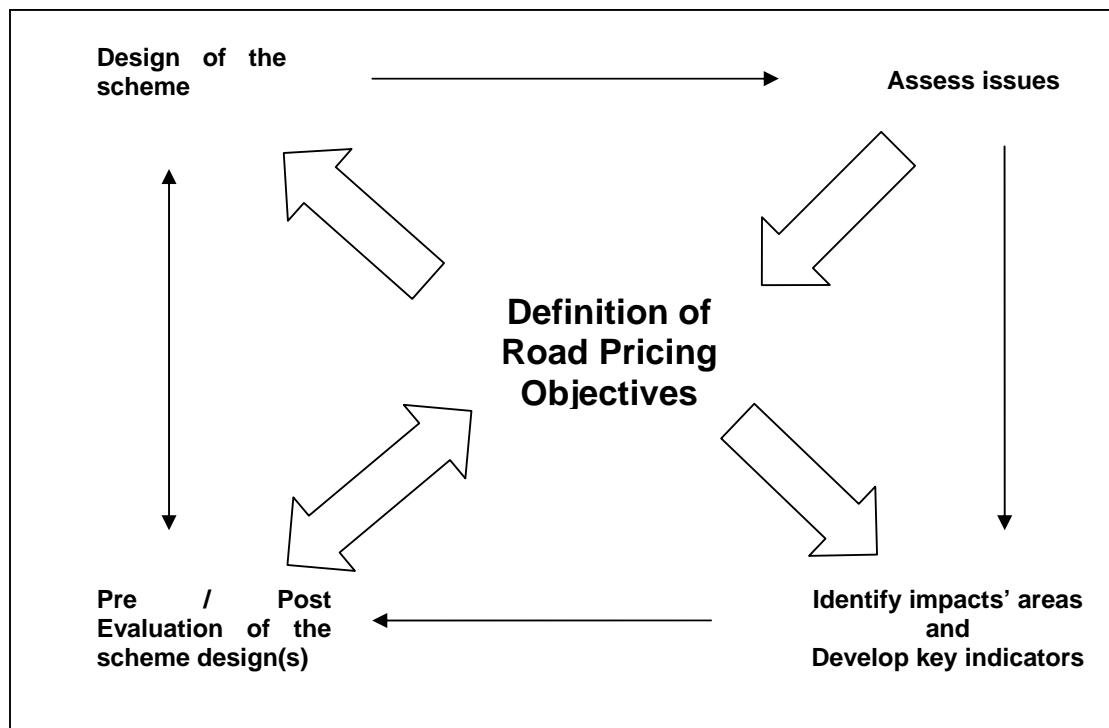
## 2 OBJECTIVES

### 2.1 INTRODUCTION

Cities are increasingly developing their transport strategies to reflect a wider range of policy objectives. The aim of this chapter is to present these objectives and to ensure that both well-known and newly-arising road pricing objectives are reviewed and understood.

### 2.2 WHY IS IT IMPORTANT TO SET OBJECTIVES?

Urban transport policies are getting more complex by the day. Impacts from implementations are numerous and induce changes in different areas. When a Road Pricing schemes are used as policy instruments, one must take into account a number of interactions. Before implementing and evaluating a scheme, it is important to accurately define the policy objectives addressed by the policy and the constraints to be faced. The objectives are thus a priority in the scheme's conception and have different functions, as shown in Figure 2-1.



**Figure 2-1 Place of Objectives in the Scheme Conception Path**

Once the objectives and the constraints are well known, it is possible to identify the impact areas affected by a road pricing scheme. The impact areas will accordingly be assessed through a range of indicators that measure the performance of the scheme. The set objectives thus serve as a benchmark for a before and after evaluation.

The initial appraisal of impacts can lead to the adaptation of the predefined objectives. The cross analysis of expected and observed road pricing impacts is important exactly because it allows to review and adjust the scheme to meet viable goals.

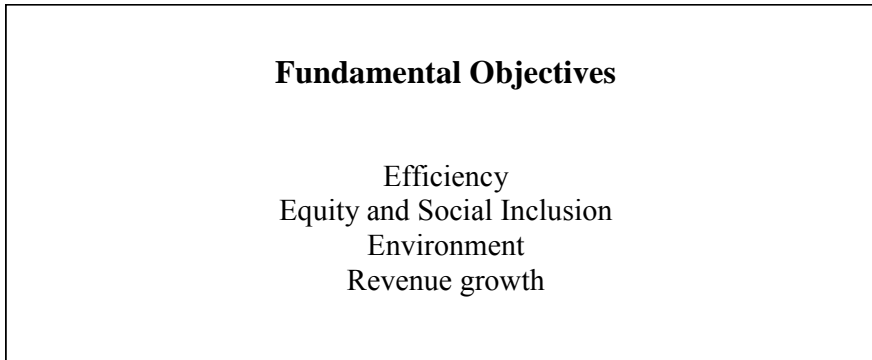
The choice of the final scheme design will thus depend on the main local concerns and on the results supplied by the appraisal of the key indicators.

The departing step is then the statement of clear objectives. It is also important to know the priority of these objectives. The objectives should be discussed with the key stakeholders in order to attain a sufficient level of consensus toward the project. Consultation must bring on board the point of view of local, regional, national and European authorities, but also users, operators and other lobbies.

### 2.3 WHAT DO WE ALREADY KNOW?

#### 2.3.1 What do we know from the European Road Pricing Experiences?

Figure 2-2 shows the objectives set out by various urban road pricing schemes existing today. The main running European charging schemes are mentioned. Outside of Europe, only Singapore has thus far implemented road pricing. Efficiency is always mentioned as an objective.

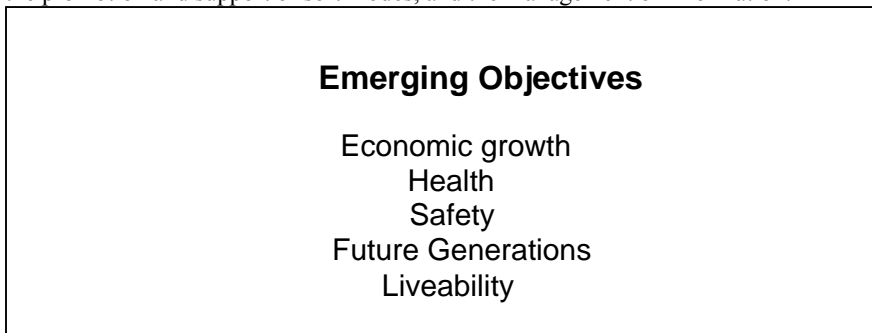


**Figure 2-2 Fundamental objectives when implementing Road Pricing**

#### 2.3.2 What do we know from PROGRESS and CUPID?

PROGRESS<sup>1</sup> and CUPID<sup>2</sup> already investigated the main objectives of road pricing in great detail. Several fundamental objectives were clearly identified as in Figure 2-2. In addition PROGRESS and CUPID provided a body of knowledge on these objectives, both in terms of description and ways to measure and to incorporate them in an overall evaluation process.

However, whilst the fundamental objectives of efficiency, environment or equity are well known, new considerations are emerging (as shown in Figure 2-3). Road pricing schemes are increasingly considered as part of a global transport plan package, which include a variety of instruments. Road pricing is not “the” solution to achieve the objectives. It rather contributes to a global and integrated transport strategy, which includes different instruments such as the improvement of public transport, the promotion and support of soft modes, and the management of information.



**Figure 2-3 Emerging objectives when implementing Road Pricing**

<sup>1</sup> For more information visit <http://www.progress-project.org/> .

<sup>2</sup> For more information visit <http://www.transport-pricing.net/cupid.html> .

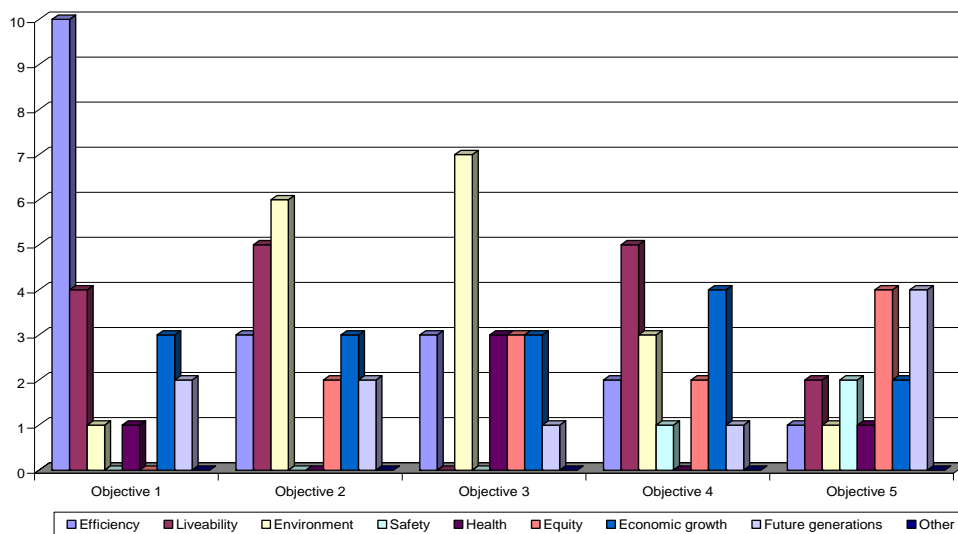
## 2.4 WHAT HAVE WE LEARNED FROM CURAÇAO'S USER NEEDS ASSESSMENT QUESTIONNAIRE?

Urban pricing policies are faced with opposition and a degree of reservation from both the public opinion and the industry. In response to this major issue, CUPID, PROGRESS and now CURAÇAO concentrate considerable resources on presenting road pricing as a concept. One of the main focuses of CURAÇAO is to consider how to promote road user charging schemes to decision-makers. In order to do so, CURAÇAO launched a new user needs assessment questionnaire (UNAQ). Table 2-1 summarises the various objectives that have been considered including the information from the user needs assessment.

The user needs assessment was conducted in partnership with the decision makers from 21 cities in Europe. The questionnaire placed great attention on the objectives of road pricing. Respondents had to indicate the five principal objectives their cities would aim to meet by implementing a road pricing scheme. The following are general conclusions drawn from the collected answers.

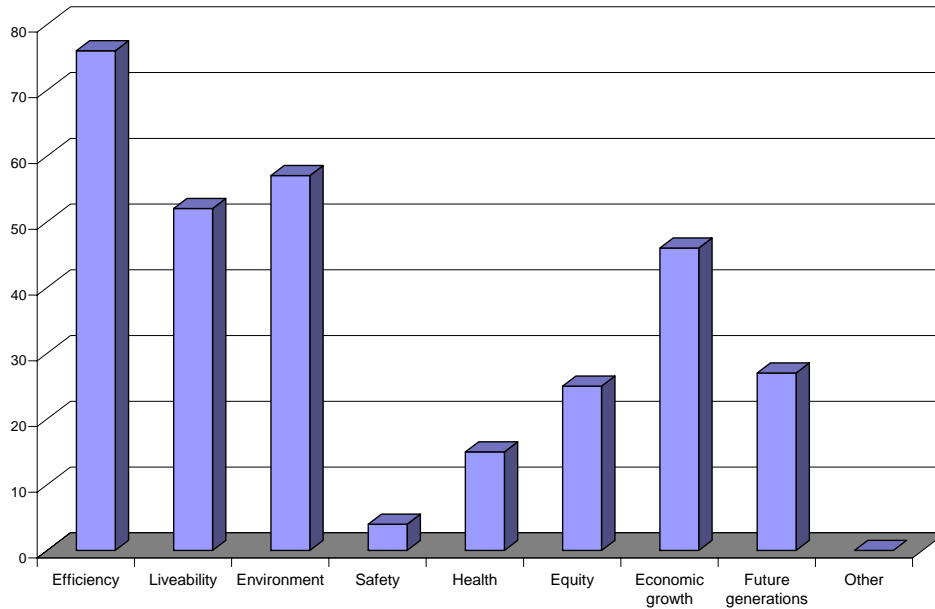
### 2.4.1 Results

**Figure 2-4 Objectives for Road User Charging (Results of UNAQ)**



Note: \*Objective 1,2,3... correspond to the order in which Road Pricing Objectives are considered

**Figure 2-5 Objectives Weighted According to Priority**



#### 2.4.2 Lessons Learnt

- Among all fundamental and arising objectives, six of them are considered as primary road pricing goals. The relevance of road pricing as a policy instrument is understood and recognised.
- Efficiency, liveability and environmental objectives are main primary objectives. This confirms the need for policy-makers to meet public expectations but also the need to work for observable and communicable effects.
- Economic growth always seems to be expected and considered, even if it is not the primary aim.
- The ever-present environmental, liveability, efficiency and economic growth aims are in accordance with the objectives of future generation and sustainable development.
- The achievement of equity through road pricing seems to have been given a much lower consideration by policy makers. Yet, equity had been identified as a fundamental objective in CUPID and PROGRESS. This demonstrates that efforts still need to be concentrated on presenting and promoting road pricing as an equity driver.
- Safety and health objectives are clearly identified as secondary concerns.
- No additional objectives have been mentioned, confirming that all objectives have been addressed by CURAÇAO, CUPID and PROGRESS.

#### 2.5 WHAT OBJECTIVES DO CITIES CONSIDER?

The classification proposed in CURAÇAO presents a wide range of objectives that can be considered by cities while implementing a road pricing scheme. Among these different objectives, it is clear that some of them are considered as side-effects more than as primary aims of the schemes. However, all of the objectives presented hereinafter can form part of the cities' policy plans and can be accomplished in part by road pricing schemes.

Some of these objectives are complementary and others are potentially in conflict with each other. For instance, when road pricing is introduced to help the "efficiency" objective, traffic speeds increase and

there may be a rise in accidents and casualties, which hampers the “safety” objective. Politicians have to arbitrate these conflicts.

Objectives of road pricing and constraints on scheme implementation are two closely related concepts. When road pricing implementation is considered, the constraints to be overcome appear as objectives to be fulfilled. Acceptability is for instance a necessary step to implementation, Chapter 0 deals with this topic. It must be remembered that while presenting the various objectives for road pricing, there is a thin line between objectives and constraints, for example, the objective of equity or ensuring acceptability is a constraint on scheme design.

### 2.5.1 Efficiency

Economic efficiency relates to the maximisation of the welfare gains induced by a transport system. The costs and benefits of road pricing are diverse, and can be defined in financial or utility terms. From a welfare point of view, different dimensions such as time, money and convenience must be taken into account. Welfare also has effects on other markets (labour, real estate, retail) and impacts on the economic actors affected by the scheme: users, operators, and public institutions.

The main reason for transport economic inefficiency is congestion. What is the link between objectives and congestion? Delays suffered on the roads could be due to any one of the following reasons:

- planned incidents: e.g. road maintenance
- unplanned incidents e.g. accidents
- bottlenecks on the road network e.g. a deliberate policy to slow traffic down for safety reasons
- demand/supply conditions, where demand exceeds the capacity available.

The fundamental economic reason for congestion is the failure of drivers to be fully aware of the delay they cause when they enter an already crowded road. Hence the theme in this report is on dealing with congestion brought about by demand/supply conditions. Congestion is a key concept because it is the starting point of transport economic analysis and of engineering traffic studies. Engineers focus on the infrastructure capacity and the road use efficiency, while economists analyse cost transfers and user utility.

For traffic engineers, congestion starts when the supplied road network is not sufficient to provide a normal flow to drivers. Hence one possible definition of congestion is *“the impedance vehicles impose on each other, due to the speed-flow relationship, in conditions where the use of a transport system approaches its capacity”* (ECMT,1998).

For economists, congestion arises when drivers create an external cost to others that are not borne by the drivers themselves and they view this as a market failure. In the economics literature (e.g. Hau, 1992) the marginal drivers always impact the speed flow relationship for all road users. Each driver creates an externality, because he contributes to all drivers’ time losses.

However, time lost is not the only external effects from congestion, the overuse of roads also leads to more pollutant emissions, to more noise and to more accidents. It can also reduce the attractiveness and vitality of city-centres and have a knock on effect on business. Finally, it is noted that the public by and large see themselves as victims of congestion, but not as contributing to congestion. It is evident that congestion abatement/reduction is one of the primary objectives of implementing a pricing scheme.

Road pricing can ensure that travel choices reflect the real cost of trips, rather than the perceived costs, in order to encourage economically efficient behaviour.

### 2.5.2 Equity and Social inclusion

The concept of equity is frequently used to describe the fair distribution of impacts across the whole population, so that everyone takes home a share of both the benefits and the disadvantages. Equity in the transport market means to afford a reasonably comparable position to all citizens when it comes to mobility opportunities. In other words, it means to ensure travel opportunities to citizens irrespective of

where they live, access to mobility irrespective of what they earn, of their age, their gender and their journey purpose.

The way citizens are confronted with environmental, health and safety impacts caused by the transport system is also part of the equity objective. Transport externalities shall be fairly borne by all inhabitants.

Addressing the equity objectives translates into inducing benefits to groups of citizens currently disadvantaged. Road pricing schemes may contribute to the achievement of this goal.

The objective of social inclusion entails the improvement of access to the full range of services available to society. Excluded individuals or groups must be addressed, such as people without a car and those with challenged mobility. However, social inclusion also refers to easy access to employment, hospitals, schools, leisure facilities and shops.

Because equal opportunities are not always guaranteed when road pricing is implemented, strong consideration must be given to the compensation of those having fewer opportunities or bearing greater costs.

Social acceptance was identified by PROGRESS and CUPID as a main barrier to road pricing implementation. That is why equity and social inclusion must always appear in any in road pricing agenda. This is discussed in Chapter 0.

### 2.5.3 Environment

Transport systems have negative impacts on the environment. Urban transport is responsible for 40% of CO<sub>2</sub> emissions and 70% of other produced pollutants (CEC,2006). The high concentration of cars and the resulting congestion contribute to this global trend. Urban traffic is responsible for 10% of total EU emissions.

The main objectives of environmental protection are:

- Reduce regional pollution responsible for today's poor air quality. Particulate Matter (PM10)particles, Nox and SO<sub>2</sub> emissions are addressed here;
- reduce the global climate change and the greenhouse effect. CO<sub>2</sub> emissions are largely responsible for it;
- Reduce Sulphur Dioxides, Oxides of Nitrogen and NH<sub>3</sub> transport's emissions, which cause the depletion of the ozone layer;
- Reduce bio-diversity severance and changes on local environment stability.

Even if few road pricing systems have been implemented as environmental measures, many are designed with this objective in mind. In some cases the objective is to reduce the impacts of traffic, but in others the intention is to protect certain areas such as city centres.

CUPID and PROGRESS demonstrated that by lowering the number and length of journeys, thus affecting the modal split, have positive impacts on local emissions. Road pricing contributes to the achievement of these changes.

Road pricing can also be used to simultaneously promote the use of clean vehicles (discounting the access to charged areas for specific standards of cars).

### 2.5.4 Raising Revenue

Implementation of Road Pricing generates revenues and contributes to financing other projects and supporting other operational costs. In the case of Norwegian road pricing, revenues were set as the primary objective. The UNAQ's results and the current experiences show that raising revenue is generally deemed a secondary purpose.

Efficient use of Revenue is also crucial from an equity point of view. If pricing schemes make someone better off, they also make others worse off. Studies like REVENUE have shown that if revenues are allocated properly then the negative effects of inequity can be mitigated.

Whilst a pure “revenue maximisation” model would not be appealing on political grounds; an interrelated objective of the agency in charge is to minimise cost of toll collection. As discussed in Chapter 0 of this report, keeping costs down will ensure that there is revenue for redistribution. This is a classical argument from the economics perspective recognising that in theory, through road pricing, the invisible hand of the collecting agency should be able to improve the welfare of society as a whole and hence efficiency, through the redistribution of revenues gained.

#### 2.5.5 Economy

Efficiency of transport systems has effects on business conditions and on local economic development. Economic benefits from road pricing come principally through accessibility improvements. The traditional argument has been that congestion hampers business productivity and labour markets. However as Chapter 7 illustrates, our understanding of the linkages between economic development and congestion on one hand and economic development and road pricing is not sufficient at present to fully provide a verdict on the impact of road pricing on economic development.

#### 2.5.6 Health

Urban transport creates considerable health hazards. The main generators are air pollutants, but noise and stress can also contribute. Increasingly, too, it is being recognised that lack of exercise through excessive car use can contribute to a range of health problems.

Pollution causes respiratory and cardio-vascular diseases. Long periods of exposure to pollutant emissions can reduce life expectancy (Bickel and Rainer, 2005). The main diseases caused are asthma, chronic acute bronchitis, pulmonary cancer, chronic obstructive pulmonary disease (COPD) and pneumonia. Many of the pollutants which contribute to these diseases are generated at higher levels when congestion occurs. In 2000, researchers estimated that in Austria, France and Switzerland, about 6% of the total number of deaths in those countries were due to atmospheric pollution and around half were directly due to motorised traffic (Künzli et al, 2000).

Urban transport health externalities have both direct and indirect economic impacts. Direct costs are hospitalisation, rehabilitation, medication and medical diagnostics. Indirect costs are due to lost productivity and premature death. The annual economic burden of respiratory diseases in Europe is estimated by the ELF<sup>3</sup> to be approximately €102 billion or €118 per capita in 2000. The factors costing the most are lost work days, accounting for €48.3 billion or 47.4%, and inpatient care €17.8 billion or 17.5%. Outpatient care contributes a further €9.1 billion (8.9%) and prescription drugs add €6.7 billion (6.6%). Premature mortality and rehabilitation are estimated to contribute another €20.0 billion (19.6%). Once more, urban transport is not the only contributor to this problem but it does contribute substantially to it.

The estimated impacts on health from noise or stress are difficult to assess, but sleep deprivation and intense stress is medically known to have a negative influence on health. One German study suggests that some 2000 deaths may be advanced each year as a result of traffic noise (Schade, 2003).

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<sup>3</sup> European Lung Foundation, <http://www.european-lung-foundation.org>.

**Table 2-1 Summary of Objectives for RUC Considered**

	PROGRESS' cities						Cities with scheme in operation						User Need Assessment		
	Bristol	Copenhagen	Edinburgh	Genoa	Gothenburg	Helsinki	Rome**	Trondheim*	London	Oslo	Bergen	Durham	Stockholm	Singapore	Sample of 21 European cities
<i>Efficiency</i>															
<i>Liveability</i>															
<i>Health</i>															
<i>Equity</i>															
<i>Safety</i>															
<i>Environment</i>															
<i>Economic growth</i>															
<i>Future generation</i>															
<i>Rising Revenue</i>															

\* Trondheim was the only city with a scheme already in operation which participated in the PROGRESS project.

\*\* Rome implemented a ZTL in 2001.

Dark Cells represent the primary objective. Grey cells indicate that the objective was secondary.

### 2.5.7 Safety

Unsafe transport systems generate accidents. The objective of safety is to reduce the number of accidents for all modes, and initiate a decline in the severity level of traffic accidents.

Urban transport is responsible for 33% of all fatal accidents involving transport. Even if the number of fatal accidents is on the decline in the EU, the European Commission highlights the need for an even greater decrease (CEC,2006). The importance given to safety issues comes from safety's external costs valuation surveys, which confirm the high willingness to pay of citizens to reduce road human damages. Then, safety improvements have positive impacts on economic transport system efficiency. HEATCO confirms high economic values assigned to safety features all around Europe and the 2004 Highways Economic Note No. 1<sup>4</sup> attest to the need for prevention and action.

Road pricing contributes to safety objectives by improving efficiency and safety of traffic management.

### 2.5.8 Intergenerational Equity

The "*Intergenerational equity*" objective seeks to improve the opportunities for future generations, ensuring that the general life conditions are equal or better compare to those experienced by the current generation.

The entire range of conditions affected by the transport system is therefore considered:

- To guarantee at least the same welfare level;
- To ensure that next generations have the same ability to meet their needs in term of financial and energy resources;
- To reach the same level of liveability in terms of environment, ecosystem and cultural heritage.

Considerations about impacts for the future generations are particularly important when targeting sustainable development.

### 2.5.9 Liveability

Poor integration of the transport system with the rest of the city has negative impacts on street and outdoor liveability.

The objective of liveability entails a variety of transport impacts that have already been mentioned as responsible for the poor quality of our cities:

- Reduce local emissions responsible for poor air quality;
- Increase safety, because insecurity create stress while walking, cycling and driving;
- Improve traffic patterns to ensure frequency and reliability of public transport services;
- Reduce noise emissions from traffic;
- Improve cleanliness of cities suffering from transport vandalism and damages.

Finally, increasing liveability translates into increasing comfort while enjoying a city. This is important for citizens (80% of Europeans live in urban environments), tourists and visitors. Higher liveability levels improve the image of a city.

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<sup>4</sup> <http://www.dft.gov.uk/pgr/roadsafety/ea/highwayeconomicnoteno12004>

## 2.6 WHAT ARE THE PRIMARY AND SECONDARY OBJECTIVES?

We briefly presented the categories of the main objectives. Each objective is also composed of different elements. In that case, primary objectives presented before are composed of sub-objectives adapted to local contexts and issues. They are presented in Table 2-2.

## 2.7 WHAT ARE THE IMPACT AREAS?

In order to understand how road pricing accomplishes the objectives it is designed to meet, it is necessary to look at the scheme's impacts. To do so, we need to explore the impacts' areas affected by the causal process following road pricing implementation.

Impact areas are key indicators and must achieve measurement of road pricing effects. Indicators are ways of quantifying objectives and/or sub-objectives so as to measure the scheme's performance. They also participate, in association with specific methods, to predict effects from a potential implementation.

Road pricing impacts can occur as an immediate response to implementation or can follow later. Environment impacts are good examples of this fact.

The selected indicators may also be adapted to the cities' context and to the purpose of the evaluation process. One of CURAÇAO's challenges is therefore to develop and aggregate impacts indicators which would warranty transferability of results between cities of the project but also to other interested cities. Let's remind ourselves that the CURAÇAO network brings together cities interested in road pricing measures and that there are now more than 30 cities Europe-wide.

Careful attention may ensure that transferability of indicators should not affect the relevancy of the evaluation. Impact areas must be chosen carefully.

## 2.8 WHAT ARE THE IMPLICATIONS FOR OTHER THEMES?

The definition of objectives is the first step of the implementation path and has obvious implications for all other themes being considered in CURACAO. "*Economy*" and "*equity*" are for instance two themes addressed in the CURACAO state of the art reports and are also potential scheme objectives.

These are the implications for the other themes:

- *Scheme design*: The final design of the scheme is an essential element to ensure the attainment of the objectives, taking into account the different constraints.
- *Technology*: The selection of the appropriate technology is a function of different variables. The objectives for which the scheme has been designed acts as a constraint to the chosen technology.
- *Prediction*: Prediction is crucial to appraise the correspondence between scheme design and set objectives. Corrective actions may ensue.
- *Transferability*: A good departing point for any transferability exercise can be the identification of objectives, whereupon the experience of cities with analogous road pricing aims may be transferred for appraisal in other urban contexts.
- *Acceptability*: Public and political acceptability is obviously influenced by the scheme and the impacts thereof. Both are strongly dependant on the challenged objectives.

## 2.9 WHAT ARE THE RESEARCH GAPS?

The aim of this chapter was to review the objectives of Road Pricing and to confirm that the scope of the analysis of CURAÇAO takes into account both fundamental and newly-arising objectives. Results from the UNAQ confirm that all aspects are covered.

There is a case for continuing to monitor the objectives of concern to cities and their relative importance, so that all objectives are effectively addressed in the guidance given. However, the principal requirement is to obtain additional evidence on the problems associated with some of the less frequently addressed objectives such as health and the economy.

**Table 2-2 Primary and Secondary RUC objectives**

<i>Primary Objectives</i>	<i>Sub-Objectives</i>
<b>Efficiency</b>	To ensure integration with inter-urban transport systems
	To reduce time and fuel lost due to congestion
	To reduce conflict between modes
	To improve users' information and communication
	To ensure easy access to urban freight terminal
	To improve integration between public transport services
	To achieve reduce transport costs through a reduction in journey times
	To ensure technologic efficiency of the system
	To reduce the number of unnecessary trips
<b>Liveability</b>	To reduce noise emissions from traffic
	To improve city comfort and cleanliness
	To improve public service frequency and reliability
	To reduce stress from experiencing transport system
	To make walkers feeling better
<b>Health</b>	To reduce the health impacts from transport local emissions
	To reduce health impacts from noise and stress due to the transport system
<b>Equity</b>	To improve access from home to school, hospitals, shops and leisure.
	To improve transportation from disabled passengers
	To improve access to local public transport services
	To increase choice of destinations by public transports
<b>Safety</b>	To insure access to mobility for all citizens of each revenue class, age, gender, residence or journey purpose
	To reduce number of fatal accidents
<b>Environment</b>	To reduce gravity of accidents
	To reduce all ranges of car's gas emissions
	To preserve local green belt and land
	To foster greater awareness of transport and environment issues
<b>Intergenerational Equity/ Future generation</b>	To protect bio-diversity
	To preserve the environment
	To ensure same level of Welfare to next generations
	To preserve patrimony from traffic impacts
	To warranty a sufficient room for financial manoeuvre
<b>Raising Revenue</b>	To make sure that next generation will be in measure to meet their energetic needs
<b>Economic growth</b>	To raise revenue
	To improve economic prosperity via access to opportunity
	To improve accessibility
<b>Economic growth</b>	To create cooperation between stakeholders

## 3 SCHEME DESIGN

### 3.1 INTRODUCTION

It can be argued that decision makers do not always realize the critical nature of the relationship between scheme design and performance for road pricing. Typically, scheme design was only ranked sixth out of nine in importance in the UNAQ survey. Addressing this is therefore a priority for CURACAO. It is hoped that this chapter will give valuable reflections on features of scheme design that help ensure effectiveness and aid acceptance from practical and political perspectives.

### 3.2 WHAT ARE THE KEY ELEMENTS TO SCHEME DESIGN?

Scheme objectives and constraints, as outlined in the previous chapter, clearly have a strong bearing on the details selected for scheme design. A reduction in congestion has been the main objective in the examples we have seen of large scale implementations in Singapore, London and Stockholm. The raising of net revenues for use on new transport infrastructure or public transport is often a strong second objective, and indeed the first objective in the examples of the Norwegian toll rings.

Key characteristics of road pricing schemes include the level and structure of the prices, where and when the prices are levied, and the extent to which prices and/or exemptions are allowed to vary by class of users (DfT, 2006a).

#### 3.2.1 Type of charging regime

Pricing schemes can broadly be classified into four types:

- Point based charges (e.g. tolls to cross a bridge)
- Cordon based pricing: A charge is levied when a cordon is crossed, and may vary with time of day, direction of travel, vehicle type and location on the cordon. There could be a number of cordons with different prices.
- Area licence based pricing: A charge is levied for driving within an area during a period of time. The price may vary with time and vehicle type.
- Distance or time based pricing: Price is based upon the distance or time a vehicle travels along a congested route or in a specified area, and may vary with time, vehicle type and location.

In real applications, there can be combinations of the above generic charging schemes. For example it is possible to combine say, a distance based pricing on a zonal basis. In this method, charges vary not only by distance travelled but also by spatial location of travel.

Distance based pricing is potentially the most effective type of road user charging. However, it will require VPS, and the complete technology is not yet available commercially for full scale implementation in an urban environment and is currently restricted to inter-urban HGV charging in Austria, Germany and Switzerland.

Multi cordon or zonal based charging could be viewed as a stepping stone towards distance based charging. An example of such a scheme implemented in Trondheim in 1998 is referred to in Section 3.2.5. However, the Trondheim scheme had charging for crossing a zone boundary in one direction only, and charging was limited to a maximum of one per hour. Obviously, in such a scheme the charge could be levied to every vehicle crossing the boundary, both inwards and outwards. The charge could be varied depending upon factors such as time, location and vehicle type. Neighbouring urban sub regions would be encircled by cordons, and trips taking place within a cordon would be uncharged.

Concentric cordons, like the inner and outer toll ring proposed for Edinburgh (Saunders, 2005) are an alternative variant of a multizonal system. Conceptually, more than two cordons could encircle a city centre, and charges could be varied according to a range of factors.

Cordons are simply combinations of point-based charges located to form a continuous boundary around an area. Point based charges are reasonably commonplace, but they are generally limited to specific small locations and not spread across the network. In modern times, estuary crossings in the UK such as the Forth Bridge, Severn Crossing, Dartford Tunnel all involve some form of point based charges.

To get people more aware of the need to bear the delay costs of their travel, point based charges can provide a way forward towards a more wide-spread acceptance of road user charging. In the US, road pricing projects generally involve many single facilities and point based charges e.g. the I95 in California (Sullivan, 2003). Demonstration projects at various “pinch points” in the network developed before more complex systems and full scale charging is introduced and could support associated public acceptability and marketing drives.

It is possible to combine point based charges with a cordon or area pricing system such as in Singapore where there are charges for expressways as well as for crossing into the Central Business District.

With regard to the selection of charging regime, complex schemes are likely to be more expensive to implement and run and harder for travellers to use. The problem of system complexities will be discussed later in Section 3.3.2

### 3.2.2 Level of charge

Likewise, a flat price may be more acceptable and straightforward to implement. On the other hand, letting the prices vary in accordance with time and location of congestion, will improve the efficiency and benefits of the scheme. Also it is important to allow for some flexibility over time. Travel patterns will evolve and, consequently, the demand for road space will vary. A relatively fixed system may become inefficient over time.

With respect to actual levels of charges, the Central London congestion charge is probably the most expensive with a basic daily charge of £8 since July 2005. When the scheme was introduced in February 2003, the daily charge for driving or parking a vehicle within the congestion charging zone between 07:00 and 18:30 Monday to Friday was £5.

The 2006 Stockholm congestion tax trial is an example of charges that were highly time differentiated. The tax per passage was SEK 10, 15 or 20 depending on the time of day. The highest amount charged was during rush hours 07:30 to 08:30 and 16:00 to 17:30. A maximum amount per vehicle and day was set to SEK 60.

With the exception of Trondheim, the Norwegian toll rings have no time differentiation during charged periods. In Oslo, the basic charge for a light vehicle is NOK 20, in force 24 hours a day and all days of the week. In Bergen the charge level is currently NOK 15 for a light vehicle and in force 24 hours a day Monday to Saturday. During 2005, the last year of operation of the Trondheim charging scheme, the basic charge (manual payment) was NOK 15 for all hours of operation (06:00 to 18:00 Monday to Friday). However, electronic tag holders enjoyed rebates on the basic charge, which depended on the time of day and the amount having been prepaid. Prices per passage (NOK) for light vehicles are shown in Table 3-1. Heavy vehicles pay twice these amounts.

**Table 3-1 Charges for Trondheim Toll Ring**

<b>The Trondheim toll ring</b>	<b>06:00-10:00</b>	<b>10:00-18:00</b>
Manual payment (basic charge)	15,00	15,00
Prepayment of NOK 500	12,00	9,00
Prepayment of NOK 2500	10,50	7,50
Prepayment of NOK 5000	9,00	6,00
Postpayment by bank giro:		
5 or less passages/week	15,00	12,00
10 or less passages/week	13,50	10,50
More than 10 passages/week	12,00	9,00

Rates in Norwegian Crowns (NOK)

The scheme objective and other equity factors clearly dictate whether there are discounts available for the scheme. Since the primary objective in Norway is generally to raise revenue for highway construction, providing discounts for an increased number of passages does not conflict with the scheme objective.

On the other hand, since the objective is congestion reduction in Singapore, the electronic road pricing system sets tolls that vary not only with travel time but does not provide discounts for multiple crossings. In addition, the charges are revised regularly and differentiated by vehicle type. An example of the charge is differentiated by time period and by vehicle classes is shown in Table 3-2. The ability to employ differential pricing is a function of the technological elements of the scheme design. Note that similar time-differentiated toll charges apply on SR91 in California, USA.

**Table 3-2 Abstract of charges on one major arterial during AM peak hours**

<i>Time Slice</i>	<i>Motorcycles</i>	<i>Cars/Light Goods/Taxis</i>	<i>Heavy Goods Vehicles</i>
7.30am -7.35am	\$0.25	\$0.50	\$0.75
7.35am -7.55am	\$0.25	\$0.50	\$0.75
7.55am -8.00am	\$0.25	\$0.50	\$0.75
8.00am -8.05am	\$0.75	\$1.50	\$2.25
8.05am -8.25am	\$1.25	\$2.50	\$3.75
8.25am -8.30am	\$1.25	\$2.50	\$3.75
8.30am -8.35am	\$1.25	\$2.50	\$3.75
8.35am -8.55am	\$1.25	\$2.50	\$3.75
8.55am -9.00am	\$1.25	\$2.50	\$3.75
9.00am -9.05am	\$1.00	\$2.00	\$3.00
9.05am - 9.25am	\$1.00	\$2.00	\$3.00
9.25am -9.30am	\$0.75	\$1.50	\$2.25

Rates in Singapore Dollars (SGD\$3≈ £1)

 Source: [http:// www.onemotoring.com.sg](http://www.onemotoring.com.sg) accessed April 2007

In theory it is possible to estimate the speed flow curves using traffic engineering relationships and apply economic theory to derive optimal charges that make drivers fully cognisant of the road user charge. The methods for doing so have been documented in the literature since Walters (1961) applied this to deriving optimal charges for the Lincoln Tunnel in New York.

In practice, for reasons of political acceptability, charges are generally derived through a trial and error process in view of information gathered during the scheme development stages. In addition, the charge level would depend on the objectives of the scheme, the associated price elasticities. This is the view articulated for example in the UK Transport Select Committee (2006) which stated that

“If the Government led with the introduction of a national distance charge as the core component of the price structure, it would then need to work with local authorities and other stakeholders to agree the calibration of variations, and establish where and when they should apply.”

### 3.2.3 Variations by vehicle type

Charges are not differentiated by vehicle type in the London and Stockholm examples. The Norwegian urban charging schemes have always charged heavy vehicles (gross weight more than 3.5 tons) twice the amount chargeable for light vehicles.

### 3.2.4 Exemptions

Public service vehicles like waste management, fire services etc are almost always exempted, as well as vehicles for disabled drivers and electric vehicles. Rules for exemptions are strongly related to obtaining acceptability, and for example the London scheme seems to have a large proportion of exempted vehicles for this reason.

Extensive exemptions have operating cost implications, and may undermine to a certain degree the objectives of a scheme. For example in the London scheme, motorcycles and mopeds are exempted. This led to a large increase in the number of these two wheel powered vehicles entering the charging area following the introduction of the scheme (Santos, 2004). As discussed elsewhere in this report, there is also an implication of the relative ease of obtaining a powered two wheeler license in the UK and elsewhere in Europe.

On the other hand, there are issues of spatial equity that are inextricably linked to scheme design. Residents in the London charging zone receive a 90% discount (Santos, 2004) while residents in the charging area in Singapore do not receive any exemptions. An interesting case in point reflecting the public's concern regarding their interpretation on spatial equity and its relationship to exemptions can be seen in the Edinburgh congestion charging proposals (Saunders, 2005). In Edinburgh the proposed an urban congestion pricing scheme involving two cordons. The outer cordon was to be located just inside the city's bypass in an attempt to control the increasing congestion on the edges of the city; while the inner cordon was designed to protect the World Heritage Site located in the inner city. The Scottish Executive's guidance required that fair treatment be a high policy goal; however, the City Council included an exemption from the outer cordon charge for city residents who live outside the outer cordon. (Saunders, 2005) During the formal public review process the issue of geographic equity was raised and a recommendation was made to remove the outer cordon exemption for city residents living outside the outer cordon in order to achieve fair treatment. (Saunders, 2005). While the City Council agreed to many of the public's recommendations, they did not remove this particular exemption. The referendum went to the public in February 2005 with the exemption still included, and the referendum failed. While the inclusion of the exemption for outer city residents was not the only reason for the cordon pricing initiative's failure, it did exacerbate public concerns about the equity of the scheme.

### 3.2.5 Charging within an overall strategy

While there are many carrots that can be used to tempt car-drivers out of their vehicles, such as improvements to public transport services, it is generally accepted that they will be insufficient on their own to reduce car use significantly. To augment the effect of these carrots, that some sticks must be simultaneously applied in transportation policy. Hence demand management through road user charging could be a way forward.

The DANTE project concluded in its summary report<sup>5</sup> that reductions in car use are most likely to occur where a series of policies are in operation which reinforce each other. Other studies e.g. PROSPECTS/OPTIMA/FATIMA have also recognised the need for synergistic combinations of measures via a package approach to combine restraint on car use with promotion of alternatives.

The DANTE project also highlighted two potential problems. Firstly purely restraining car use might lead up to freed-up road space being used by others. This points to the need for a coordinated and consistent approach to achieve the best possible results even when road user charging is in place. Secondly, in some cases any travel reduction 'gains' are overwhelmed by travel growth in a relatively short period of time.

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<sup>5</sup> <http://cordis.europa.eu/transport/src/danterep.htm> (accessed April 2007)

Road charging is not a panacea for transport problems and works best when part of a package of complementary and reinforcing measures that combine to achieve the objectives of the policy. These measures include more traditional forms of traffic management, using information technology to direct traffic, public transport improvements, walking and cycling enhancements, parking policies and modification of road infrastructure (Short, 2004).

Road pricing is increasingly being seen as part of an integrated strategy, in which individual policy instruments complement one another, or overcome the barriers to the implementation of other instruments. Recent research has suggested that integration can be achieved by reinforcing the benefits, reducing political and financial barriers, and compensating losers. It highlights that road pricing is able to reinforce the benefits of other types of policy instruments, while at the same time generating income to contribute to their costs. At the same time, other policy instruments can help to reduce the political unacceptability and adverse distributional impacts of road pricing (May *et al*, 2006).

For instance, the 1991 single cordon system in Trondheim was developed during a six year long planning and decision-making process. During these years, several decisions were made concerning the principles of pricing, the design of the cordons and the charge structure, the use of revenues, and the division of responsibility between different institutional levels. The initial system was fully electronic with non-stop lanes from the start, and it had time-differentiated charges for tag holders.

Already in 1996, the City Council decided on a revised system that divided the city into six zones, and traffic crossing the boundaries was to be charged. Two main objectives motivated this change which came into operation in 1998: Firstly, more revenues were needed to fulfil the transport investment plans. Secondly, a more equitable scheme was called for (interpreted as a system charging a higher proportion of the motorists). This way of thinking was taken one step further in 2003, when an almost complete inner ring close to the city centre was added. This system was in operation until the end of charging 30 December 2005.

### **3.3 WHAT ARE THE IMPORTANT REQUIREMENTS OF ANY ROAD PRICING SCHEME?**

#### **3.3.1 The Smeed criteria**

The nine design criteria set out as important in the Smeed Report of 1964 are still valid as an aid for today's designers:

1. Charges should be closely related to the amount of use made of the roads
2. It should be possible to vary prices for different areas, times of day, week or year and classes of vehicle
3. Prices should be stable and readily ascertainable by road users before they embark upon a journey
4. Payment in advance should be possible although credit facilities may also be permissible
5. The incidence of the system upon individual road users should be accepted as fair
6. The method should be simple for road users to understand
7. Any equipment should possess a high degree of reliability
8. It should be reasonably free from the possibility of fraud and evasion, both deliberate and unintentional
9. It should be capable of being applied, if necessary, to the whole country and to a vehicle population expected to rise to over 30 million

According to Richards (2006), Vickrey (1992) has added two other useful criteria:

1. Charges should not be used as a means of redistribution, on the grounds that there are more efficient and equitable means of achieving redistribution
2. All vehicles should be charged without exception, both on the grounds of avoiding disputes over qualifications for exemptions and to ensure that the true cost of operating vehicles is understood, even if it is only an accounting transfer

Other requirements that have emerged include easy accommodation of occasional users and visitors, the permission of users to check the validity of charges incurred, multi-lane operation and effective enforcement to be operable under all reasonable traffic, lighting and weather conditions.

### 3.3.2 How do people deal with Scheme Complexity

The various scheme design elements once combined could lead to a permutation of potentially very complex schemes. Some recent research has been carried out by Bonsall *et al* (2007) that recognised the potential conflict between theoretical desirability of differentiation in charging systems and the ability of the travelling public to respond to them effectively. Using both surveys from a variety of transport sectors on pricing and results from theoretical literature, they concluded that it might not be realistic to expect drivers to be able to or even willing to calculate the precise charges that they would incur for their trips. In particular, people might underestimate distance when distance pricing is used as they do not perceive distance as accurately as time.

### 3.3.3 What are the key lessons from CUPID/PROGRESS?

CUPID was a Thematic Network supported by DG TREN of the European Commission. An important part of CUPID was the liaison with eight demonstration cities constituting the PROGRESS project (Bristol, Copenhagen, Edinburgh, Genoa, Gothenburg, Helsinki, Rome and Trondheim). A brief summary from the Executive Summary of the CUPID Final Report of answers to key questions related to scheme design is given below:

#### WHO SHOULD BE CHARGED?

Cycles, buses, emergency vehicles and disabled drivers should be exempted. Motor-cycles are often exempt for practical reasons.

#### WHERE SHOULD ROAD USERS BE CHARGED?

This was found to depend largely on urban form and the scheme objectives. If the main objective is to reduce congestion (maximising economic efficiency), then city centre or citywide, using either area licensing or cordon charges. If main objective is “mobility management”, then metropolitan area, using distance-based charging.

#### HOW SHOULD ROAD USERS BE CHARGED?

In general Dedicated Short Range Communication (DSRC) solutions were preferred. Vehicle Position Systems (VPS) is envisaged to be a useful alternative in the future.

#### HOW SHOULD ENFORCEMENT OPERATE?

Most cities felt that Automatic Number Plate Recognition technology was the optimal approach.

#### WHEN SHOULD ROAD USERS BE CHARGED?

Working weekdays, either “all day” or morning peak only. Charging in the evening, depends on characteristics of evening traffic in the city concerned.

#### HOW MUCH SHOULD BE PAID?

€1-3 were suggested by cities with fixed priced schemes. Charges of between €0.01 and €0.6 per km were suggested for distance-based charging (when feasible), with the figure depending upon the size of the charging area.

#### HOW SHOULD REVENUE BE USED?

Should be used within the transport system (i.e. “hypothecation”). Widespread interest in investing revenue in public transport.

#### HOW SHOULD PRIVACY BE ENSURED?

All cities were concerned, but privacy did not appear to represent a fundamental barrier.

#### WHAT IS THE BEST WAY TO INTRODUCE ROAD PRICING?

All cities recommended that it should be part of a package of measures, and most cities recommended that infrastructure investment should be included in the package.

### 3.4 HOW CAN A SCHEME BE DESIGNED?

#### 3.4.1 Design of overall strategy

As a result of interest in the development of integrated transport strategies where policy instruments are combined to complement each other and to achieve improved performance against a set of policy objectives, May *et al* (2005) applied an optimisation procedure to identify optimal strategies for packages of urban transport improvements to achieve various policy objectives. One of the conclusions of this study was that well performing strategies for a given set of European cities tended to include peak period cordon charges to enter the city centre. These cordon charges charge traffic for crossing the boundary into the charged area and this boundary serves to separate the charging area from the rest of the network.

The performance of any road pricing cordon or boundary will be affected by the combined effects of a reduction in traffic entering the area and an increase in traffic bypassing it. While congestion will be reduced within the area, it might well be aggravated outside it. Since these conflicting impacts will depend on both the topology of the road network and the pattern of demand for its use, it is difficult to offer general advice on cordon location. All that is known is that the benefits of road pricing, usually measured in terms of welfare economic impacts, are critically dependent on the choice of cordon (May *et al*, 2002).

Yet it has been observed that there has actually been very little technical advice on the best location for such boundaries. Most designs are based on a mix of professional and political judgment, with little or no assessment of whether alternative locations would be more effective.

#### 3.4.2 Judgmental approaches

A study on judgmental approaches to cordon design among six UK local authorities at different stages in the development of road pricing proposals is reported in May *et al*. (2002). It involved an initial questionnaire and a subsequent in-depth interview with a responsible transport planner. The study covered the context of the proposal, the objectives of the scheme and the detailed design process. A general finding was that the context and objectives had little impact on detailed design. The key elements in the design process were to avoid adverse impacts and to gain public acceptance. The practical aspects were generally less important. The criteria which emerged from the survey is listed below, under the same three headings.

- Avoid adverse impacts
  - Alternative routes for drivers who want to bypass the charged area
  - Avoid dispersion of environmental or congestion problem to other areas
  - Should only cover area having good public transport service
  - Interchange facilities outside the cordon
  - All entries to the charge area should be charged
  - Entry points should not be visually unattractive
  - Cordon should be placed at boundaries between land use types
  
- Gain public acceptance
  - Simple and easy to understand cordon and charge structure
  - Charge levels to be perceived as fair and acceptable by the public
  - Avoid the problems of local and commercial inequities
  - Traffic which contributes most to congestion and pollution should be charged
  - Traffic which is of least benefit to the area should be charged
  - The city's residents should not be charged
  - People from low income areas of the city should not be charged
  
- Practicality
  - The number of charging points should be minimised
  - The design should limit the scheme's operating costs
  - Avoid types of road that cannot be tolled

- Avoid areas or locations that may cause communication problems for the system
- Locate cordon wholly inside the city authority area

### 3.4.3 Theoretical Approaches

There has been some work carried out at ITS on Cordon Design and to some extent this represents the state of the art of research at present. Two separate methods have been developed thus far. The first of these uses an application of genetic algorithms to represent design options and to highlight those which are most effective. The second provides a short cut method which is analytically less complex and involves the planner directly in the design process. Both have been shown to provide two- to three-fold improvements in performance over judgmental designs. They are not, however, intended to supplant the need for professional and political judgment; rather they are offered as design tools which will help to focus such judgment on those designs which are likely to be technically the most effective.

Further details on current research on optimal designs by a genetic algorithm based approach and a “short cut” approach are given in Appendix A to this report.

### 3.5 WHAT ARE THE IMPLICATIONS FOR OTHER THEMES?

- **Objectives:** Scheme design should be consistent with the overall objectives of the scheme. A scheme design aimed at maximising revenue from a cordon charge would be theoretically very different from one that is aimed at curbing congestion (Sumalee, 2004b). There has been theoretical literature examining trade-offs in a multi-objective framework (Yin, 2002; Sumalee 2004b). The fundamental concepts that stem from the literature however are that the scheme design must be part of an integrated strategy package of measures and in this context, road user charging is only one of the many elements of the entire transportation demand management strategy.
- **Technology:** Technology has implications for scheme design in terms of the possibility for the tolling authority to fine tune the toll levels. In Singapore, with the introduction of advanced technology for charging vehicles using on board transponder units, tolls could be differentiated so that the charges to travel during the peaks and shoulder peaks could be set higher than during the off-peak charging hours. This differentiation could not have been achieved with the vignette system operating between 1975 and 1998. In addition, technology enables dynamic adjustments to be made to the charges quite often (usually every quarter) to maintain a targeted service level on the arterials and expressway network (Olszewski and Xie, 2003). In addition, technology is important in terms of enforcement issues associated with the scheme so that violators could be determined. In this way, this reduces the possibility of evasion, which will affect indirectly equity and acceptability e.g. law-abiding drivers would not feel that they are paying while others are not and are not penalised for evading.
- **Prediction:** It is recognised that some schemes cannot be modelled within some tactical models. It is difficult given the state of the art to model say the area license scheme without the use of tour based representation (see Chapter 5).
- **Appraisal/Evaluation:** The appraisal/evaluation process of a scheme (see Chapter 0) focuses on assessing the scheme to consider how well a particular scheme design has fulfilled the objectives. Information obtained through this process can be used to iteratively refine scheme design elements such as charge levels/location of toll points/mitigation measures to counter negative impacts etc.
- **Economy:** In theory road pricing should have a centralising effect, areas with a good transportation supply should become more attractive and the increased transportation costs should reduce travelling distances. (Eliasson and Lundberg, 2002). However the precise nature of this complex interaction varies depending on the permutation of scheme design components. More research is required to understand the nature of land use and wider economic implications of various scheme design options. For example, the exact location of tolling points on the network might affect businesses since some businesses located in the cordon might lose out due to reduction in shopping traffic.
- **Equity:** This bears close relationship to acceptability. The perceived unfairness caused by the Edinburgh scheme design was interpreted as one of the possible causes of the

rejection at referendum (Saunders, 2005). In addition, accessibility to jobs and opportunities might be increased for some disadvantaged groups since who travel by public transport since they benefit from reduced congestion; on the other hand, those disadvantaged groups that are captive to the car may be made much worse off.

- **Acceptability:** Decision makers focus on the simplest designs, and may be overlooking designs which achieve greater economic benefit. On the other hand, acceptability of the scheme may dictate a simpler design. Hence cities might approach the scheme design process with “one hand tied behind their backs” and scheme design is subject to practical acceptability constraints.
- **Transferability:** In different settings, the scheme designs that are considered optimal will vary from region to region. This is due to factors such as network topology/local geography etc. However, the process, of generating insights from various prediction/appraisal tasks will be similar and the ensuing iterative scheme design refinement can be applied.

### **3.6 WHAT ARE THE RESEARCH GAPS?**

While there is a general understanding of the range of design options for road pricing schemes, guidance on good practice in scheme design is still limited. This is true both of specific road pricing schemes and of their incorporation into wider transport strategies. This is an issue which interacts with several subsequent themes, including technology, prediction and appraisal, acceptability and transferability.

One issue not addressed in this chapter is the link between scheme design on the one hand and administration and enforcement on the other. While the evidence on this is limited, some practical advice can be gleaned from existing schemes.

## 4 TECHNOLOGY

This chapter will be developed in the second edition of the State of the Art Report.

## **5 PREDICTION**

### **5.1 INTRODUCTION**

The focus of this chapter is on the topic of prediction. It considers the contribution of work carried out in advance of implementing a road pricing scheme in order to judge its expected impacts, including levels of success in achieving desired objectives and potential negative effects that may need to be addressed.

### **5.2 WHAT IS THE IMPORTANCE OF THE TOPIC?**

#### **5.2.1 What is prediction?**

Prediction may be defined to include the full range of activities carried out in advance of implementation in order to aid understanding of the impacts of road pricing. In particular, it incorporates both empirical survey work and model-based studies designed to test the performance of scheme options.

A broad definition of prediction may also be taken to include the appraisal of road pricing schemes, such as the calculation of economic benefits and the assessment of wider impacts via multi-criteria approaches, through which the outputs of other empirical and model-based work are interpreted for policy-making.

We make a purely artificial distinction between prediction on one hand and appraisal/evaluation on the other by separating them out. Prediction is discussed here while appraisal is covered in the next chapter. These two are however inextricably linked.

#### **5.2.2 How important is it to decision makers?**

Road pricing is being considered for widespread implementation because there is a large and longstanding body of research which suggests that it has the potential to improve the efficiency of road transport, reducing congestion and providing time savings to travellers while leading to economic and environmental benefits to society. As the number of real road pricing schemes that have been implemented is still quite small, much of the evidence to support this view comes from various forms of prediction, especially transport models. Therefore, prediction is likely to be central to the decision of an authority to formulate a road pricing policy and to play a key role in the technical process of scheme design and the political process of winning support for the policy among stakeholders. The robustness of prediction will have direct consequence for the appraisal of scheme benefits and for the identification of negative impacts that may require mitigation measures.

Using simple aggregate scoring, the UNAQ results have indicated that prediction ranks number 2 among the themes considered, with only acceptability being rated as more important. However, these two themes are not mutually exclusive, because prediction is likely to be an important catalyst for or against acceptability. For example, predictions of improved travel conditions and enhanced environments might be expected to increase the acceptability of road pricing, while any doubts over the robustness of the predictive approaches being used to support such outcomes may tend to reduce it.

The emphasis placed on prediction in the UNAQ results may be viewed as an acknowledgement of the extent to which authorities rely on modelling approaches to help them choose the best policy options and to justify them, both as part of formal government processes and to their electorate / local stakeholders.

### **5.3 WHAT DO WE ALREADY KNOW ABOUT PREDICTION?**

A considerable volume of work has been carried out over many years to attempt to predict the impacts of road pricing. It is not the purpose of this report to summarise everything that has been done. Rather, it is intended to focus selectively on issues of direct relevance to current and future road pricing schemes.

### 5.3.1 What does prediction cover?

A critical starting point for the prediction process is to define the range of impacts that need to be predicted. These may, perhaps, be listed to include:

- type of scheme; the best charging approach, the most appropriate locations and, ideally, the optimum charge level
- demand impacts; the effects of charging on road travel demand and the likelihood of switching to alternative modes, times of day, destinations etc
- supply impacts; the redistribution of traffic across transport networks and the consequent changes in travel times, travel distances and delays
- second order impacts; effects on economic wellbeing of the area and trends towards relocation of residence, employment and activity
- objective output indicators; such as - distributional impacts on *equity* affecting the population; changes in emissions, air pollution, noise etc affecting the *environment*; changes in the levels of marginal external congestion cost affecting *efficiency*; in general the prediction process should predict impacts relevant to each of the agreed objectives of a given scheme
- short and long-run impacts; disruption during implementation, opening day effects, changes in impacts over time due to lagged responses, need for mitigation measures and migration strategies etc

### 5.3.2 How does empirical work contribute to prediction?

Empirical survey work has tended to focus on people who are considered likely to be affected by road pricing schemes, collecting information about their characteristics and their expectations of how they will be affected alongside data that enables prediction of their behavioural responses. Other types of empirical survey work that may have an important role to play during the prediction process include the investigation of the driver behaviour impacts of road pricing technology and the exploration of expected business impacts and intentions in response to proposed schemes. However, in this study, these areas are being dealt with under other themes.

### 5.3.3 How do models contribute to prediction?

Model-based work has centred on approaches that use economic generalised cost to represent the impacts of road pricing upon travel decisions, road networks, multi-modal transport systems, land use, the environment and the economy. The AFFORD project gave detailed consideration to the use of models for representing road pricing and produced the following classification of alternative modelling approaches (Milne *et al*, 2000):

- detailed simulation models:  
*features*: provide very detailed estimates of network and junction delays that are, potentially, vehicle specific  
*road pricing applications*: may provide sophisticated approach for improving understanding of how marginal external congestion costs occur on road networks; relatively little usage so far except as a calculation tool for delays as part of wider modelling frameworks; city applications becoming increasingly widespread
- tactical network models:  
*features*: focus on spatial redistribution of traffic on transport networks in response to changes in travel costs; some software packages are able to represent junction delays in detail; some software packages allow travel demand to vary due to changes in cost .

There is also a distinction between static models and dynamic models in which the latter 'follows' traffic through the network.

- road pricing applications:* widespread use for investigating the network effects of urban road pricing (eg May and Milne, 2000; May and Milne, 2004; Santos, 2004); also widespread city applications and have been frequently used as partial (and in some cases primary) modelling approach for investigating the impacts of road pricing schemes; potential problems for robust analysis of demand impacts if used in isolation; currently the basis for research to identify optimal locations for road pricing cordons (May *et al*, 2002)
- strategic transport models:  
*features:* focus on travel demand choices, especially modal splits and time periods; frequently rely on very coarse estimates of transport supply, including limited spatial detail and lack of explicit transport networks; main strength lies in testing packages of measures affecting different parts of the transport system  
*road pricing applications:* widespread use for testing the potential economic benefits of road pricing, as part of optimal packages of measures (OPTIMA, FATIMA, PROSPECTS, AFFORD); also widespread city applications and have been used to investigate the impacts of road pricing schemes, both alone and in conjunction with tactical network models
  - geographic models:  
*features:* focus on the long-run interaction of transport systems land use decisions; do not normally include detailed representation of transport supply or explicit networks, but are frequently used in conjunction with tactical network models; relationships based on relatively limited understanding / evidence and outputs hard to verify due to long-run nature of responses  
*road pricing applications:* have been used to test the land use impacts of road pricing schemes both in a research environment (MEPLAN+EMME2 in Helsinki; MARS – Milne *et al*, 2004 and PROPOLIS, Lautso *et al*, 2004) and in practice (MVA *et al*, 2004); still a relatively small number of city applications
  - general equilibrium models:  
*features:* focus on the impacts of the transport sector within the wider economy, including the labour and property markets; include very little by way of spatial detail  
*road pricing applications:* generally restricted to high level economic research applications (such as the models developed as part of the TRENEN model (Van Dender *et al*, 1999); may be useful for investigating broad principles, such as the efficiency impacts of alternative uses of charging revenue

From this classification, it is clear that most evidence from modelling exercises to predict the impacts of road pricing come from the medium levels of detail represented by tactical network, strategic transport and geographic models. The story over the last quarter century is one of increasing degrees of complexity in attempts to predict the impacts of road pricing. During the 1980s and 1990s, it was common for individual models to be used to investigate road pricing schemes in isolation. However, this now tends to be considered insufficient, due to the inconsistencies it implies regarding the range of responses represented by alternative modelling approaches, which would mean that the predicted benefits from a scheme in one city using one type of model could not easily be compared with those in another city with a different model. Thus, it is now becoming standard practice to construct larger modelling frameworks, involving models of different types being used together with passage of data between them. In the UK, the range of impacts that needs to be considered during prediction is increasingly being specified by government (DfT, 2006). However, it is important to understand that specifying the range of responses to be modelled may not be sufficient to reduce variability between prediction approaches to insignificant levels. In addition, the passage of data between models that have very different features as part of a framework may result in significant definitional issues that have so far not been explored in depth.

Regardless of the modelling framework used for prediction, segmentation of the model into willingness to pay is particularly important. The fact that the value of time will affect the composition of travellers on the road following the implementation of the road pricing scheme is well-known in the economics literature (Hau, 1992). Francis and Ingrey (2000) commenting on the EUROTOLL findings pointed out that participants modify their travel behaviour to obtain a net increase in utility and other road users chose to “stay and pay”, gaining from the fact that travel times have been reduced. Without proper segmentation therefore, appraisal made on faulty prediction outputs will be unreliable for the purpose of decision making. The UK’s revised modelling approach strongly requires scheme

promoters to segment and evaluate schemes using values of time derived from research and performing sensitivity analysis (DfT, 2006).

#### 5.3.4 What are the main activities of the prediction and appraisal process?

A summary of the main activities / dimensions that can be considered part of the prediction and appraisal process may include:

1. surveys to assess traveller attitudes to / acceptance of proposed road pricing schemes and to gauge their behavioural responses
2. modelling and forecasting of traffic and interactivity between decision makers (e.g; transportation authorities, users, operators etc). This includes issues such as the forecasting of modal splits and route choices following the introduction of road pricing
3. formulating adequate strategies to deal with the above forecasted scenarios, to ensure that public transport and the surrounding road networks have sufficient capacity to accommodate the expected changes
4. calculation of the revenues generated by road pricing, leading to assessment of the feasibility of proposals for recycling them, such as through investment in the transport system, investment in measures to reduce the need to travel, or (as generally preferred by economists) reductions in taxation outside the transport sector
5. consideration of long-run planning issues including, potentially, modelling of land use changes, since the main long-run benefits of road pricing may come from the evolution of development and activity patterns to be more transport-efficient
6. modelling the distributional impacts of road pricing across the population of travellers, residents, business etc in order to assess equity impacts
7. modelling the environmental impacts of road pricing schemes in terms of vehicle emissions, noise etc, to assess the extent to which existing environmental problems are likely to be reduced, increased or transferred as a result of the scheme
8. modelling / surveys to assess the expected effects on business and economic activity

#### 5.3.5 What examples exist of prediction, appraisal and evaluation in the context of urban road pricing?

Of the many research studies that have been carried out involving predictions of the impacts of road pricing schemes, the following short paragraphs provide just very limited summaries of the work that is currently known to the authors and that appear to be relevant.

The TRANSPRICE project used Stated Preference surveys to investigate the modal shift potential of various pricing-based policies in nine European cities and used this data to calibrate parameters for a model-based analysis (Ghali et al, 2000). Subsequently, numerous studies have used similar approaches to investigate changes in all travel behaviour in response to road pricing (May and Milne 2004). The general finding of these studies is that travellers are sufficiently responsive to road pricing to produce significant benefits on the road network under the best performing schemes. Experience in London suggests that predictive work may actually tend to underestimate the scale of behavioural response, leading to higher than predicted reductions in road travel demand (TfL, 2004).

UK research has used tactical network modelling approaches (eg SATURN) to investigate the network effects of alternative road pricing systems, focussing primarily on the spatial redistribution of traffic, both with and without demand response. This work has shown fairly conclusively that cordons (as designed judgmentally by policy-makers) tend to perform less well than continuous charges, such as charging related to distance travelled (May and Milne 2000; May and Milne 2004). It has also suggested (backing up work carried out for Leeds during TRANSPRICE) that the performance of cordon-based systems may be critically dependent on network design and decisions about precisely where charges should be levied.

Following on from the above work, there is a continuing theme of UK research investigating how the performance of road pricing schemes can be improved from initial policy-maker driven scheme

designs. This work has suggested that substantial improvements are possible (Sumalee, 2005) and, having initially been reliant on complex models and small synthetic networks, is now moving towards some relatively simple modelling techniques for practical implementation (Shepherd *et al*, 2006).

A number of EU funded studies (e.g. OPTIMA, FATIMA and PROSPECTS) have used strategic transport models to assess the potential of transport policy packages including road pricing to lead to benefits across multi-modal transport systems. These studies have shown that policy packages including road pricing schemes tend to perform best. They have also confirmed the suggestion from more detailed work that continuous charges may tend to perform better than judgmental cordons (Fridstrom *et al*, 2000).

A small number of studies have used geographic models to represent road pricing schemes. These have shown that pricing may be expected to have quite significant long-run impacts on land use and activity. The general trends suggested appear to be towards encouraging closer proximity of homes and workplaces and increasing the desirability of living close to public transport networks. Dependent on the design of the road pricing scheme, the models suggest it may also have the potential to reduce urban sprawl (Fridstrom *et al* 2000; Milne *et al*, 2004).

Environmental impacts of road pricing schemes have been investigated by linking tactical network models (which are able to provide spatially disaggregate data about traffic flows and network speeds) to models that predict vehicle emissions and resulting atmospheric pollution level (e.g. SATURN+TEMMS work in Leeds, Mitchell *et al*, 2003). This work has shown that road pricing schemes can lead to environmental benefits due to reduced travelling, but it has also demonstrated the potential for spatial transfer of environmental problems and has shown that, where road pricing leads to longer distances being travelled to reduce / avoid charges, reductions in numbers of trips may not be matched by reductions in vehicle kilometres, emissions and pollution.

The modelling work carried out by the PROGRESS cities was variable in nature, scope and detail, representing the range of planning cultures that exist across the EU. In the UK cities (Bristol and Edinburgh) quite complex and sophisticated modelling frameworks, involving surveys and the construction of multiple model applications of different types, were undertaken prior to implementation. This seems to be a reflection of the current trends towards increasing complexity in UK government guidelines relating to prediction (DfT). In contrast, in the Italian cities (Genoa and Rome), the effort expended on predictive modelling prior to implementation was smaller. Rather, the emphasis was more on using implementation trials for data collection purposes in advance of constructing more sophisticated models to use for longer term planning (PROGRESS).

The objective of PROPOLIS (Lautso *et al*, 2004) was to research, develop and test integrated land-use and transport policies to find sustainable long term urban strategies and to demonstrate their effects in 7 European cities (Bilbao, Brussels, Dortmund, Helsinki, Inverness, Naples and Vincenza). Policy instruments tested were based on a package approach that combined investment, pricing and land use policies. With regard to pricing, the main focus was on cordon pricing and distance based charging.

PROPOLIS results suggested that road user charging can produce positive benefits but the land use tests showed that Road pricing tended to make inhabitants and jobs move to locations where they can avoid paying the extra charges and they argued that this might affect the vitality of central areas. This is probably an issue of consideration from the perspective of Economy which is being studied separately as part of CURACAO and can be found in Chapter 7.

Similar results were also shown in the UK's Road Pricing Feasibility Study (MVA *et al*, 2004), in that there would be a migration of households and employment away from the charged area. This same study also pointed out that, although it is known that mode switching from car-driving to car-passenger (increasing vehicle occupancy) is regarded as a possible impact of road user charging, it was recognised that none of the tactical network models utilised for this study could model this occurrence effectively.

In the Netherlands, national road pricing schemes are normally modelled using the National Model System. In this model system different travel choices are based on discrete choice models estimated using Stated Preference surveys. A static assignment technique is used to determine route choice and network flows. Junction delays are not taken into account. Recent developments in macroscopic dynamic assignment models and departure time choice models have shown that the travel times from

static models are of far less quality. Travel time is an important determinant in travel choices and in networks with congestion and strong interaction between motorways and urban streets, dynamic traffic assignment models yield better results. For different regions and mainly for toll road studies, dynamic models have been applied. Using the transportation model results the environmental effects of road pricing measures can be determined.

#### **5.4 WHAT ARE THE POLICY IMPLICATIONS?**

At present, there is no set standard for predicting the impacts of road pricing schemes. The evidence from research studies and real applications suggests that considerable variations exist in the scope and approaches adopted. In the UK, government guidelines are moving towards standardising the range of responses that predictive modelling exercises need to include, but this does not yet mean that results from different situations can be considered directly comparable. The degree of variation is much greater where international comparisons may be desired. This presents a challenge for all those involved in the prediction process and may have particularly significant impacts for transferability.

#### **5.5 WHAT IMPLICATIONS DOES PREDICTION HAVE FOR OTHER THEMES?**

There are the following implications for other themes:

- **Objectives:** The objectives of road pricing schemes will determine the outcome indicators that need to be predicted; the ability to represent impacts in faithful and informative ways is likely to be important in demonstrating the extent to which objectives can be met; on the other hand, the inability to predict impacts in some areas may act as a significant constraint on the pursuit of related objectives.
- **Scheme design:** Prediction has, potentially, an extremely important role to play in informing scheme design, through representation of the impacts of a range of alternative scenarios. Depending on the scheme design, traffic flows may be reduced on some routes but increased on others.
- **Technology:** Predictive work that focuses on the performance of technology can help show which options are feasible and assist with technological design
- **Appraisal:** As will be discussed in Chapter 0, information for appraisal and evaluation is generally derived from predictive models. Hence these two are inextricably linked.
- **Economy:** Prediction of the wider economic impacts of road pricing is one of the most problematic / least well developed areas; in economic theory, road pricing is considered to improve efficiency in the travel market leading to benefits throughout the economy; in practical policy-making, concerns exist about whether real road pricing schemes will lead to positive or negative benefits for economic activity within charged areas and whether unilaterally implemented schemes may affect economic competition between localities.
- **Equity:** Prediction of distributional impacts of road pricing across the population are likely to be central in determining likely equity effects; this may also be expected to feed into consideration of mitigation measures within scheme design
- **Acceptability:** The acceptability of road pricing may be related to perceptions of its effectiveness; prior to implementation, prediction is likely to be the main source of this information;
- **Transferability:** The ability to predict the impacts of road pricing may sometimes be critically dependent on whether information can be transferred reliably between situations; variation in approaches to prediction may also affect transferability of outputs between situations. The differences in appraisal process across countries will also lead to have implications for the transferability of results.

#### **5.6 WHAT GAPS EXIST IN OUR CURRENT KNOWLEDGE ABOUT PREDICTION?**

At present some gaps have already been identified within the context of modelling and prediction and they have been published as part of DISTILLATE (Shepherd *et al*, 2006). From that review the gaps in

modelling can be summarised below. The first 4 points relate to the difficulty in modelling of schemes themselves.

- 1) Modelling of different schemes. In general distance based charging and cordon schemes can generally be modelled reasonably accurately. However, because conventional modelling makes a per trip assumption, it is difficult to model area based charging schemes. Note that there are models that deal with tour based representations but these are generally not adopted widely.
- 2) Modelling of exemptions or discounts. Within the conventional modelling framework as cited above, it is difficult, if not impossible to match data to trips in the assignment. The conventional approach would be to apply some factors outside the main modelling process. This could reduce the robustness of forecasts without further thorough sensitivity testing. In Edinburgh, the congestion charging proposals involved limiting the maximum charge to £2 a day and if trips crossed the first cordon to enter the innermost cordon, they would not be charged twice (Saunders, 2005). Unfortunately, attempting to model this form of exemption within most tactical level models is not feasible at present.
- 3) Models used for road pricing modelling tend to be static and they are quite unable to handle dynamic changes e.g. predicting the influx of traffic into the charge area at the end of the congestion charge period.
- 4) Modelling the possibility of purchasing monthly tickets/passes. If users can purchase a fixed price monthly pass, this would affect their timing, frequency and mode choice, since once that pass is purchased, the marginal cost of using that pass is zero.

The next points relate to the modelling of changes in travel behaviour as a result of the introduction of a road user charging scheme.

- 5) The possibility of trip chains being formed as a result of a congestion charging scheme is limited unless sophisticated modelling techniques are used. Even if the models are available, the data collection and the effort required to do these will be extremely demanding.
- 6) The possibility of changes in vehicle occupancy. Vehicle occupancies are normally assumed to be fixed in most models, yet road user charging would give an incentive to increase vehicle occupancy (Glaister and Graham, 2004)
- 7) Park and ride could possibly be important and it is still quite difficult to model these with much robustness.
- 8) Modelling of land use changes. It is uncertain whether cordons for entry into the city centre may lead to extensive development of out of town urban development sites which can be accessed by un-priced routes and what implications these outcomes might have on future urban form.
- 9) Lack of integration between private car modelling and public transport modelling. This is important if the extent of the Mohring effect is to be quantified and exploited as advantageous to public transport operators within the framework.

These prediction gaps imply that there might be a potential problem using the output generated from predictive models to support the appraisal process.

In addition, it is difficult to predict the acceptability of a scheme with conventional modelling tools. At present, our understanding of what constitutes an acceptable scheme is limited and more discussion of this theme is in Chapter 0.

## **6 APPRAISAL**

### **6.1 INTRODUCTION**

This chapter introduces the important topics of appraisal and evaluation within the context of road user charging system. Appraisal is an “ex-ante” activity, defined as work carried out in advance of implementing a change in order to quantify and assess the expected impacts, including economic costs and benefits. In contrast, evaluation is an “ex-post” activity, defined as work carried out after implementation to find out what the actual impacts of a change have been.

### **6.2 WHAT IS THE IMPORTANCE OF THE THEME?**

Evaluation is extremely important in the medium and longer terms, to both the academic and decision-making communities, in order to further knowledge about the predicted and observed impacts of road pricing schemes. However, in the aftermath of an implementation, there may be a danger that it will not be given the priority it deserves by local decision-makers. The history of transport planning innovations suggests a general lack of “after” studies, probably because by that stage the major political decisions have been taken and thus such studies have not been seen as having a critical role to play in future policy. In the case of road pricing, the level of academic, political, media and public interest in the relatively small number of implementations to date has encouraged the collection and dissemination of a considerable volume of “after” data. In particular, decision-makers have been concerned to make sure that they have sufficient evaluation information to justify their decision to implement against possible criticisms. However, there remains a challenge to ensure that the work carried out is useful for furthering our wider understanding of the impacts of road pricing (such as through common indicators that can be compared across different schemes) and that the motivation for evaluation work does not diminish as schemes become more commonplace.

Appraisal, considered independently in the UNAQ results, was ranked 5 out of the 9 options. Thus, considering it as an element of the prediction process generally reinforces the importance of the prediction theme, while its lower individual ranking may be an acknowledgement that appraisal activities are potentially less open to variation and uncertainty than the model-based work that feeds into them. However, the importance of appraisal to decision-makers cannot be overestimated, as the outcomes are critical to decisions about whether to implement a given scheme and may be used as the primary basis for choosing between alternative scenarios.

### **6.3 WHAT IS THE LINK TO PREDICTION?**

Prediction does not include evaluation, but there is clearly an important relationship between the impacts that were expected and those that were actually found. Evaluation activities provide a critical opportunity to investigate the performance of the prediction process, leading to opportunities for improved understanding of both our approaches to prediction and of actual outcomes. Given this link, evaluation will be considered to a limited extent in this note. However, a much more thorough treatment of evaluation is taking place in Work Package 3 of the CURACAO project.

### **6.4 HOW CAN THE OUTPUTS OF PREDICTION BE USED FOR APPRAISAL?**

As noted in Chapter 5, it is important that prediction methods estimate the impacts relevant to each of the agreed objectives of a given road pricing scheme. It is even more important that appraisal and evaluation assess performance against the full set of agreed objectives. Indeed, there is a case, given the limited information available on the performance of road pricing, for evaluations to assess performance against all of the objectives listed in Chapter 2, so that cities which wish to pursue such objectives will be able to understand the contribution of road pricing to them.

Appraisal techniques have developed alongside the alternative modelling approaches described above. Economic Cost Benefit Analysis (CBA) has developed primarily to work with models that focus on demand impacts (i.e. strategic transport and geographic models). Similar approaches can be applied to work with tactical network models, but there are fewer “off-the-shelf” applications. In addition, Multi-Criteria Analysis (MCA) techniques have developed to cater for the fact that not all the impacts of transport schemes (including road pricing) can easily be summarised in common units, leading to a single overall benefit value for a given scenario. In particular, where schemes have multiple objectives of differing nature, it may be necessary to evaluate them separately against those objectives, using a range of different output indicators and benchmarks for judging overall success. Therefore, large research projects, such as CUPID / PROGRESS, which have needed to evaluate the performance of a range of different road pricing schemes in a variety of cities, have put considerable effort towards developing sophisticated evaluation frameworks. These frameworks are, essentially, MCA-based, but may include CBA approaches in some areas (e.g. as a measure of economic efficiency).

One of the latest studies of appraisal methods in the EU states (excluding Luxemburg) and Switzerland is from the HEATCO project (Odgaard *et al* 2005). It concluded that the standardisation of principles for project appraisal varies considerably across countries and modes. In addition, differences also can be found in the way CBA approaches are employed. In most of the countries, CBA is used as a means to choose between different project alternatives (including “doing nothing”), to demonstrate the need for a measure and/or to prioritise between different variants. It also pointed out that in a few countries, e.g. Belgium and UK (see Appendix B), the CBA works as an input to a multi-criteria analysis. These findings support the earlier work of Grant-Muller *et al* (2001) who in addition stated that “*All appraisal frameworks contain a mixture of monetized impacts, impacts measured in both physical and qualitative forms*”.

Obviously variations in appraisal approaches/assumptions, even within the EU and Switzerland, can affect the transferability of the model predictions from, an issue taken up in Chapter 11 of this report.

#### 6.4.1 What are some examples of appraisal practice?

In this section, we consider several issues dealing with the appraisal of a road pricing scheme. However the main theme to bear in mind is that more often than not, a road pricing strategy is part of a overall transportation strategy that includes pricing as part of its policy instruments. Hence it is often difficult to disentangle the various elements and appraise road pricing. Nonetheless, important lessons can still be learnt.

##### 6.4.1.1 Road Pricing Appraisal Guidance in the UK

In Appendix B, the British WebTAG (DfT, 2006) advice to local governments and their consultants on the appraisal of road pricing scheme is outlined. Effectively, the British approach requires that schemes are evaluated according to the objectives to which the transport strategy is designed. The guidance needs to be followed if Central Government funding is to be requested for funding (e.g. for parallel rail or highway projects etc).

A road pricing scheme is treated to be similar to any other transportation scheme in terms of economic evaluation requirements. The first step involves appraising the scheme’s overall contribution to the Central Government objectives. In fact for “uniformity” in appraisal across the England and Wales, it is a requirement that an “Appraisal Summary Table” (AST) is completed summarising the road pricing scheme’s impact five over-arching objectives for transport outlined in DETR(1998). The 5 objectives are :

- 1) Environment
- 2) Safety
- 3) Economy
- 4) Accessibility
- 5) Integration

The UK approach has followed the “Willingness to Pay (WTP) calculus” to establish a money measure for the net welfare change for each of the major stakeholders in the project and to sum these to arrive at an overall cost-benefit. This can be seen by the segmentation identifying the economic benefits to

differing groups of society (taxpayers, private sector operators, car users etc). Analysis of these separate impacts has advantages in that: it helps ensure that all relevant costs and benefits are included and aids decision-making by establishing the distribution of benefits among various stakeholders.

However monetization is only applicable to a small segment of the benefits i.e. in demonstrating contribution to the Economy and the Safety Objectives. Other impacts are generally assessed using qualitative methods (e.g. noise mapping; air quality studies). We understand that there is a move towards more monetary based evaluations for environment but to our best knowledge have not seen information from this as yet. The British approach is also thus attempting to provide information and creating a framework for MCA.

While the guidance explicitly suggests a link between scheme design and severance, it does not explicitly require scheme designers to provide alternatives. There is no explicit appraisal of the scheme design itself in accordance with the design objectives. In addition, there is no comparison of how schemes compare against the various criteria or other qualitative criteria for the design of road pricing proposals.

The British approach avoids the question whether the objective of the appraisal is to compare the road pricing scheme or a package of measures of which the pricing strategy is just one component.

This framework does not lead to rigorous sensitivity analysis of the operating cost of the scheme, although there is extensive reference to sensitivity analysis of the outcomes of the scheme e.g. requiring that appraisal be carried out based on behavioural values of time as well as equity values of time so as to estimate efficiency trade-offs as a result of adopting equity values in appraisal for fairness purposes.

#### **6.4.1.2 The ROCOL Study**

The current scheme operating in London is very similar to one of the options adopted by the Road Charging Options for London (ROCOL) study group in 2000. Chapter 5 of that study report (GOL, 2000) provides a reasonably clear appraisal of the “core scenario” which involved a £5 licence charge (£15 for HGVs) to drive within Central London between 06:00 to 20:00. Table 6-1 summarises the core impacts of the scheme. Note that this is “appraisal information” i.e. before the charging scheme was introduced.

**Table 6-1 ROCOL (2000) Sample Appraisal Result of Core Scenario**

	£m / annum
<b>Car benefits</b>	
Journey time savings and reliability	50 to 85
Cost to car users	-160 to -200
Other costs	10 to 15
<b>Commercial vehicle benefits</b>	
Journey time savings and reliability	80 to 120
Cost to car users	-70 to -80
Other costs	10 to 15
<b>Public Transport Benefits</b>	
Bus journey times	5 to 10
Rail crowding	-1 to -2
<b>Charging authority; transport operators, government</b>	
Area license net revenues	-230 to -270
Net fare, parking revenues, fuel taxes	-45 to -50
<b>Accident benefits</b>	15 to 25
<b>Total annual benefits</b>	125 to 210
Annual Operating costs	30 to 50
<b>Overall net benefits</b>	95 to 180
Scheme implementation costs	30 to 50
Charging revenues	230 to 280
Penalty revenues	30 to 40
Scheme recurring costs	30 to 50
Net revenues	230 to 270

In addition, they analysed the impacts on the environment (air quality), accessibility, employment and wider economic impacts qualitatively as required by UK appraisal practice and in line with the British Transport Guidance outlined in the appendix.

#### 6.4.1.3 The ARPES Study

Another study that provided a cost benefit analysis of congestion pricing was that of the Auckland Road Pricing Evaluation Study (ARPES) and reported in (MOTNZ, 2006). This study provided detailed assessment of the various options including road pricing in Auckland. The road pricing options included, single cordon, double cordon, area scheme and strategic network wide charging. Further information on this study will be included in the second edition of this State of the Art Report.

## 6.5 WHAT ARE SOME EXAMPLES OF EVALUATION?

This section provides some information on the evaluation of three major schemes and is based on reviews of the literature.

### 6.5.1 London

Using data from the congestion charging experience in London, Santos (2004) analysed the initial impacts (i.e. impacts 3 to 6 months from charging introduction), comparing TfL's forecasts with outturn observations. The following were noted:

*Immediate (short-term) Impacts on public transport*

- 1) There was an increase in bus patronage of 14000 to 15000 during morning peak (7 to 10 am) and half of those was travelling during the peak of the peak from 0800-0900. This was in line with forecasts.
- 2) Time spent waiting for a bus was reduced, which was a deliberate policy measure (e.g. increases in bus capacity and frequency to cater for expected increases in patronage).
- 3) The prediction of 5000 travellers switching from car to the underground did not happen for extraneous reasons (such as terrorism and the closure of Central Line due to a train derailment)
- 4) There were no significant changes in demand for trips by rail which was in line with TfL expectations.

#### *Immediate (short-term) impacts on vehicular traffic*

- 1) There was a 15% reduction in vehicles (four or more wheels) entering the congestion charging zone reduced by 15%. This was almost inline with expectations
- 2) However, while total traffic fell in line with forecasts, the actual reduction in cars entering the zone was much larger at 31% compared with forecasts of between 17%-28%.
- 3) The reduction in cars entering was offset by the Increase in buses entering which was a deliberate policy move (noted above) and also due to increases in taxis entering the charging zone.
- 4) The number of pedal and powered two wheelers (moped and motorcycles) had increased and was much higher than expected.

#### *Immediate impacts on revenues*

The estimates of revenues were less than forecasted and attributable to:

- 1) Higher than predicted reductions in traffic
- 2) Higher than predicted administration costs
- 3) Higher than predicted exemptions and discounts

The annual revenue was initially estimated at £121 million but the actual outturn revenues were £68 million initially rising to £90 million in 2004-2005. (Vickerman,2005).

#### *Analysis*

The increase in the number of taxis entering could be explained as follows. Since the London scheme was on a “charge per day” system, the marginal cost to the taxi-driver for an additional trip into the zone was zero. There was no disincentive to entering the zone once the charge was paid for the day and this is exacerbated by the probability of attracting affluent passengers within the city of London who had given up their cars. The key point to note here is that current trip based forecasting methods would not be able to predict this effectively.

Compared to the Singapore scheme (see below), there was a surge in the number of two wheeled powered vehicles entering the zone. It is relatively easy to obtain a moped<sup>6</sup>, and this could account for the popularity of using this mode following the introduction of the charging. It remains an open question whether this phenomenon would transfer to other British or European cities

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<sup>6</sup> All car drivers who gain their driving licence before 1<sup>st</sup> Feb 2001 are automatically granted moped entitlement. Drivers who passed after that date and non-licence holders only had to undertake an assessment (at minimal expense) to obtain moped entitlement (Source: <http://www.dvla.gov.uk>, accessed April 2007).

in the event of charging being introduced. There are also implications here for scheme design (should mopeds/motorcycles be exempted from the charge?).

Estimated toll elasticity was approximately -0.8 (Vickerman 2005, Prud'homme and Bocajero 2005). However, Vickerman (2005) mentioned that TfL assumed an elasticity of -0.5. This could account for the higher than forecasted reductions in traffic and consequent revenue impacts.

In addition, there was a significant Mohring<sup>7</sup> effect which was observed in later studies (Vickerman, 2005). This point has usually not been raised much in the literature. As TfL put on more buses to cope with the initial increases in passenger demand, waiting times have reduced and there continues to be an increase in bus passengers entering the zone ever since. There is also an observed reduction in bus travel time and idle time. If it can be argued that bus passengers are better off as a result of benefiting from reduced travel times, and that bus passengers are less affluent, there are equity implications from this outcome which may need further analysis.

What is even more interesting however is the debate between Prud'homme and Bocajero (2005) and Mackie (2005) and Raux(2005) regarding the economic benefits from the scheme. Taken from Mackie (2005) and shown in Table 6-2 below, we compare the evaluations of the London congestion charge carried out by Transport for London with that from Prud'homme and Bocajero (2005).

**Table 6-2 Annual Costs and Benefits of London Congestion Charge Scheme (in millions € converted at £1 = €1.4)**

Item Number	Item	TfL	Prud'homme and Bocajero
1	TfL Admin and other costs	7	
2	Scheme Operations	126	139
3	Additional Bus Cost	28	7
4	Charge payer's compliance costs	21	
5	Amortisation and interest	0	37
	<b>Total Costs</b>	<b>182</b>	<b>183</b>
	<b>Time Savings:</b>		
6	Business	105	} 68
7	Private	56	
8	Commercial Vehicles	28	
9	Bus Passengers	28	31
10	Reliability Benefits	14	
11	Reliability Benefits to bus users	14	5
12	Accident savings	21	
13	Disbenefits to transferred traffic	-28	
	<b>Total Benefits</b>	<b>252</b>	<b>104</b>
	Revenue	161	165
	Penalty Payments	70	
	Benefit Cost Ratio	1.4	0.6
	Revenue Cost Ratio	1.3	0.9

<sup>7</sup> The Mohring (Mohring,1972) effect is that as demand increases, transit frequencies increase, wait times decrease, demand increases, and transit frequencies can increase again.

The following points have been raised regarding comparisons of TfL's analysis with Prud'homme and Bocajero's:

- TfL's benefits assume a very high proportion of the time saving benefits accrue to travellers outside the congestion charging zone.
- The values of time (for the time savings) assumed in Prud'homme and Bocajero was much lower than that assumed by TfL.
- TfL's calculations of the time savings (Items 6-8) sum to €189 m while the revenue stream (excluding penalty payments) sum to €161 m. This actually implies that ALL road users are better off with the scheme than without the scheme primarily because of the high "external to charging zone" benefits. This result conflicts with classical economic theory which argues that welfare can only be improved with redistribution of revenues by the authorities.
- Prud'homme and Bocajero did not consider safety benefits, which although is far lower than that suggested by TfL, should still be included in the analysis.
- Prud'homme and Bocajero did not consider reliability benefits which could be substantial and amount to as much as a third of the benefits of the scheme (Small and Brownstone, 2005). The reliability of measurement of these benefits continues to be problematic.
- Raux(2005) argues that there are clear measurement difficulties associated with measuring the effect of reduced congestion and hence the magnitude of time savings and is clearly sensitive to the assumed pre charging and post charging speeds.
- The scheme's operation costs are very high and TfL's own analysis indicates that without the penalty payments of €70 m, the scheme will not break even ( $€182 > €161$ ). This implies that there is nothing to distribute to improve the welfare of society through the toll regime. This issue is also taken up by Raux(2005) who carried out a sensitivity analysis using a Norwegian system, and showed that with changes to the technology, the scheme could become more positive in the Revenue/Cost ratio measure.

### 6.5.2 Stockholm

Information from the Stockholm trial is obtained from City of Stockholm (2006). Firstly, it must be pointed out at the outset that "The Stockholm Trial" itself comprised an integrated strategy of three parts: expanded public transport, environmental charges/congestion tax (the scheme) and additional park-and-ride sites in the city and in the rest of the county. The objectives were as follows:

- 1) 10-15% reduction in the number of vehicles that cross the innercity segments during the morning and afternoon rush hours.
- 2) Improve access on the busiest roads in Stockholm
- 3) Reduce emissions of carbon dioxide, nitrogen oxides and particulate matter
- 4) Better street-level environment perceived by people in the inner city

The pricing strategy involved 18 charging points with charges made on entry and exit (unlike the London scheme) and with one free route available (E4/E20). In addition, the scheme employed differential time of day pricing where the cost ranged from €1 to €2 (busiest periods) with a maximum charge of €6 per day.

An evaluation of the charging trials indicated that:

- 1) There was a 14% reduction in vehicle miles travelled in the charged area and 1% less reduction in vehicle miles travelled outside the charged area.
- 2) There was an increase in travel time reliability
- 3) Reduced traffic volumes by 20-25% on most congested roads

A review of the evidence supports the conclusions that most of the objectives of the scheme were achieved. There might have been some understatement of the elasticities of responses since traffic levels were cut “even more than expected”. Due to the differential pricing arrangements in place, a simultaneous observation was also that reduction in traffic entering the charging zone was greater in the afternoons than in the morning. This suggests that the journeys made in the afternoon were more elastic e.g. non-work trips.

With regard to the environmental objective, achievement of the objective was supported by an overall reduction in pollutants harmful to health observed in the charge zone (14% Carbon Dioxide, 7% Nitrogen Oxides, 9% Particulate Matter). There were no observable impacts on noise and this was in line with the predictions. The attainment of the last objective of a “better” street environment was recognised as difficult to measure and the authorities felt that it was “risky to comment on the goal on a more general level”.

Unlike in London, the expanded public transport during the trial did not reduce motor traffic to a demonstrable extent. This again brings into light the question of transferability of experience.

In addition, park and ride facilities built for the trials were utilised but the reasons for this is unclear. The increase in park and ride of 2000 cars per day is negligible compared to the reductions of approximately 100000 fewer crossings into the charge zone. Similarly, there was not much increase in car-pooling and the average occupancy continued to be approximately 1.27 persons per car before and after implementation of the charge.

In Table 6-3 we compare the analysis of Prud’homme and Kopp (2006) and with that of Eliasson (2006)

**Table 6-3 Annual Costs and Benefits of Stockholm Scheme (in millions SEK)**

Notes	Item	Prud’homme and Kopp (2006)	Eliasson (2006)
1	Time gain for Car Users	+111	+496
2	Reliability gain for Car Users	0	+78
3	Losses for evicted car Users	-61	-68
4	Gain for mode/shifters	+12	0
5	Environmental/Safety Gains	+102	211
6	Toll Operating Cost	-240	-220
7	Public Transport Supply	-584	-64
8	Public Transport Congestion Costs	-222	
9	Reduced Fuel Tax Revenues		-53
10	Public Transport Revenues		+184
11	Marginal Cost of Public Funds	+122	+118
	Net Benefits	-768	+683

The following points and questions can be raised regarding the evaluations

- The operating cost (item 6) is similar under both methods of analysis.
- There is once again a massive difference in time savings; this has to do with the problem of estimating the external to zone benefits. In addition, this depends on the value of time assumed for each vehicle
- The question of whether reliability benefits should be included is once again raised. The general consensus suggests that it should be; the problem is how it can be estimated and disentangled from other effects.
- Simultaneous with the congestion charge implementation in Stockholm, there was an increase in fuel duty of 5% in Sweden as well. Therefore the question of causation is once again raised; can we attribute external to zone time savings to be due to the congestion charge or due to the fuel duty. Prud’homme and Kopp argue that traffic would have fallen by 5% based on increase

in fuel duty alone while Eliasson's analysis suggests that there would be no change due to fuel duty.

- Since net benefit is the sum of producer's and consumer surplus, changes in the public transport fare revenues accruing to the operator should be included.
- In item 7, Prud'homme and Kopp includes in the public transport costs the costs of additional suburban buses to the congestion charging scheme; Eliasson does not include them. Are there no Mohring effect benefits to existing uses? Are the costs of additional buses part of the assessment?
- The additional rail capacity costs under both analysis are very different. Prudhomme and Kopp argue that the overcrowding costs amount to 222 M SEK/ year (Item 8). Is it correct to apply the whole of the percentage change in standing to the whole of the rail/bus traffic for the whole of the in-vehicle time?

### 6.5.3 Singapore's ALS

Despite the fact that Singapore is outside the European context and the well documented cultural and political differences between Asia and Europe, there are some interesting insights based on evaluation of the evaluation of the vignette based scheme<sup>8</sup>. When the scheme was first implemented, Phang and Toh (1997) reported that speeds went up from 19 km/h to 36 km/h. However, this massive increase in speed has led McCarthy and Tay (1993) to argue that too much traffic was restrained due to the scheme and this led to underutilisation of road capacity and offset the efficiency gains from pricing.

McCarthy and Tay (1993) argued that the S\$3 (≈£1) charge for entering the charged area was too high. They based their analysis on the value of time computed as a percentage of the average wage rate of the working population. However, with a view to restricting car ownership, Singapore government transportation policy had increased the purchase price for all vehicles and only the very affluent could afford to own private cars. Koh and Li (1998) and Li (1999) argued therefore that using the average wage rate to calculate the value of time was misleading. In fact Li showed that with the average car owner's wage rate, the license fee was reasonably optimal.

Nevertheless the one unexpected outcome was that there was a massive influx of traffic in the period immediately before and after the charging hours (Holland and Watson, 1978). This observation has led to the implication that welfare levels with charging might decrease if commuters incur scheduling costs as a result of (avoiding to pay) the toll (Wilson, 1988). Time period switching is not practical in London or much less practical in Stockholm especially for commuting trips.

As car pools (defined as vehicles with 4 or more occupants) were exempted from the charges, there was a surge in the number of car pools travelling into the charge area. While the number of cars entering during the charging period fell by 75%, the number of carpools increased by over 53% (Holland and Watson, 1978). This phenomenon underlies the importance of developing models capable of handling the impacts of pricing regimes.

The number of goods vehicles entering the CBD during the charging period had increased. The argument is that operators were rescheduling trips to take into account reduced congestion. This supports the argument that there is a positive impact on the economy due to time saved to businesses. In addition, Holland and Watson (1978) did not report on detrimental economic impacts during its implementation. However, it is also borne in mind that the implementation of the pricing scheme coincided with the period of the oil shocks (1970s) and hence it might not have been possible to discern the two impacts on the economy.

While motorbikes and mopeds were exempt, they noted only a small increase in their use following the implementation of ALS. This last point was particularly important for the transferability assessment of the Singapore scheme into the European context. The relative ease of obtaining a moped license in the

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<sup>8</sup> The vignette system, which formed the core of the Singapore area licensing scheme, operated in this city state between 1975 and 1998. It has now been replaced by the Electronic Road Pricing System.

UK and Europe would also have implications for design and exemptions of the scheme as discussed in Chapter 3.

#### 6.5.4 Lessons from Pricing Implementations

There is a need to assess and evaluate outcomes in terms of the overall transportation strategy context in which pricing schemes are applied. It is important to recognise that there exists an “economically efficient level of congestion” and that over-restraint of traffic may be as harmful as a free use strategy. Related to this point is the ultimate question of the object of our assessment; in other words, is it the pricing strategy alone that we are assessing or is it the whole package of measures that includes pricing as a strategy? To illustrate this point most clearly, we consider the example of Singapore’s pricing scheme. While most studies have regarded the Singapore scheme as innovative, much less has been written about the overall cohesiveness of its transportation policy, except from official sources. The authorities have only just begun to shift in the direction of recognition of the difference between car ownership and car usage (Phang and Toh, 1997). It must be remembered that car ownership does not necessarily imply congestion. Given the relatively high vehicle ownership costs in Singapore, the relatively low rates of tolls may not necessarily serve to deter affluent vehicle owners from using their vehicles even during peak hours. To the owner, the marginal cost of car use is negligible given the high cost of the initial outlay. Whilst the congestion charging strategy is regarded as a success, the fact remains that there are far fewer cars to begin with.

The preceding examples also suggest that modes that are exempted from charges generally face an increase if conditions allow it to occur. In Singapore, it was the carpool surge that was noted. In London, it was the powered two wheelers that gave rise to increases in traffic. There is no clear indication in Stockholm if the number of exempted vehicles increased.

Differential pricing is effective and can achieve a considerable reduction in elastic vehicular traffic as can be seen by the reductions in Stockholm.

Elasticities play a key role in examination of the impacts of tolls on traffic and revenue forecasts.

The optimum level of charge is extremely sensitive to the value of time. A process of iterative refinement may need to be undertaken to revise the toll level.

### 6.6 WHAT IMPLICATIONS DOES APPRAISAL HAVE FOR OTHER THEMES?

There are the following implications for other themes:

- **Objectives:** Fundamentally, the appraisal process provides indication as to the achievement of the overarching objectives of the road user charging scheme. The appraisal of the scheme provides vital information for understanding the impact of the scheme on different user groups.
- **Scheme Design:** The appraisal outcome is dependent on the scheme design and analysis of the impacts of the scheme can provide insight into ways to iteratively refine the scheme so as to appreciate the positive and mitigate the negative impacts of the scheme. In addition, appraisal provides information for complementary measures that may be required in support of a package of measures for which road pricing is an instrument. For example, if the appraisal indicates a possible increase in public transport patronage and significant mode switching, adequate capacity could be provided on the public transport capacity (e.g. by running additional buses as in the case of London).
- **Technology:** The relationship between technology and appraisal is less clear. The main message from the London experience suggested that if costs could be reduced, then the benefits could be increased. One of the main cost drivers for most road pricing schemes is the enforcement/penalty mechanism. If the right technology options are chosen, costs could be reduced.
- **Prediction:** To a large extent, the prediction and appraisal processes are usually conducted simultaneously. We draw a reasonably artificial distinction in this report for expository convenience. Clearly information from prediction methodologies is used to support the appraisal process and these two activities are thus inextricably linked.

- Economy: Analysing the economic implications of the scheme should form part of the appraisal process. In addition, the appraisal process can also provide clues as to the business groups that might be affected by the pricing scheme design.
- Equity: One key element of appraisal is to assess the equity aspect of the scheme. A positive Net Present Value or Economic Benefit does not automatically imply that a scheme will be equitable. The information from appraisal can be used to gauge the vertical and horizontal impact groups of the schemes. Ways to reduced real and perceived inequity can then subsequently be sought again probably through an iterative refinement process.
- Acceptability: It is important to point out here that while a scheme that ticks all the right boxes in some appraisal may not be deemed acceptable by the public.
- Transferability: Scheme appraisal methods differ even amongst the EU countries. However, it is recognised that vital lessons may be learnt from different implementations and this includes unsuccessful attempts at introducing road pricing.

## 6.7 WHAT ARE THE GAPS IN OUR KNOWLEDGE?

For the authorities, ensuring that scheme evaders are penalised/prosecuted is a critical part of scheme design. The financial outlays required for this element of the scheme can be measured. For the commuter, complying with the requirements of the charging regime could be onerous. Economic theory ignores transaction costs and there are no available methods at present for measuring the cost of compliance from the commuter's perspective. There is a clear link to scheme design here.

What is the correct proportion of the time benefits that accrue to travellers outside the congestion charging zone? It is difficult to measure this because we are attempting to quantify small (seemingly insignificant) changes in very large numbers over a large area (Mackie,2005).

None of the analysis above so far considered wider economic impacts, an issue we will deal with in Chapter 7. There is emerging evidence on economic impacts (Quddus *et al*, 2004) but that still leaves open the question what the period of adjustment required and whether any economic changes could be attributed exogenously<sup>9</sup>.

With regard to the labour market, the analysis of Parry and Bento (2001) suggest that tax on commuter traffic can discourage labour force participation by reducing the household wage (net of taxes and commuting costs). Should this be accounted for in the cost benefit tables, and if so, how?

Spatial Computational General Equilibrium (SCGE) modelling work by Laird *et al* (2005) suggest that transportation affects the economy via the labour market, the goods market and the agglomeration economies. Laird *et al* argue that if network effects that appear in the wider economy (e.g. changes in output and employment) are considered a crucial argument in infrastructure decisions, careful economic analysis of their strength and significance on a case by case basis should be made. What is more difficult is attempting to quantify these in real world situations.

There has been less consideration of the streetscape benefits i.e. accounting for the cities being a more pleasant place for activities etc. Techniques from hedonic pricing or contingent valuation literature could be used for this analysis. Should these benefits be included in the evaluation?

In addition, since all the work reported here (apart from Singapore) were done only 2 years at most after the scheme's introduction, we cannot be sure if all the impacts have already been considered. The points raised in relation to this are as follows:

- Is there a gestation period for the impacts?
- What is the period required for their adjustment if any?
- Where and when do we stop measuring?
- Have we accounted for all second order impacts or are the impacts still manifesting themselves?

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<sup>9</sup> Simultaneous events that occurred when the congestion charge was introduced in London included the temporary closure of a Central (underground) line due to derailment. This was augmented with a global downturn in tourism and a (continuing) terrorism threat.

The very high operating costs of the London scheme has already been criticised in the literature. Amdal (2006) found that the operating cost of a sample of toll projects in Norway accounted between 10-12% of the revenues of the scheme. Although not directly related to evaluation, the lesson learnt from the London scheme is that that reduction of scheme costs would be crucial to increase the benefit cost ratio. Fundamentally, if the scheme costs swallows up the revenues as much as it does in London, there is a much smaller financial pot leftover for the authority to either invest in alternative modes, redistribute tax revenues or otherwise reduce distortionary taxes elsewhere in the economy and hence improve social welfare i.e. the economist's traditional argument for road pricing falls apart.

What is the framework required for assessing the Mohring effect of additional public transport supply to be offset against the costs of increased overcrowding and increasing supply to cope with and support modal shift caused by road pricing? When drivers are "tolled off", some mitigating factors are required, are these to be assessed as part of the scheme?

When overcrowding is considered, how do we measure it? Is it correct to apply a blanket factor for each vehicle for the whole of their in vehicle travel time? The bus may not be full throughout its route. Is this blanket overcrowding factor too simplistic?

Congestion charging/area licensing reduces the number of vehicles entering the charging zones. Since economic benefit is the sum of producer and consumer surplus and if revenues from public transport operators are to be included, how do we deal with and measure the revenue loss from reduced parking? The various assessments did not consider the loss of revenues to the car park operator(s). What is its magnitude and how substantial is it?

Projects have impacts on public funds through the need to finance capital expenditure on the one hand, and the impact which the project will have taxation receipts on the other. For most projects, there will be a net funding requirement imposed on the Exchequer. This funding requirement may be met through raising taxes. Taxation tends to impose further costs on society through the distortion of price signals and other incentives. It is thus argued that for each €1 raised through taxation gives rise to a social cost in excess of €1. This is known as the Marginal Cost of Public Funds or alternatively as the shadow price of public funds (Browning, 1976). How should it be treated? In UK appraisal practice, it is ignored. In Sweden it is taken into account. Both countries have similar tax systems which could be highly distortionary and there is a gap in the way this is treated. This has implications for transferability.

## 7 ECONOMY

### 7.1 INTRODUCTION

This chapter addresses the theme of economic impacts for cities considering or planning the implementation of a road pricing scheme. The main reason for economic inefficiency is congestion. Other externalities must also be considered, for example in situations where the price paid for road space usage is different from the effective social cost. Externalities create inefficiency. The OECD estimated that 4.1% of GDP was lost to transport externalities in 1994.

Road pricing can ensure that travel choices reflect the real cost of trips, rather than the perceived costs, in order to encourage economically efficient behaviours.

### 7.2 WHAT IS THE IMPORTANCE OF THE THEME?

Road pricing will change the costs of travel by car and by competing modes. It will also change the cost of commercial vehicle operation. Behavioural responses to these changes will also affect the environment in and around the charged area. All of these changes can be expected to influence the costs of doing business in the charged area, and the turnover of customer-focused businesses. They may also change property prices and residential location choices. The scale and direction of these impacts are difficult to estimate, and will be further affected by perceptions of the impact of pricing, any complementary policy initiatives, the resulting image of the charged area, and its relationship with competing centres.

These uncertain economic impacts are frequently cited as one of the main reasons for cities' reluctance to introduce road pricing. This is reflected in the results of the User Needs Assessment Questionnaire, in which our 21 city users ranked this topic second out of nine in terms of importance to them.

### 7.3 WHAT IS KNOWN ABOUT THE THEME?

The economic and relocation impacts of transport schemes are notoriously difficult to measure or predict. For road pricing, the lack of empirical evidence makes the problem worse. The early study of Area Licensing in Singapore did not attempt to assess the impacts on land use. It did ask business people for their assessment of the scheme, which was largely positive, but this may well have reflected a general view in Singapore at the time that government was making the right decisions. In analysing the economic implications of Singapore's Area Licence Scheme Holland and Watson (1978) did not report on detrimental economic impacts during its implementation. They noted that the number of goods vehicles entering the CBD during the charging period had increased. The argument is that operators were rescheduling trips to take into account reduced congestion. This supports the argument that there is a positive impact on the economy due to time saved to businesses. However it is also borne in mind that the implementation of the pricing scheme coincided with the period of the oil shocks (1970s) and hence it might not have been possible to discern the two impacts on the economy. Ten years later another attempt was made to assess the impacts retrospectively. It was concluded that there was no evidence of adverse impacts on economic activity in the city centre (Armstrong-Wright, 1986). However, this assessment was made difficult, both because parking restrictions had been introduced at the same time, about which businesses were much more critical, and because the Singapore economy had expanded rapidly in the intervening period, masking any impact of road pricing.

#### 7.3.1 Desk Studies

An earlier study asked businesses in three cities, Cambridge, Norwich and York, what they expected to be the impacts of a road pricing scheme which charged £3 per day to enter the city centre in the

morning peak (Gerrard, 2000). The majority anticipated positive impacts on the environment and congestion, but negative ones on the economy and tourism, and on their own staffing and profitability. When asked whether road pricing would influence their next location decision, 53% said it would, and 26% that it might.

Model-based predictions typically suggest much smaller impacts. An analysis of the impacts of congestion charging in London was carried out using the MEPLAN model of London and the South East, which reflects the effects of changes in accessibility on location (May *et al.*, 1996). For a £4 charge to enter central London, the predictions were:

- central London employment would rise by 1.0%
- inner and outer London employment would fall by around 0.5%
- household numbers would fall by 0.2% in central London and 0.1% in outer London
- household numbers would rise slightly in inner London
- higher income household numbers would increase in central London.

A subsequent study in Edinburgh, using the START/DELTA model, which includes responses to both accessibility and environment (Bristow *et al.*, 1998), indicated that a £1.50 charge to enter or leave the city centre would increase city centre population by 2.2%; an earlier study with a similar model, but with different parameters, (Still *et al.*, 1998) had suggested a 1.8% reduction in city centre population, and a 3.1% reduction in city centre employment. Both studies suggested that the impacts of changes in accessibility were larger than, but opposite in sign to those of changes in environmental quality.

Research has been carried out to measure the potential economic impact of road pricing strategies. The general view is that the size of this impact is quite small but there is a need for more research to study actual schemes after they have operated for a number of years. The general consensus is that it has had little economic impact in Singapore (where a road pricing scheme has been in existence for over 30 years). In simulation studies, Eliasson and Lundberg (2002) estimated that congestion pricing would result in redistribution two percent of households and a slightly higher redistribution for businesses in a typical European city.

An EC FP5 City of Tomorrow project, PROPOLIS, has assessed the impact on seven cities of packages of measures including road pricing. It is intended to incorporate their results into the next version of this report.

### 7.3.2 Agglomeration

The interaction between firms and individuals in close environments allows the sharing of knowledge and the development of new ideas. The clustering of activity in one area is known as agglomeration. Whilst transport cannot generate clusters, it can play an important role in facilitating their expansion by reducing travel time and costs, bringing firms, workers and consumers closer than would otherwise be the case.

Transport improvements that deliver time, cost and journey time reliability savings, particularly for businesses and freight traffic, can significantly contribute to GDP through an increase in cost savings for businesses. The Eddington report (Eddington, 2006) attempted to consider the role that transport could contribute to productivity benefits within agglomerations. The report discovered that not all firms within an area are equally agglomerated and therefore the improvements experienced as a result of a transport improvement will not be uniform. The contribution to the improvement made will depend upon the characteristics of the industry. However, Eddington considered that the relation between agglomeration and transport is a relatively new and untested one.

Attempting to quantify the impact of transport policy on the wider economy has led to some Spatial Computational General Equilibrium (SCGE) modelling work by Laird *et al* (2005). These authors suggest that transportation affects the economy via the labour market, the goods market and the agglomeration economies. In particular, road user charging can influence the labour market by discouraging labour force participation through a decrease in the household wage (Parry and Bento, 2001). Laird *et al* argue that if network effects that appear in the wider economy (e.g. changes in output and employment) are considered a crucial argument in infrastructure decisions, careful economic

analysis of their strength and significance on a case by case basis should be made. As argued in Chapter 0, the difficulty here is attempting to quantify these in real world situations.

Weisbrod *et al* (2001) studied the relationship between urban traffic congestion and the production of economic goods and services in terms of business costs, productivity and output. Past research has found it difficult to assess the economic implications of congestion, mainly due to the fact that those that will have been affected prior to the research may already have left the charging zone and those remaining businesses are in a difficult position to comment under a non-congestion scenario. Congestion has an impact on scale economies in terms of lowering business market areas and reducing the agglomeration benefits of operating in large urban areas. The research findings from the study found that congestion does reduce the agglomeration benefits of urban areas by reducing access to specialised labour and delivery markets.

### 7.3.3 London Congestion Charging

In London, work looking at monitoring the impacts of congestion charging has been completed by Transport for London, which found out the following:

- The introduction of charging in February 2003 coincided with a temporary economic slowdown, as well as a wider set of local, national and international conditions that were not favourable to general economic performance
- Analysis of several different indicators of economic performance, including measures of business population and turnover, did not reveal evidence of a significant congestion charging impact.
- Shops within the inner core of the charging zone found that their rental values increased.
- TfL's business surveys conducted in 2004 showed a continued recognition of the transport benefits associated with congestion charging.

Other work conducted during 2005 found that trends in business registrations for VAT remained strong and that within the charging zone, the retail sector has increased its share of enterprises and employment since 2003. A majority of businesses in the congestion charging zone recognised that decongestion has created a more pleasant working environment and easier journeys for employees using public transport for work. Ernst and Young were commissioned to undertake an independent review of the monitoring of the business impacts. Their work reasonably concluded that the (then) £5 charge has had a broadly neutral impact of the central London economy. However, as charging had only been in place for 2½ years (the date of the review), this had made it difficult to draw definitive conclusions on the long term impact.

The Mayor's original business case for the scheme suggested that congestion costs the London economy around £2 - £4 million per week in lost time. This is coupled with TfL prediction that the range of public transport services available is saving Londoners in the region of £3.5 million per week.

TfL's view about 'concerns over the detrimental impact of charging on economic activity appear to be misplaced' is not shared by all business organisations. London Chamber of Commerce and Industry's two surveys found that 85% of the retailers who took part considered the charge had 'failed to improve their productivity'. John Lewis conducted some of their own research and concluded that the effects of charging had led to an estimated sales reduction of 7.3% at their Oxford Street store. However it is unknown as to how John Lewis conducted the study and any potential bias included in the research that may have influenced the results.

There is also prima-facie evidence to suggest the potential affect of external non-transport related issues that may have had an impact on business, particularly retail productivity. The most notable event relates to the 7<sup>th</sup> July 2005 bombings on the London Underground and bus network and the knock-on negative impact this had in terms of reduction in tourism.

Whilst it is plausible to consider that the July 2005 bombings in central London could have contributed to a downturn in business activity, Transport for London's work suggests that the impact of the

bombing on the business economy was short-term leading to short-term decline in retail sales, the trend has reversed with growth rates returning to 'normal' levels.

Work undertaken by Ernst and Young suggests that all TfL's work and conclusions are broadly in line with their own but that further quantification of all the benefits and costs arising from the scheme should be explored further to support the view that the charge delivers overall economic benefit even when all costs have been taken into account.

Whilst there is a degree of support amongst the business community for congestion charging (London First, 2006), it is also believed that many smaller businesses may have experienced a drop in custom which could have a likely impact on reducing future investment decisions.

Empirical evidence has now been obtained in London, in the context of early claims of a roundly 10% reduction in retail trade. Transport for London's early assessment was that retail firms were reporting reductions in turnover of around 2% in the first half of 2003, with food shops reporting reductions of 6%. However, much of this appeared to be due to other factors such as the decline in international tourism (TfL, 2004). The most recent assessment suggests that the impact of the £5 charge on the London economy has been broadly neutral (TfL, 2006). A more detailed study has been conducted by Bell, on which information is still being obtained.

#### 7.3.4 Norwegian Toll Rings

Evaluation work completed in Trondheim by the Chamber of Commerce between 1991 and 1992 indicated that there was some evidence of businesses located within the toll ring having lost trade during the early part of 1992. However from the summer period of 1992, no significant negative impact on business trade could be read out of the figures and hence the Chamber of Commerce concluded that there was no significant effect of the toll ring on trade at all.

Tretvik (1999) reports an analysis of the impacts on turnover within, and outside the Trondheim toll ring. Before implementation, a shopping survey concluded that 25% of shoppers were likely to change the location or timing of their shopping activity in response to the toll ring. A second survey in 1992, a year after implementation, recorded that 10% had in fact changed destination or timing of their shopping trips. However, the impact on retail turnover did not reflect this downturn in activity. In 1992 the Chamber of Commerce concluded that there had been hardly any effect on trade as a result of the toll ring. Longer term time series data from 1987 to 1997 on Trondheim's share of county retail sales and on annual turnover in different parts of Trondheim showed that Trondheim as a whole, and the CBD in particular, had been losing market share between 1987 and 1990, but that the city's market share within the county grew in most years from 1991 to 1997, and that the toll ring's share was maintained throughout that period. While turnover will be affected by a wide range of factors, there is thus no evidence to suggest that the toll ring adversely affected trade within the ring.

#### 7.3.5 Stockholm

In Stockholm, the congestion tax has two opposite and opposing effects on companies' transport costs. Clearly the congestion tax has led to increase costs for transportation in pure financial terms. Conversely, the introduction of the congestion tax should lead to a reduction in general traffic, implying that all traffic will be faster moving. The reduction in congestion with associated knock-on benefits, for example quicker loading / unloading times for delivery vehicles. The effect of the charge on local consumer purchasing power will depend to a large degree on whether consumers continue to drive after the charging system begins or whether they either begin or continue to use public transport. For those who use public transport under a congestion taxed scenario, the economic impact will be reduced relative to those who choose to make the journey by car. For most companies, it is thought that the congestion tax has only a small impact on the transportation requirements for most companies and so would not have a significant impact one way or another.

In terms of the congestion tax and its impact upon consumer purchasing is thought to be very slight as the revenue from the tax would represent no more than approximately 1% of the total GDP for the whole of Stockholm County.

In the case of the Stockholm Trial, sales and consumer surveys show that the congestion tax had minor or no effects on retail trade. The business community is dependent on a well-functioning road transport system and before the start of the trial there was a sense of worry that the congestion tax would change consumer behaviour and have a negative effect on the economic situation in the region. However, during the Stockholm Trial the retail trade increased by approximately 7 % within the zone, which should be compared to an equivalent rise in the trade outside the zone and in the whole country. The consumer durables trade in department stores and shopping malls rose by 7.5 % and 8.2-8.6 % outside the zone and in the whole of Sweden. The growth of consumer durables trade in street-facing shops climbed to 7 % during the trial. Moreover, sales of non-durables within the tax zone increased by 6.3 % compared to 8.8 % outside the zone and 6.6 % nationwide. The differences between growth rates is principally due to special events such as the creation of new retail areas outside the zone and renovation and rebuilds of department stores and malls inside the zone. Trend related changes in the retail trade also had an impact.

At an aggregated level it seems that the congestion tax had little effect on the companies total transport cost and the households disposable income and purchasing power. However the situation varies between individual households and companies. The total production of goods and services in the county (the gross regional product) amounted to an estimated SEK 750 billion in 2005. Compared to this the contribution made by the Stockholm Trial (SEK 1 billion) is minimal.

A model based analysis of a permanent congestion tax in Stockholm shows that there will be an effect on the appeal of certain areas effect measured by falling housing prices. However, the effect on housing prices were extremely modest compared to the changes that normally occur on the property market. The model also assumed the effects on traffic and accessibility to be worse than what was actually measured during the trial. Most likely it will be other factors than congestion tax that determine housing price trends in the various part of the county.

Model calculations of the effect on the location of residential premises and places of work also show that over the long term the inner city area and the surrounding area would fall by 1 % as a result of the change in accessibility with a permanent congestion tax. However, over the 20-30 year prediction period this is not a great change. Therefore the conclusion is that congestion charging most likely will not have any great effects on the future expansion of residential or commercial areas.

### 7.3.6 Impact on Freight

An often neglected topic is the impact of congestion pricing on freight traffic. One study considered changes in freight operators' behaviour as a result of the introduction of a time of day pricing initiative by the Port Authority of New York and New Jersey<sup>10</sup>. The authors claim that their study is the first comprehensive study on freight response to peak load/toll pricing (Holguin-Veras *et al*, 2006).

Through a survey of users of the system, the authors found that freight users actually responded through a combination of the following three methods

- increasing their productivity to offset the increased transportation costs
- changing to untolled facilities
- passing costs on to consumers.

The authors also speculated that the ability to pass on the costs depended on the nature of the “balance of power” between the carrier (i.e. freight operator) and the receiver. When the balance of power was in the receiver's favour, the freight operator had no choice but to increase their productivity to offset the charges.

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<sup>10</sup> Despite its name, the Port Authority of New York and New Jersey manages bridges, tunnels, airports and transit in New York City and Northern New Jersey. Variable Time of day pricing is implemented on its network of bridges and tunnels (George Washington Bridge, Lincoln Tunnel, Holland Tunnel, Goethals Bridge, Outerbridge Crossing, Bayonne Bridge) (see for example <http://www.panynj.gov/CommutingTravel> ,accessed April 2007, for more details)

These findings have very important implications for a truly integrated transportation policy that takes into account not only the movement of people but also the movement of goods and hence considers developments in the logistics industry. As Holguin-Veras *et al* argue, “the objective of moving traffic from peak to the off-peak hours necessitates a comprehensive approach that targets various links in the supply chain”.

#### **7.4 WHAT ARE THE POLICY IMPLICATIONS AND IMPLICATIONS FOR OTHER THEMES?**

There appears to be a mismatch between the perception that road pricing will lead to substantial out-migration of residents and business, and the generally low level of measured impact. However, this may be explained by the characteristics of those few cities which have as yet implemented road pricing, which are typically dominant centres in their regions, and subject to only limited economic competition. It may well be that smaller centres with closer competing centres would experience greater impacts.

In due course it may be possible to assess this further through additional empirical research. In the meantime research will have to rely on the results of predictive studies and broader analysis of the urban economy.

There are the following implications for other themes:

- Objectives: Support for the urban economy should be considered either as an objective of, or a constraint on, road pricing schemes
- Scheme design: It seems probable that schemes can be designed which have a lower adverse impact on the urban economy, or are more supportive of it; further work is needed to identify the critical design elements
- Technology: It is not clear that there is a link between technology and the urban economy
- Prediction: The availability of models which reflect the impact of accessibility and environmental quality on location choice and economic activity is fundamental to an improved understanding of this theme
- Equity: Economic impacts can have substantial secondary impacts on equity; poorer households are more likely to have to move if residential areas become more attractive, and are more vulnerable if they become less attractive; those without good public transport access are more vulnerable if shops and facilities close or leave an area.
- Acceptability: Most acceptability research focuses on the public rather than businesses, though economic impacts can be expected to have a significant impact on business acceptability; lack of public acceptability may well have an adverse impact on the urban economy and on residential choice
- Transferability: It seems likely that there will be marked differences in economic impact between cities; it will be some time before we understand this fully.

Here is a summary of the linkages between the other main themes and agglomeration:

- Objectives: The concept of agglomeration should be considered as an aid to urban pricing schemes
- Scheme design: Schemes could be designed in agglomerations that would be more effective than in a dispersed environment.
- Technology: It is unclear as to whether there is a linkage between the state of technology and agglomeration
- Prediction: The linkage between prediction and agglomeration is unclear
- Equity: The clustering of particular industries in one area could have an impact upon equity in terms of the re-location of particular types of workers. For example, the re-location of city professionals to one new hub of economic activity may have equity implications for those living outside the agglomeration
- Acceptability: Agglomeration has benefits in terms of concentrating economic agents together in clusters hence reducing travel time and cost – therefore the opinion of such a mass market may impact positively upon acceptability

- **Transferability:** It is likely that there will be differences in the sizes of agglomerations across cities and hence transferring knowledge / information between them may not be effective, e.g. what works for London won't necessarily work for New York.

## **7.5 WHAT ARE THE RESEARCH GAPS AND PLANS FOR FUTURE RESEARCH?**

This remains an area of considerable uncertainty, on which more evidence is needed. There is a growing interest in the interaction between road pricing and the urban economy in the UK, which may well lead to new research results. It would be helpful to know of any other predictive research in partners' countries. It may be useful to commission an international expert to review work in this area in other countries.

Whilst it is recognised that there is a "compelling link between the transport system and economic prosperity, with new transport connections enabling new economic relationships to be forged" (Eddington,2006), little is known about the relationship between productivity and transport policy. This is one area in which more research is required. It is also recognised that there is limited knowledge of the relationship between the potential exploitation of agglomeration economies and the themes of this study.

It is generally thought that higher value of time users such as freight should benefit from road pricing. However this argument is based primarily on theory. There is little practical evidence to consider the implications on freight traffic. For example, there is little knowledge regarding the impact of congestion charging on just-in-time inventory systems and this is a topic that needs a considerable amount of further research.

## 8 ENVIRONMENT

This chapter will be developed in the second edition of the State of the Art Report.

## 9 EQUITY

### 9.1 INTRODUCTION

This chapter addresses the theme of equity impacts for cities considering or planning the implementation of a road pricing scheme.

### 9.2 WHAT IS THE IMPORTANCE OF THE THEME?

While definitions of equity vary, they all involve defining groups of potential winners and losers from congestion charging (Langmyhr, 1997). The two principal dimensions are vertical and horizontal equity. The vertical dimension concerns the distribution of impacts by income and socio-economic characteristics. The horizontal dimension also referred to as spatial or territorial equity, concerns the impact on people living in different areas or making differing types of journey. While there are also issues of equity between firms, these are covered under economic impacts. Treatment of equity impacts therefore focuses on differences between individuals.

Road pricing will change the costs of travel by car and by competing modes. These will differ by type and location of journey. Vertical equity impacts are, as a result, complex. Lower income car users in the charged area will be adversely affected, but lower income residents are more likely to use buses, which will benefit, and walk and cycle. Horizontal equity impacts depend on the location and nature of charges. With a charge to cross a cordon, differences are marked, with those making short journeys across the cordon experiencing the greatest proportional cost increase, and those within the cordon benefiting from reduced congestion and a better environment. With multiple cordons or distance-based charges, the differences are less acute, but more complex. There is also a set of horizontal equity considerations which concern the nature of the user or journey. Disabled drivers are an obvious category of concern. So, to a lesser extent, are those travelling when public transport is less available and those carrying bulky loads.

All of these types of potential inequity can potentially be tempered by the use of exemptions and rebates, by provision of alternatives, or by reallocating road pricing revenues in other ways.

Concern over inequity was frequently cited as one of the main reasons for rejecting many early road pricing proposals. More recently they appear to have been less frequently mentioned. This is reflected in the results of the User Needs Assessment Questionnaire, in which our 21 city users ranked this topic sixth out of nine in terms of importance to them. Despite this, it has been agreed to include this as a theme for review within CURACAO.

### 9.3 WHAT IS KNOWN ABOUT THE THEME?

#### 9.3.1 What are some of the Vertical Equity Arguments?

The majority of this section is taken from May and Sumalee (2003) with some updating of literature on the London Congestion Charging Scheme.

As outlined by Hau(1992) the fundamental problem with congestion charging is that three groups of people are made worse off by the charge. Those who are tolled are made worse off because they face a higher price, those who are “tolled off” because they wish to avoid paying the toll, and even those who are “untolled” because they are using routes that are not affected by the toll can be made worse off because diversion of the tolled off may lead to congestion. He argues that these three groups of people are the reasons why there is a lot of scepticism regarding road user charging.

Early attempts in dealing with the equity issue mainly involved analysing the impact of road pricing on vertical equity (see Anderson and Mohring, 1995; Fridstrom *et al.*, 2000; Giuliano, 1994; Gomez-Ibanez, 1992; Langmyhr, 1997). There are several conflicting arguments regarding road pricing in the literature (AECOM, 2006).

Firstly it is likely that the wealthy experience greater costs than the poor; since wealthy people are more likely to drive cars than the poor, they pay more under road pricing. However, one could also equally and validly argue that the poor experience greater costs than the wealthy; since the toll is a flat rate tax, a disproportionate share of their income is required to pay road pricing fees. This technically makes the flat road pricing charge “regressive”. In addition, the poor are less able to alter their driving times to avoid peak period travel to incur the highest charges. A general conclusion from various studies is that low-income car users or less-flexible car users (e.g. based on gender or flexibility of working schedule) are likely to be the worst-off groups as a result of road pricing.

In addition, it is possible to argue that the wealthy experience greater benefits than the poor since by definition, the wealthy possess a higher value of time and will be less likely to be “tolled off”. Equally valid though is the counter-argument that the poor experience greater benefits than the wealthy because the poor are more likely to use public transport and therefore less affected by the cost of road pricing; moreover where lower income users are more likely to use bus services than drive, they may be better off (May, 1975).

The way the revenues are distributed has a significant impact on the equity issue. Returning to Hau’s argument regarding the winners and losers of road pricing, Hau recognises that one important actor, the government gains. The gain of the government has to be redistributed back to society. If revenues are not redistributed in any way, road pricing generally results in gains for higher-income groups and losses for lower-income groups (Else, 1986; Cohen, 1987).

### 9.3.2 What are some of the Horizontal Equity Arguments?

Some research has looked at the horizontal dimension of equity. Fridstrøm *et al* (2000) analysed the spatial impact of road pricing cordons using spatial accessibility for each zone segregated by modes as the indicator. They suggested that the main adverse impact of a charging cordon is its boundary effect which also depends on the actual design of the scheme. A small cordon would affect residents inside the cordon most whereas those outside the cordon are the main victims of a wider cordon scheme. In the study of the Singapore ALS, Holland and Watson (1978) indicated that the cordon gave more advantage to the commercial firms outside the cordon. This problem may be reduced by the introduction of time-based, distance-based, or delay-based regimes (Jones, 2002). Halden (2003) also used the accessibility ratio between car and non-car users from different zones for different purposes. The results showed a great diversity of impacts on different areas in the city and classes of users.

Recent research has been looking at the approach to including equity aspects in the design of road pricing systems. Mayeres and Proost (2001) proposed a weighted welfare indicator giving more weight to the benefit/cost incurred by less advantaged groups. The test results showed that road pricing is an important element of the tax reform even when there is a greater emphasis on equity. Meng and Yang (2002) developed a framework for calculating the optimal road toll (to maximise social welfare) with constraints on the spatial equity impact. Sumalee (2003) proposed an analytical method to identify the optimal location for a charging cordon with spatial equity constraints. The results for Edinburgh are shown in Sumalee *et al* (2005). Jones (2002) proposed a simple approach to address equity concerns through scheme design, exemptions, and discounts.

### 9.3.3 What is being considered on Equity in real world schemes?

The recent report (Atkins, 2006), published on behalf of the Commission for Integrated Transport in the UK, lists a number of global cities for which the concept of road pricing has been considered alongside other demand management policies. The issue of equity does not appear to be well documented among many cities within the report.

In Auckland, New Zealand, a feasibility study (Auckland Road Pricing Evaluation Study) has been undertaken to look at road pricing, parking levies and strategic network tolling (MOTNZ, 2006).

Among the five options under consideration, the report considers that an area or double cordon scheme results in the most beneficial impacts. Further work looking at a number of semi-related equity issues is expected to concentrate on coverage of any scheme, charging period, application to vehicle types, exemptions and discounts and application of different technologies.

Whilst not definitive, there are plans to introduce complementary pricing measures in Shanghai China and move away from a “predict and provide” policy. A recent investigation recognising data sparsity performed a qualitative analysis (Ma *et al*, 2005) of an Electronic Road Pricing Proposal and concluded that there was limited equity implications provided the revenues were ploughed back into public transport.

In the Netherlands, whilst there is no finalised plan to introduce Road Pricing, there is to be a discussion of introducing distance-based road pricing by the year 2012. The financial burden there is to shift from owning a car to running a car. Cleaner vehicles will be cheaper to run than those that are more polluting. Public acceptability has been researched and over 50% support the scheme if it is considered equitable (Atkins, 2006). However, no further information appears to be available in terms of how to look at scheme design in order to reduce inequality.

#### 9.3.4 Edinburgh Case Study

EC DG-TREN project, REVENUE, sought to understand current practices of transport revenue usage for a selected number of urban case study cities (Oslo, Warsaw and Edinburgh). Case study work conducted in Edinburgh looked at both the economic case and cross-boundary acceptability issues for the proposed scheme.

The scheme proposed before the Public Inquiry was a two cordon scheme, including one inside the ring road, and one outside of the historic city centre. It was also suggested that Edinburgh residents residing outside of the outer cordon be exempt from the charge. This matter was of considerable concern to the residents of neighbouring authorities, who would not be exempt from the charge and hence there was a degree of concern over whether all residents would be receiving “fair” treatment. (Saunders, 2005) A range of public transport improvements had been promised before charging was due to commence, however the service improvements were not planned significantly enough before the start date of charging, hence no real benefit from the improvements was experienced prior to charging. Bus service improvements were defined late in the planning process, and should have been planned in greater depth sooner in order to demonstrate the degree to which all communities would benefit. The main view of Edinburgh’s neighbouring authorities was, therefore, one opposed to the concept of road pricing as had been placed before the Public Inquiry.

Three of the neighbouring authorities opposed the charge on the basis that the plans were not seen to be equitable. Plans for revenue hypothecation were viewed as unfair to non-city residents who would have been expected to pay the charge, yet not receive any direct benefit. The neighbouring authorities had no legal grounds on which to secure any of the public transport improvements they needed the scheme to support. The scheme was contested on the premise that city residents would receive huge exemptions but would be the main benefactors. City residents would also have benefited disproportionately more from the public transport improvements. The issue of the exemption given to outer city residents of Edinburgh was a critical acceptability problem, controversial in terms of the specific outer cordon exemptions.

A particularly important issues affecting equity/fairness, be that perceived or ex-post, is the allocation of revenues. Past research has shown that the allocation of revenues plays a key role in enhancing acceptability, mainly via fairness considerations, which may influence the distributional impacts in the desired direction. Attention has been paid mainly to the use of generated revenues.

#### 9.3.5 Norwegian Road Pricing Experience

Considerations of road pricing and equity dealt with two main themes, how to allocate the burdens of charges and how to distribute the benefits. One important point found out is how to relax on the ambition to

design "optimal" schemes, in a way that responds to important con-arguments and reduces opposition. The following attributes were included in the toll ring:

- A "one-hour rule" whereby one would only get charged once per hour regardless of the number of crossings of the cordon made;
- Free crossings of the toll ring for disabled drivers;
- A system allowing free passage after 5:00pm and all day at the weekends. There was an equity argument here which was to avoid charging for "social travel".

An assessment of the distributive effects of road pricing must take into account how revenues are spent. Road pricing attracts much equity based opposition on the basis that high-income motorists and commercial traffic constitute the "winners" predominately. Those likely to lose out on the grounds of equity are predominately those who are low income and car-dependent families. The most commonly used solution here is to use pricing revenues to improve public transport. Trondheim's experience has been to earmark revenue not only into public transport improvements but also to walking and cycling.

Writers on equity issues find out of the proposed dichotomies suitable for analysis horizontal v vertical equity, which is believed to be too crude a measure to use to capture the complexity of equity management.

A set of principles illustrate a reduced influence after implementation. Formal equality attracted less importance in Kristiansand, where the choice of toll stations on two sides of the city was considered to be 'fair' solutions. In the city of Tromsø, responsibility was a main argument for the petrol fee alternative (you pay for the degree to which you use the roads).

One particular difficulty for the Norwegian authorities was where to locate the toll stations in a "fair" way. The 1991 ring was a compromise between fairness arguments and revenue maximisation.

Road Pricing has led to financial success for a number of cities and towards the reduction of congestion and better quality of surface public transport in cities like London and Stockholm. The improved quality of surface based public transport would be assumed to have reduced inequities from a position ex-post whereby non-car owners would have experienced lower quality public transport. There is an overall acknowledgment of a loss of cohesion as a consequence of road pricing as a congestion charging solution, in terms of those who cannot pay the charge and have experienced no further improvement in the quality and availability of alternative public transport alternatives.

Surprisingly, there appears to be little empirical research on equity impacts. The original Singapore study only looked briefly at the issue, and there is no mention of equity impacts in the recent London results.

While there remain some uncertainties over equity impacts, they mainly relate to issues of scale, which will depend on detailed design, and of design approaches which can be adopted to mitigate these impacts.

#### **9.4 WHAT ARE THE POLICY IMPLICATIONS AND IMPLICATIONS FOR OTHER THEMES?**

As noted, fears of inequity appear to be less dominant in decisions on road pricing than they once were. However, it is still probable that those opposed to road pricing will use equity concerns as a supporting argument. It therefore remains important to understand the scale of both vertical and horizontal inequities, and this will require a disaggregated analysis by person type, income level, journey type and specific person and journey characteristics.

The principal solutions to equity problems lie in the design of the scheme itself, including location, time of day and level of charge; the use of exemptions and rebates; the application of complementary policies, particularly to provide alternatives; and the use of surplus revenues to provide direct or indirect support.

In due course it may be possible to assess these issues further through additional empirical research. In the meantime research will have to rely on the results of predictive studies using disaggregate models.

It can be particularly problematic to predict the impacts on narrowly defined groups such as disabled drivers, or of special treatments such as rebates.

The User Needs Assessment Questionnaire results for CURACAO demonstrated that for equity, the achievement of this through road pricing has been given a low priority by key-decision makers. There is a demonstration here of the need to concentrate efforts on presenting and promoting road pricing as an equity driver.

There are the following implications for other themes:

- Objectives: While equity now appears to be of less concern, it should continue to be considered either as an objective of, or more appropriately a constraint on, road pricing schemes
- Scheme Design: Schemes can be designed which are less inequitable; key characteristics include location, time of day, level of charge, exemptions and rebates, complementary instruments and use of revenues; more guidance is needed on how to incorporate equity considerations into scheme design
- Technology: It is not clear that there is a link between technology and equity
- Prediction: For equity considerations, models are needed which predict the impact of road pricing on individuals, and individual journeys, disaggregated by income, location, time of day and journey purpose; ideally those models should also identify impacts on special needs, such as disabled drivers and those carrying bulky loads; where scheme design includes exemptions and rebates, models should ideally be able to assess their impacts
- Economy: Economic impacts can have substantial secondary impacts on equity; poorer households are more likely to have to move if residential areas become more attractive, and are more vulnerable if they become less attractive; those without good public transport access are more vulnerable if shops and facilities close or leave an area; conversely, inequities are less likely to have serious impacts on the economy, since those who are likely to be adversely affected are typically less economically active.
- Acceptability: Those who are, or perceive that they are, more adversely affected can be expected to find road pricing less acceptable; perceptions of inequity to others may also increase concerns over acceptability; it would be helpful to have more information on the scale of these impacts.
- Transferability: The transferability of equity impacts and underlying equity concerns and resulting design responses to inequities are likely to differ between cities; little is known about these impacts as yet

## 9.5 WHAT THE RESEARCH GAPS AND PLANS FOR FUTURE RESEARCH?

Equity issues are reasonably well understood, but more information is needed on the ways in which inequities differ by type of scheme and between cities and the ways in which they affect acceptability. Clearer guidance is also needed on ways of designing schemes to reduce inequities.

Considerations of equity are major determinants of attitudes to road pricing. Yet the concept does not appear to be widely researched, or to exist generally as an integral component of proposed and implemented schemes. Thus a greater understanding is needed of the different perceptions of fairness amongst the range of stakeholders, and how these may be incorporated into scheme design.

Evidence will continue to come from both predictive and empirical research. It would be helpful to know of other predictive analysis on equity issues, and of attempts to assess the equity implications of schemes such as those in London, Norwegian cities, Rome or Stockholm. Information on current research into equity-focused design tools would also be of interest.

There are also research gaps that need to be addressed in terms of the relationships between progressive and regressive dimensions of equity, and the relationship between equity, perceived fairness and social inclusion.

## 10 ACCEPTABILITY

### 10.1 INTRODUCTION

This chapter provides an overview of recent acceptability studies, surveys and experiences and to identify open issues, acceptability barriers, and issues where additional knowledge is needed.

Acceptability refers to the attitude of relevant stakeholders towards road pricing. It describes the prospective judgement of road pricing to be introduced in the near future. As relevant stakeholders in the implementation process have been identified: i) the citizens; ii) decision makers and technical experts in the cities; iii) the business community and iv) the media (Schade and Schlag, 2000).

The chapter is organised as follows: First, the importance and relevance of acceptability for the implementation process is outlined. Second, the present knowledge concerning the acceptability of road pricing among the stakeholders identified above is presented. Third, implications for the implementation process as well as links to the other report themes are addressed. Finally research gaps and directions for future research are identified.

### 10.2 WHAT IS THE IMPORTANCE OF THE THEME?

Economists have favoured the use of pricing in regulating transportation for decades. However, with a few exceptions, urban road pricing is rare. Practical experience shows numerous kinds of barriers to the suggested pricing policy measures. While important institutional barriers remain in many countries (e.g. Glazer *et al* ,2001) most commentators acknowledge that the main barrier to implementing transport pricing strategies is now a lack of public and political acceptability (Jones, 2003; Schade and Schlag, 2003).

Several good reasons exist for considering acceptability. Firstly, we live in a democratic society, i.e. societal, political and technological innovations must be introduced via the democratic process and must prevail against competing innovations (Frey and Eichenberger, 1999). Usually they cannot be imposed against public will. Secondly, the acceptability concept stresses the user perspective (Bartley, 1995). Even if most technological and political innovations might result in societal benefits, opinions and intentions of the people concerned are often not canvassed when new measures are being considered for implementation. This may lead to “irrational” resistance not only from the people concerned, and ultimately to the failure of an originally useful innovation.

Insufficient acceptability of a certain policy may have several consequences: for instance, strong public resistance may inhibit implementation, as political parties fear consequences for their next election. Secondly, with a sensitive topic such as mobility, the introduction of road pricing may lead to active resistance by different groups, which might be exhibited in the form of demonstrations, boycotts or even sabotage. Several examples demonstrating the power of resistance are known e.g. from nuclear energy, information technology, biotechnology and even from transport. Thus, acceptability of systems is assumed to have major influence on the effectiveness of the implementation and maintenance of a system (Van der Laan, 1998). Lacking acceptance might even undermine efficiency of a per se useful innovation.

This is reflected in the results of the *User Needs Assessment Questionnaire*, in which 20 out of 22 city users ranked this topic as very important to them (CURACAO, 2006). Low acceptability of citizens as well as the politicians and administrative decision-makers are regarded as the most important barriers to successful implementation of road pricing schemes. Furthermore a rather negative media attitude adds to the currently unfavourable climate for road pricing implementation in cities and regions.

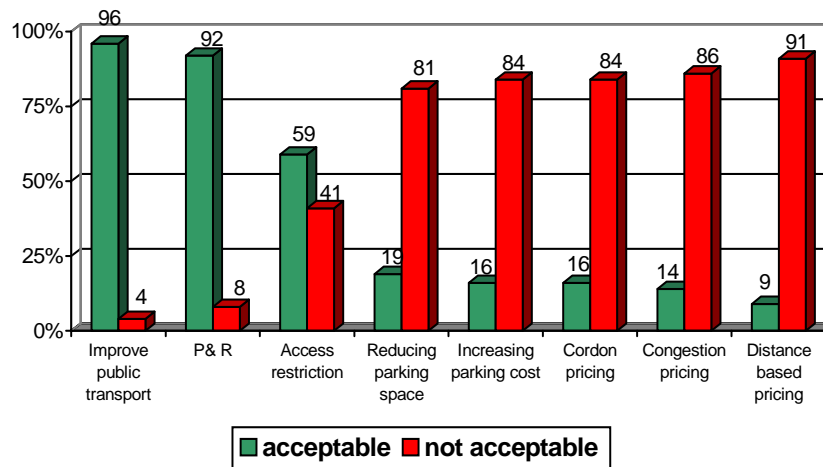
### 10.3 WHAT IS KNOWN ABOUT THE THEME?

#### 10.3.1 Public Acceptability

##### 10.3.1.1 Levels of Acceptability

Meanwhile, an extensive literature demonstrates the low public acceptability of (urban) road pricing schemes (e.g. Jakobsson *et al*, 2000; Schade and Schlag, 2000, 2003; Jaensirisak, Wardman and May, 2005). For example, Figure 10-1 illustrates the acceptability of various travel demand management measures among other different forms of road pricing. Road pricing is the least accepted form of travel demand management. Only up to 20% of the respondents agree with this form. Somewhat more optimistic Jaensirisak *et al* (2005) found in their review of a number of British acceptability study a mean acceptability of 35 %. However, they also found considerable variations in the levels of public acceptance of road pricing ranging from 8 % to 76 %.

**Figure 10-1 Acceptability of Travel Demand Management Measures**



Source: Shade(2003)

##### 10.3.1.2 Individual Characteristics and Acceptability

Concerning factors determining the degree of acceptability, in particular personal attitudes, expectations, perceptions and subjective evaluations about road pricing have been investigated. Among these, variables like negative outcome expectations, perceived unfairness, negative social norms and perceived infringement on freedom have been identified as important determinants (for a comprehensive overview see Schade and Schlag, 2003). Socio-economic factors like income revealed a clearly lesser and rather unsystematic impact on acceptability than did attitudinal factors (Jaensirisak *et al.*, 2005). Schade (2005) found that especially the individual's personal outcome expectation explains most of the variance of acceptability. The impact of personal outcome expectation is exerted mostly indirect through other variables; i.e. those who perceive more disadvantages also view urban road pricing as less fair, less effective and less socially desirable! Those who expect advantages evaluate road pricing an all dimensions more positive.

### 10.3.1.3 Scheme Characteristics and Acceptability

Furthermore, the system characteristics of road pricing schemes and its impact on acceptability have become a matter of research. In particular, the preferred use of revenues has been investigated. The principal result of a number of studies is that with a **hypothecation of revenues** acceptability of road pricing considerably increases. Numbers vary, but in most cases such a package solution was accepted by the majority of respondents (e.g. 45% in Schade and Schlag, 2000; 55% in Jaensirisak *et al.*, 2005). Jones (1998) concluded that, “*Most professional and governmental bodies in the UK now accept that hypothecation of revenues will be part of the price that will have to be paid to gain sufficient public support for urban road pricing to ensure its introduction in this country*”. It appears from the literature, that an integrative package which includes road pricing as well as some form of revenue hypothecation increases acceptability. However, the design of the package, that means which measures and form of revenue use will be included, is very much dependent on local circumstances (Ubbels, 2006).

Another important factor is the **level of charge**. The level of charge should not be too small in order to be noticed. But on the other hand high level of charges may not be acceptable and therefore not implemented (Schuitema, 2003). In almost all cases where the charge has received attention, no quantified relationship between acceptance and the charge has been developed. As an exception Jaensirisak *et al.* (2005) systematically varied the level of charge and replicated the results by Cain and Jones (2002) and Harrington *et al.* (2001) that public acceptability diminishes as the level of charge increases. In a similar vain experiences from the PRIMA case cities indicate that rather low starting levels are needed and that the charges can be increased successively to meet financial requirements (Harsman, 2003).

According to economists variable or dynamic road pricing is the best way of overcoming congestion problems in urban areas. However, people have a clear preference for simple price structures (Bonsall *et al.*, 2004). People want to know what their journey will cost before they start. If price levels are changing according to the congestion levels, time of the day etc. it creates considerable uncertainty of the real costs of a journey. People may oppose complex road pricing schemes, since they find certain behavioural outcome more attractive than uncertain ones (Kahnemann and Tversky, 1984). Empirical research about the acceptability of complex versus simple urban road pricing scheme is so far lacking. Schlag and Schade (2000) found little difference between distance-based, congestion based and cordon pricing concerning acceptability. The Singapore experience with road pricing suggests that differentiated charges, and periodic well-advertised adjustments to them, are accepted as a sensible way to reduce peak period congestion and that the resulting variability in prices does not seem to have been a serious issue. However in a European context the German railway’s failed attempt to introduce a complex charging structure shows that if the public regard price differentiation as unfair they will object very strongly and that, against this background, any perceived complexity will be one of the targets of criticism. The case of Edinburgh illustrates how a misconception of scheme characteristics increases opposition (see below).

The design of a road pricing scheme also determines who is to which degree affected by the scheme. The acceptability of the scheme is in turn influenced by the degree to which people are affected. It is known that motorists are much less in favour of urban road pricing than non-motorists are. Also citizens living within the charged area are much more in favour than people living outside the charged area. Furthermore, people who need to travel inside the charged area e.g. for commuting are much less in favour (see the examples of cities below).

Rather unclear at the moment is the question how the benefits or road pricing schemes influence acceptability. The assumption is that once the scheme has been introduced the effectiveness of such a scheme becomes apparent to the citizens and changes their mind in a positive direction. However the exact nature of the relation between scheme benefits and acceptability is not known. The scheme benefits that will influence acceptability are the time savings and environmental improvements. However, it is uncertain that travel time reduction and environmental improvement are perceived by the public to be worthwhile enough to compensate for the charge (Giuliano, 1992; Harrington *et al.*, 2001). Jaensirisak *et al.* (2005) found that among the potential impacts of charging, an ability to

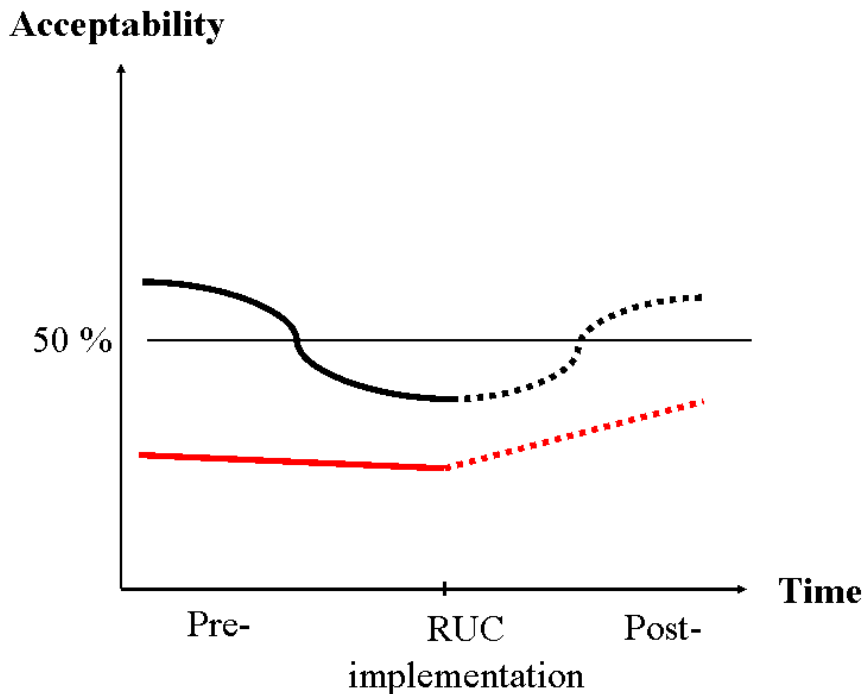
achieve substantial environmental improvements was the single most important contributor to increased acceptability, followed by contributions to reducing delayed time for cars.

### 10.3.1.4 Implementation Process and Acceptability

The report has so far discussed individual and system characteristics that affect the level of public acceptability. This might give the impression that acceptability is a static factor within the implementation process. However, acceptability is not static but highly dynamical throughout the pre-, the decision- and the post-implementation phase.

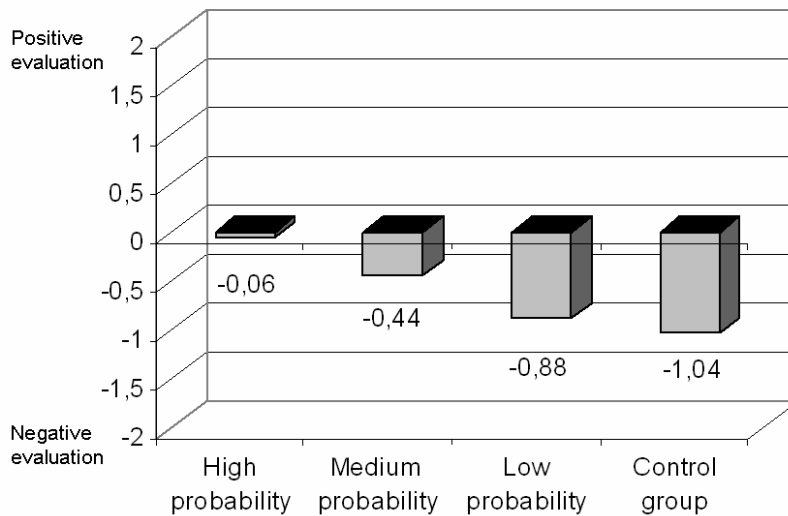
Figure 10-2 illustrates possible acceptability developments as observed in cities implementing urban road pricing. After initial support acceptability decreases the closer and more specific the proposal gets. In addition, the higher the initial ex-ante acceptability the stronger may be the decrease of positive attitudes in the course of the implementation process. After implementation support increases again. So far the reasons for these shifts are unclear.

**Figure 10-2 Possible developments of attitudes towards road pricing**



Source: Schade, Seidel and Schlag (2004)

One of the assumptions is that once a road pricing scheme has been introduced the effectiveness of such a scheme becomes apparent to the citizens and changes their mind in a positive direction. Schade and Baum (2007) have challenged this assumption. They show that persons with a strong convictions that road pricing will be introduced indeed developed more positive attitudes than persons who were less convinced of an early introduction (see Figure 10-3). However, the authors explain the results on the basis of the theory of cognitive dissonance (Festinger, 1957) which predicts that people increase the attractiveness of an unavoidable event in order to maintain a consistent cognitive belief system. They conclude that the positive effects of road pricing scheme benefits after implementation might be overestimated.



**Figure 10-3 Impact of perceived likelihood of road pricing implementation on road pricing acceptability (mean values).**

Experiences gleaned from countries that have implemented road pricing measures are discussed in the appendix to this chapter.

### 10.3.2 Political Acceptability

The opinion of local politicians and their subsequent actions are of utmost importance for the successful implementation of urban road pricing schemes. This is one common experience of all cities implementing or attempting to implement urban road pricing. They directly or indirectly determine whether or not the pricing scheme will be introduced as well as the speed of the policy implementation process (Schade *et al.*, 2004).

Politicians obviously can influence the implementation process in two different ways. First, they may prevent consciously and actively the implementation of the scheme. Second, they may avoid a clear commitment to the scheme, especially if they are not sure about the outcome of the political process. But a lacking strong political commitment acts as benchmark for other stakeholder. Their attitude may become more negative as well. This also contributed to a slower or even stopped introduction.

In this situation a political champion or figurehead, who takes ownership of the congestion charging concept clearly facilitate the implementation process. However, unlike the officials involved in the preparation of any scheme, politicians depend on re-election, and the fear of losing elections by promoting road user charging holds many politicians back. Even where there is strong enough political support to go ahead with charging plans, politicians can easily be disheartened if they find that public support is eroding in the run-up to the scheme introduction (PROGRESS, 2004).

One way of divorcing the road pricing issue from elections is to hold a referendum. It should be noted, though, that a referendum just before the last steps of the scheme introduction is very likely to hit the lowest level of support, and therefore runs the greatest risk of failure. An alternative to an early referendum is the Stockholm approach: here the referendum is to be held around one year after a congestion charging scheme will have been implemented “on a trial basis”. Whilst this approach carries a large financial risk, it provides the best chances for the referendum to be won, since has been shown that public support for a charging scheme increases again once it is up and running and people start to feel its benefits. In that respect the public opinion is the most important source of information for the

politicians in the implementation process. Thus, presenting not only the benefits of the scheme to the politicians, but also pointing out where the public agrees with the road pricing scheme may increase political acceptability considerably.

Furthermore the factors influencing political acceptability are somehow similar to those that have been found to be important for public acceptability. Examples are problem perception, fairness and revenue allocation. Thus results concerning the public may be to some extent transferable to political acceptability as well. Further research is needed to enlighten the factors influencing political acceptability and the relations to public acceptability.

### 10.3.3 Business Acceptability

The business community is one stakeholder which opinion counts in the introduction process. This is due to the fact that they are important local taxpayers and politicians fear relocation of important business sectors. The attitude of the business community toward the road pricing schemes can be described as awaiting and sceptical up to a negative attitude and opposition towards the scheme. This appraisal is not dependent on the progress of the implementation process (Schade *et al.*, 2004).

Retailers that are located within the envisaged charging zone are generally among a scheme's most vociferous opponents. They fear the competition from retailers located outside the zone, and a resulting reduction in their customer numbers. Since it is clearly the purpose of most of the current and currently envisaged schemes to deter car traffic from entering the charged area, this fear is understandable, and can only be allayed if retailers can be convinced that the public transport alternatives offered to their current customers are good enough to provide viable alternatives to the car. Another mitigating measure for the potential loss of customers would be to invest some of the charging income on promotional measures for the charged area. Further to the fears about loss of customers, there are also concerns that those customers that still come have less money in their pockets to spend. Ways to meet this fear would be a parking policy that would reduce parking charges during the main shopping hours, the creation of additional spaces (although this may turn out to be counterproductive for congestion reduction) or the use of some of the road pricing revenue to allow a reduction of public transport fares. The final concern for retailers is that they may have to increase the prices of their goods to accommodate additional costs for deliveries, and thereby become less competitive than their out-of-town rivals. However, especially where there is only a daily charge rather than a charge per trip and delivery vehicles that come into the charged area several times during the charging period, they have much more to gain from reduced congestion than to lose from the charge they pay once per day. Moreover, the low level of charges foreseen currently by European cities, will only add very marginally to the cost of any goods for sale (PROGRESS, 2004).

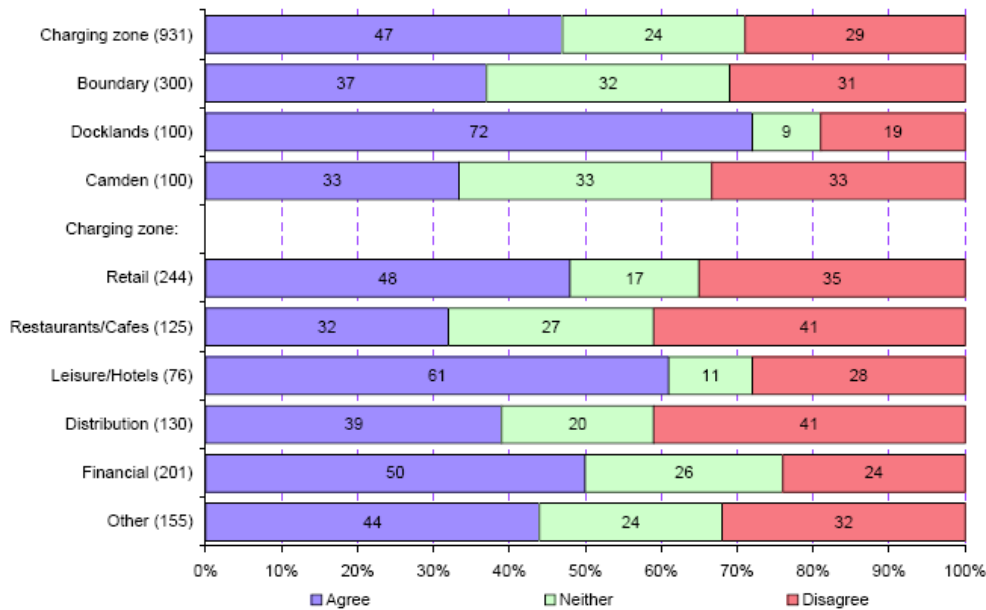
However, these expectations do not correspond with the experiences available in cities that have introduced successfully road pricing schemes. These cities have not reported considerable business relocation (Seidel *et al.*, 2004). For example, in its own study, the Trondheim Chamber of Commerce concluded that the 1991 toll ring hardly had any effect on trade at all. During the first months of 1992 there was evidence of some businesses located inside the toll ring losing trade, but from the summer of 1992 on, no distortion of competition due to the toll ring could be read out of the trade statistics. It was concluded that there was no distortion of trade competition due to the toll ring. Thus, the concerns about the negative effects prior to the implementation were not justified by the evaluation (Tretvik, 2003). Furthermore, Rome also experienced a shift in business attitudes after the implementation of the electronic access points at the Limited Traffic Zone. There has been a 5 % reduction of retailers perceiving the access control system negatively. In summary, there has been an increase in the percentage of respondents believing that the electronic access system has positively affected both air quality and the modal split (Schade *et al.*, 2004).

Consequently, business acceptability of the implemented road pricing schemes may also increase after the introduction, similar to the public opinion. For example in Stockholm between 2005 and 2006 there was a change in attitude towards the Stockholm Trial as a whole. The proportion of companies that were negative fell from about 65% to 45%. The proportion of those who were positive rose from about 20% to approximately 35%. The attitude to a permanent congestion tax changed in the same direction. The proportion of companies that were negative to a permanent congestion tax fell from about 65% to

50%, and the proportion of positive rose from about 20% to approximately 30% (City of Stockholm, 2006). That may imply that business representatives do not only judge a road pricing system on the basis of a pure rational cost-benefit analysis. Since the benefits of the road pricing system are often hypothetical and abstract prior to the introduction whereas the costs can be calculated in more detail, they may be weighted more than the benefits. The result would be a negative assessment of the road pricing scheme. A second possible explanation refers to the expectations of the business representatives. The perceived effectiveness is only one factor influencing the expectations. Other psychological variables may be relevant as well. Again there is more research needed to investigate the factors influencing business acceptability (Schade *et al.*, 2004).

On the other hand experiences from the Congestion charging scheme in London shows that business support for congestion charging continues to be relatively mixed. Businesses were, on the whole, more supportive of the scheme than opposed to it. A majority of businesses continue to support the scheme, provided that there is continued investment in public transport (see Figure 10-4). When analysed by sector, the leisure, financial and retail sectors were the most supportive of the scheme, whilst the distribution and restaurant sectors were the least positive. The increased level of support from the retail sector in 2005, compared to the previous year, is the most positive trend of all the sectors (TfL, 2005).

**Figure 10-4 Level of business acceptability of the London congestion charging scheme under the provision of investment in public transport**



Source: TfL(2006)

### 10.3.4 The Media and Acceptability

The media is an often overlooked factor in the policy implementation process. However, by choosing the topics and the way of presenting it, the media can influence not only the public opinion, but also the opinion of all relevant stakeholders considerably.

The main focus of the media in reporting about urban road pricing is the opinions and behaviour of the key actors. This issue also becomes more important the more advanced and detailed the plans for implementation are. Whereas it mostly reports facts such in the technology trials it already focuses more on opinions of the stakeholder in the pilot demonstrations. It furthermore, acts not only as an opinion reporter but also as an opinion former (see Ryley, 2006 for a demonstration of this effect for the failed Edinburgh congestion charging scheme). This is certainly more relevant in latter stages of the

implementation process where the key actors actively position themselves and try to exert influence in their favour (Schade *et al*, 2004).

Concerning the tonality of the media coverage it must be stated that the overall assessment of the road pricing scheme in the media has been negative at best neutral (see for example Gaber (2004) for an analysis of the London congestion charging reporting). Thus, the media will hardly be supportive in the implementation process. This result corresponds with general media research which has shown that especially the mass media focuses on aspects which can be presented in an emotional and thus empathetic way. Stories about people that are forced to change their travel behaviour and thus their daily life because of the scheme are far more suitable for this than abstract measurements of improved air quality for example. That might be also a reason, why the negative opinions are highly represented in the media.

Politicians and decision-makers have to take possible reactions of the media into account. In particular, they should avoid as much as possible everything which allows the media or opponents to negatively emotionalise the topic. This may mean, in some cases, that the policy measure has to be adjusted to prevent a negative media response. It may well be that this adjustment will lead to substantial departures from the “first best” policy.

#### **10.4 WHAT ARE THE POLICY IMPLICATIONS AND IMPLICATIONS FOR OTHER THEMES?**

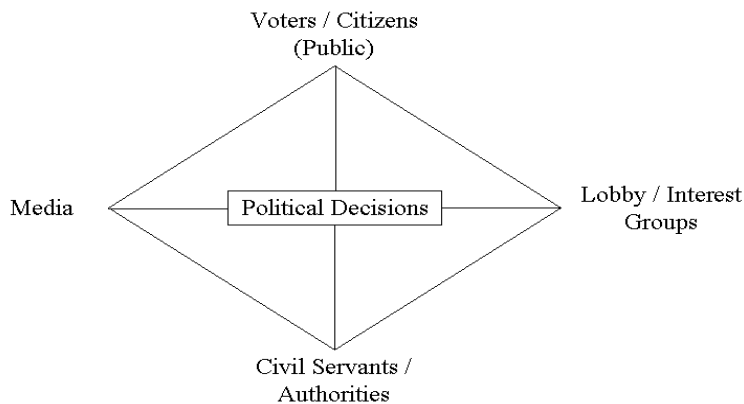
There are the following implications for other themes:

- Objectives: Acceptability of urban road pricing varies considerably with the stated objectives of the scheme. If road pricing is presented or discussed without any objective it faces strong rejection. But if the stated objectives of the pricing strategy meet main public concerns, the willingness to adopt urban road pricing increases considerably.
- Scheme Design: system characteristics, especially the hypothecation and the level of charge influence acceptability. The higher the charge the less acceptable they are. However, if it is combined with investments in public transport they become more acceptable.
- Technology: Privacy is no longer a major obstacle for acceptability. However, the technology needs to work and easy to use for the citizens. Any problems will be taken of by the media and subject to public discussion and in this sense may become an obstacle to the implementation
- Prediction: For equity considerations, models are needed which predict the impact of road pricing on individuals, and individual journeys, disaggregated by income, location, time of day and journey purpose; ideally those models should also identify impacts on special needs, such as disabled drivers and those carrying bulky loads; where scheme design includes exemptions and rebates, models should ideally be able to assess their impacts. It is recognised that the prediction of acceptability is also a major barrier.
- Appraisal: A scheme that may perform well in the appraisal which measures economic welfare/benefit may not be an acceptable scheme in the eyes of the public who have to bear the congestion charge.
- Economy: The scale and direction of impacts on the local economy are difficult to estimate, and will be further affected by perceptions of the impact of pricing, any complementary policy initiatives, the resulting image of the charged area, and its relationship with competing centres. This uncertainty is one of the main reasons for cities’ reluctance to introduce road pricing. It is certainly a reason for low business acceptability prior implementation. On the other hand lack of public acceptability may well have an adverse impact on the urban economy and in the long-term on residential choice.
- Equity: Distributional as well as procedural aspects of equity and fairness needs to be considered very carefully. Problems which are not an issue in the pre-implementation phase may become more critical the closer the introduction gets (e.g. privacy which relates to technology, reliability, trust)
- Transferability: The acceptability of road pricing may differ between locations for many reasons, including the level of familiarity with alternative transport pricing / travel demand management approaches, prevailing perceptions of transport problems, the history of local transport planning processes etc. But there seem to be similar patterns of response of the

various stakeholders in the process of implementing urban road pricing schemes which are independent from the individual city and its context.

### 10.5 WHAT THE RESEARCH GAPS AND PLANS FOR FUTURE RESEARCH?

It seems that there is now at least some reliable scientific consensus about the structure of acceptability. Likewise there is agreement about the groups of actors that play a key role in the transport policy process. **Figure 10-5** illustrates the main groups within the implementation process of urban road pricing. That is first the politicians and decision makers, that implement the policy, second the affected citizens, third lobby and interest groups that try to influence the policy and implementation process in favour of their clients' needs and finally the media which inform as well as influence the implementation process.



**Figure 10-5 Key actors in the implementation of urban road pricing**

However, the same does not hold true for the relationships between these key actors and its impact on their acceptability and how these relationships and acceptability may change over time, for instance by coalition forming. The dynamics of acceptability is certainly an issue that needs further attention. The experiences in cities show a certain degree of changeableness of acceptability. In the future it needs to be determined what the causes of these changes are and how it can be utilised in favour of the implantation process.

Stockholm and Edinburgh are the first two cities (see the appendix) that have used referenda as a form of public participation with mixed success. Public participation can be one way of increasing public acceptability and the credibility of the implementation process. However there is a lack of knowledge under which circumstances could public referendum be a promising way to introduce urban road pricing. And if a referendum does not hold its promise, how could it be implemented even against the majority of voters and car drivers?

## 11 TRANSFERABILITY

### 11.1 INTRODUCTION

Transferability may be defined as covering all issues related to how evidence gained about the performance of road pricing systems in one situation may be applied to others. It should be defined to incorporate evidence from both real and synthesised implementations and to include the full range of themes that are considered important in assessing the success of schemes.

Transferability of experience from one city to another will be affected by a wide range of factors, including city size, density and transport supply and demand; cultural impacts on user response and acceptability; the detailed design of the scheme, any complementary policies and the ways in which revenues are used; and, fundamentally, the objectives of a given scheme. It is difficult enough to assess how the performance of a given type of scheme, designed to meet a given set of objectives, will transfer to another city with the same objectives. It is altogether more difficult to assess transferability where the two cities have differing objectives.

### 11.2 WHAT IS THE IMPORTANCE OF THE THEME?

Transferability is extremely important for advancing knowledge about the potential of road pricing schemes for achieving their objectives in alternative situations. An urban road pricing policy is very unlikely to be formulated in isolation of activities elsewhere and the processes of setting objectives, designing measures, predicting their impacts and winning acceptance are all likely to be affected by perceptions of experience gained in other cities.

For example, much of the current impetus for cities to consider pricing may relate to the perceived success of the London Congestion Charging scheme and ongoing events in Stockholm may further inspire Europe's urban transport planners.

It is, therefore, essential that we understand which aspects of implemented or synthesised schemes may be expected to be repeated in other locations and which may not. We also need to understand which variables are likely to be important in determining the extent to which evidence can be transferred between situations.

In the findings of the User Needs Assessment Questionnaire, transferability was considered to be the least important of the nine themes presented to respondents from 21 cities. This may appear to conflict with the statements made above about the importance of the theme. However, it may also be the case that it is simply a reflection of the perspective of policy-makers and planners from individual cities, who are primarily focussed on their local situation rather than on the wider picture. In that case, transferability may be perceived as a more remote "high level" theme, while many key transferability issues may be assumed to be part of other themes that are closer to hand. For example, the accuracy of model predictions may be critically dependent on relationships that are being driven by parameters derived from other situations, rather than from specific local data. Thus, the transferability theme may naturally be seen as more important by academics and higher level planners, responsible for advising cities on transport policy issues, than by the city planners themselves.

### 11.3 WHAT IS KNOWN ABOUT THE THEME?

#### 11.3.1 How is Transferability defined?

In general academic literature, a distinction tends to be drawn between the concepts of *generalisability* and that of *transferability*. *Generalisability* is normally defined as the extent to which data obtained from a particular population, under unique study conditions, at a particular point in time and space can be applied more widely to other populations, conditions, times and spaces. So, in the case of road pricing, assuming that the results of a limited trial provides data that can be used to predict impacts

elsewhere, be it expanding the trial to the full city / region or to another country would be classed as generalisation. *Transferability* is normally seen as a subset of generalisability, which applies to more specific occasions where we may be attempting to generalise research results to a context in which they were not studied. This is most commonly found in the desire to generalise results from one location to another (e.g. between cities and countries), but it could potentially apply to any critical dimension that limits the meaning of research findings. The main point is that transferability analysis focuses on identifying contextual differences and understanding / dealing with their impacts.

### 11.3.2 What Approaches to Transferability have been adopted in previous studies?

Transferability has regularly been addressed as a theme within individual transport research projects and has sometimes been a significant focus of the work undertaken. However, there have also been research projects which have investigated the potential for implementing road pricing schemes that have not considered transferability in any significant or formal manner. Therefore, experience in this area is somewhat variable.

The most significant work on transferability within transport policy may be that carried out by the TRANSPLUS project, which built on work carried out by Rose (2001) to produce a series of guidelines for how cities might best learn from previous experience. The concept of transferability was subdivided into three typologies:

- *territorial transfers*, described as “horizontal” and covering the full range of situations where experience may be transferred between different locations
- *transfers between institutions at different levels*, described as “vertical” and covering issues relating to the scaling up or scaling down of policies
- *transplanting of institutions and related competence instruments*, covering situations where changes of institutional structures may be required

While the first of these areas may be the one most commonly associated in relation to road pricing schemes, the role of institutions and institutional structures in the successful implementation of urban road pricing has been seen as important (Milne et al, 2001).

The practical consideration of transferability within the TRANSPLUS project focuses primarily on mechanisms for fostering the transfer of desirable innovations, so turning transferability into an explicit objective of transport policy rather than a technical feature to be studied and understood. It identifies four levels of activity in the transfer of innovations from one location to another: collaboration, networking, dissemination and osmosis. This appears to assume implicitly that territorial transfers dominate and underlie most institutional issues. It proposes knowledge sharing through mechanisms such as benchmarking as potential approaches for increasing the transfer of desirable innovations.

The DANTE project, which was primarily based on interviews with decision makers and implementers in nine case study cities, considered transferability as part of assessing the potential for implementing travel reduction strategies. Most of this work involved identifying and categorising barriers and considering the extent to which they could be overcome. Five explicit categories of barriers were defined:

- resource barriers
- institutional / policy barriers
- social / cultural barriers
- legal barriers
- side effects

Pricing and taxation measures were considered to have the greatest probability of barriers occurring but, interestingly, one of the lowest levels of seriousness in terms of issues that may not be possible to overcome. In contrast, barriers to land use planning measures, which were also considered to have a high probability of occurring, were considered the most difficult to overcome. The approach to transferability involved simply creating a checklist to help identify the most appropriate choice of

measures and to assess the barriers that may arise. As for TRANSPLUS, transferability is seen from the viewpoint of being a high level policy objective, rather than an outcome.

In the UK, The Commission for Integrated Transport commissioned a report focussing on transferability issues in European best practice, affecting the delivery of integrated transport (W S Atkins, 2001). However, this comprises little more than a very general consideration of barriers and an assessment of the extent to which they may prevent certain perceived transport policy success stories being repeated in the UK.

Most of the key research studies about urban road pricing to date (eg TRANSPRICE, CUPID / PROGRESS, EUROPRICE) have provided little more than an informal commentary on transferability issues. Consistent with the above discussion of the importance of the theme, studies that have been centred on cities have tended to focus very much on their individual perspectives and have been much weaker on generalisation issues. However, some more academic studies (eg IMPRINT-EUROPE) have given explicit consideration to barriers, which suggests that they may have considered transferability issues implicitly when comparing different locations / contexts.

An exception here is the SPECTRUM project, within which transferability was a significant theme. This work, drawing upon Richard Rose and TRANSPLUS, emphasized the nature of transferability as a learning process. In particular, it distinguished between two approaches to studying transferability:

- an *ex-ante* or *prospective* assessment of transferability, which attempts to anticipate under what circumstances, and to what extent, a programme or policy that “works there” will also “work here” (Timms et al, 2005)
- an *ex-post* or *retrospective* assessment of transferability, involving an historical account of how policies were identified in exporter jurisdictions as worthy of emulation, and how they were applied in importer jurisdictions (Timms et al, 2005)

While it may be inevitable that current studies about urban road pricing schemes will tend to focus on the *ex-ante* perspective, due to the general lack of operating schemes and the future-orientated nature of such projects, the *ex-post* approach should not be forgotten and may provide valuable insights as opportunities emerge.

The analysis of urban transferability issues in SPECTRUM was undertaken by comparing predictive case studies carried out during the project with results from CUPID / PROGRESS, via construction of a *logical framework*, that attempts to encapsulate the features of instruments tested and the characteristics of cities. However, in practice, the scope of the exercise was quite limited. While it is encouraging to note that the results from SPECTRUM tend to be consistent with the recommendations from the PROGRESS cities, the analysis is ultimately rather vague and unable to lead to many powerful conclusions.

A review of the related METEOR project will be included in the next edition of this State of the Art Report.

### 11.3.3 What Evidence Exists About Transferability from Real Urban Road Pricing Applications?

Beyond the environment of research projects, a number of common observations have been made about the transferability of evidence from real urban road pricing applications. In summary:

- **Singapore:** It is widely understood that the city-state and island geography of Singapore has made adopting road pricing much simpler than in other locations, where competition from alternative cities may be a significant factor. In addition, the unique cultural setting is regularly cited as having reduced resistance compared to what might be expected in Europe.
- **Norwegian Toll Rings:** The longstanding history of toll payments for using transport infrastructure in Norway is widely considered to have helped achieve acceptance for the principle of urban toll rings. In addition, the sole objective of raising revenue for transport infrastructure projects has allowed policy-makers to sidestep many of the controversial issues relating to demand management and justify the tolls on the basis of new infrastructure that

travellers benefit from. So, acceptability experience may not be so easily transferable, although the Norwegian cities face a unique acceptability problem once the infrastructure funding justification for pricing runs out!

- **London:** It is generally accepted in the UK that London's size, the scale of its public transport network and the very high proportion of journeys to central London by rail (around 70% prior to the implementation of congestion charging) make it atypical. On the one hand congestion is seen to be more serious there, making the case for charging stronger. On the other, it was much easier to accommodate the diverted journeys on bus and rail services. The dominance of central London's economy will also have diluted the threat to economic activity (May, 2006).
- **Durham:** At the other end of the spectrum, the single road scheme in Durham is also atypical, though there is some interest in replicating it in rural tourist attractions (May, 2006).

#### 11.4 WHAT ARE THE POLICY IMPLICATIONS AND IMPLICATIONS FOR OTHER THEMES?

In a recent paper reviewing policy insights from urban road pricing case studies, de Palma *et al* (2005) raised the following points that will limit the transferability of experience of road user charging:

Since charging is meant to deal with the externalities of transport, the physical impacts of externalities themselves depend on location specific factors such as geography, weather etc. Willingness to pay to reduce externalities is a function of socio-demographic characteristics. This implies congestion cost and the optimal level required to internalise them vary widely across urban areas.

It is also noted that the effectiveness of road pricing schemes and their optimal network designs are sensitive to the topology of the network (May and Milne, 2004).

Effective and acceptable schemes can only be developed by conducting detailed research on local population. This has important implications for acceptability of pricing schemes.

Success at implementing road pricing does not imply success in implementing it elsewhere, even within the same country. This is particularly evident comparing the London implementation vis-à-vis Edinburgh's failure to implement a scheme. This issue is highlighted by the fact that some of the key design elements, including the use of ANPR technology and revenue earmarking, were similar in both cities.

- The concept of transferability may be seen to cut horizontally across the other themes being considered in CURACAO, having potential implications for all of them:
- objectives: transferability issues will be important in determining the extent to which objectives of road pricing may be met in different situations; the objectives set for schemes may also differ between situations, which may have knock-on effects for other themes (e.g. scheme design and acceptability), impacting significantly on how evidence from schemes may transfer; as identified in the TRANSPLUS project, increasing transferability may potentially be seen as an explicit high level transport policy objective
- scheme design: the most appropriate scheme design may be expected to vary between situations due to transferability issues (an example may be the effects that network topology may have on determining the best locations for charging); in addition, the finer details of a scheme may be expected to have significant impacts on its performance, meaning that understanding the impacts of those details may be critical for assessing the success with which it may be transferred to other locations
- technology: the most appropriate road pricing technology to adopt in different situations may vary for many reasons, including the prevailing technological base, local geography, legal and institutional issues, variations in politics and culture etc
- prediction: transferability and prediction are inextricably linked, because the basis of the transferability theme is the need to assess the extent to which evidence gained in one situation can be used to predict what may happen in another; for example, the accuracy of

model predictions of the performance of road pricing schemes may be critically dependent on the transferability of traveller response information obtained for different schemes and / or in different cities; even where most model parameters are based on local data, it is still likely that some of the higher level conceptual features of any modelling framework may be based on (and potentially constrained by) expectations related to other previous situations

- economy: impacts on the economy may not always transfer easily between different situations, because they may be critically dependent on local issues, some of which may be difficult to measure; in particular, the economic impacts of road pricing on the charged area may depend on issues such as prevailing economic strength, the extent of competition from other locations, the impacts of planning processes on relocation decisions etc
- equity: perceptions of equity may differ between cities, regions and countries based on demographic comparisons and/or political cultures, meaning that the basis for assessing equity implications of road pricing schemes may vary by situation and may not always transfer easily
- acceptability: the acceptability of road pricing may differ between locations for many reasons, including the level of familiarity with alternative transport pricing / travel demand management approaches, prevailing perceptions of transport problems, the history of local transport planning processes (including previous occasions where road pricing may have been considered), issues of political trust etc

## **11.5 WHAT THE RESEARCH GAPS AND PLANS FOR FUTURE RESEARCH?**

The transferability of road pricing schemes is an area that has generally been under-researched, at least partly due to the limited opportunities that have existed previously to compare expectations with actual outcomes. The range of work covered in this note suggests that most considerations of transferability issues to date have been very informal, lacking both scope and structure. The exception is the emerging area of work from Rose and TRANSPLUS that has been taken a little further within SPECTRUM.

The challenge for CURACAO will be to build on a fairly small volume of previous work, most of which has been of limited scope, to try to produce a more formal and rigorous analysis of transferability issues.

The approach adopted should cover transferability of both predicted and actual outcomes of road pricing systems. It also seems likely that a simple methodology which focuses on issues that are likely to be appreciated as useful by end users will prove best.

Following on from the review work of the SPECTRUM project, it would perhaps be interesting to adopt an ex-post assessment of how experience gained in London may have transferred to Stockholm and how it may be impacting upon other cities considering road pricing schemes.

## 12 CONCLUSIONS

### 12.1 OUTLINE

This concluding section draws together conclusions under four headings:

1. findings from past research, which appear to be reasonably stable, and thus can be relied upon by end users
2. policy implications from these conclusions
3. issues which need further work for the next edition of the State of the Art Report
4. issues on which further research is needed.

It should be stressed that the first of these is not intended to be comprehensive, but simply to highlight the key messages. Readers are referred to the relevant chapters for additional information. Equally it should be stressed that it is not the intention that CURACAO itself carries out the research identified in the final section; the project is not funded to conduct new research. Instead this final section serves as guidance to those commissioning or conducting research into road pricing.

### 12.2 PRINCIPAL FINDINGS

It appears that the nine objectives identified in Figures 2-2 and 2-3 reflect the full range of objectives for which road pricing is likely to be pursued by cities, but that the objectives of efficiency, environment and revenue generation remain the dominant objectives.

Road pricing can be implemented in a number of ways, using point charges, cordons, area-pricing or distance-based pricing. There is increasing evidence that distance-based pricing is the most efficient, but it relies on technology which is still being developed. In the meantime, cities will need to rely on cordon and area-based schemes. Selecting the correct boundaries for these is critical to their success.

Road pricing will be more effective if integrated with policies to promote public transport, to reallocate road space and to manage land use. These measures are also likely to reduce the adverse impacts of road pricing on those travellers who are most disadvantaged by it. However, the best combination of these policy instruments will depend critically on the city context in which they are being applied.

There is now increasing experience of methods for predicting the impacts of road pricing schemes. However, the complexities of road pricing make conventional prediction methods less reliable. Moreover the lack of empirical evidence means that the elasticities to be used in those models remain uncertain.

Appraisal of road pricing proposals and evaluation of implemented schemes should reflect the full range of objectives listed in Figures 2-2 and 2-3. There have been recent valuable developments in appraisal methodology, as outlined in Appendix B. The empirical evidence from London and Stockholm summarised in Chapter 6 is of considerable value to other cities, and reflects good practice in the conduct of such evaluations.

While the evidence remains limited, it is increasingly clear that the impacts of road pricing on the urban economy are likely to be small and, in particular, much smaller than the business community predicts.

The assessment of equity implications relies on the clear identification of the relevant impact groups, and on assessment of the extent to which each is likely to be affected. Good practice on the listing of such groups is now available. However, for many such groups the prediction of impacts remains uncertain. This is an area in which empirical evidence is still needed.

Acceptability remains the principal concern of cities considering road pricing. Acceptability is mainly based on personal outcome expectations, which are typically negative. The roles of complementary policy instruments and of the use of road pricing revenue are critical to increasing acceptability. However, acceptability can also be influenced by pro-social values, and appeals to concerns over the environment or social justice may help to increase acceptability. There is increasing evidence that

levels of acceptability are highly dynamic, and in particular are likely to decline as the proposal becomes more concrete and more imminent.

### **12.3 POLICY IMPLICATIONS**

While it will be for individual cities to determine their own objectives for road pricing, it is essential that these objectives are made clear at the outset and consistently adhered to. There is a case for keeping the list of objectives short and simple, while not omitting objectives which will help foster support for the policy.

Road pricing design should follow a logical sequence, in which the overall strategy is determined first, and the role of road pricing determined as part of that strategy. This will help demonstrate that road pricing is needed, and also help to identify those complementary policy instruments which are needed to support it. Road pricing should then be designed in the context of those complementary policies. It is at this stage that it is appropriate to consider the type of road pricing regime to be adopted and the location and level of charges. There is a strong case for keeping that design as simple as possible, but the important role of exemptions and discounts in increasing acceptability should not be overlooked.

The performance of road pricing schemes will depend critically on the behavioural responses induced. It is important to identify the full range of both first and second order responses, and to understand their likely levels. In particular, motorists can be expected to change mode, route, destination, timing and number of journeys, but so too can those who use bus and rail or walk or cycle. Similar types of response can be expected from freight operators and drivers. Second order effects will include changes in the location of economic activity, homes and jobs, either directly in response to road pricing or, more probably, as part of the gradual process of change in individual, household and firm activity. More empirical evidence is needed on all of these responses, and particularly the second order ones.

Acceptability can be enhanced by demonstrating that there is a serious problem to be overcome, that a measure as dramatic as road pricing is needed, and that it is likely to work. However, it is also essential that the impacts, both positive and negative, on individuals and on society are clearly identified and effectively communicated. Understanding of the concerns of the public, pressure groups, politicians and the media is essential, and needs to be achieved through a continuing two-way dialogue. In particular, it will be important to discourage politicians from overestimating the concerns of the public.

The use made of road pricing revenues is critical to determining the acceptability and effectiveness of the scheme. Most charged drivers will initially be made worse off by road pricing, and it is only when the revenues have been channelled into transport (or other) improvements that they begin to appreciate the personal benefits. It is thus particularly important that the costs of operating road pricing schemes are kept as low as possible. It is also essential that the surplus revenues are available to the city authorities to use in support of their overall strategy.

There is potentially a conflict between pursuit of acceptability, through lower charges and increased use of discounts, and pursuit of effectiveness, which may require higher charges and fewer exemptions. More work is needed on this issue.

While decisions on implementing road pricing will usually be taken by cities, national governments have a responsibility to develop a clear national transport strategy, to explain it clearly and consistently, to indicate who is likely to gain and lose from that strategy, and to take steps to compensate those who are likely to lose. Moreover, they need to provide the governance which enables city authorities to implement both road pricing and the policy instruments which will complement it, and to stimulate strong political leadership at local levels.

### **12.4 FURTHER WORK**

In the order in which they arise in this Report, the next edition of the State of the Art Report should expand on:

1. approaches to the design of overall strategies and of road pricing within such strategies

2. specific tools for the design of road pricing schemes
3. the technologies available, at the level of detail needed by end use cities
4. the implications of design and technology for enforcement and for equity
5. prediction methods, and the strengths and weaknesses of those currently available
6. appraisal methods and in particular ways of appraising second order effects
7. the chapter on environmental impacts (subject to ensuring that sufficient resources can be diverted to covering this theme)
8. evidence on equity impacts for different impact groups
9. the interaction between acceptability and equity
10. the interaction between acceptability and effectiveness.

## **12.5 FURTHER RESEARCH**

The following areas merit further research:

1. methods for the design of road pricing schemes
2. prediction methods, covering the issues listed in Section 5.6
3. understanding of behaviour, and particularly second order responses and the behaviour of users of other modes
4. the resulting impacts on the urban economy, and the separation of these from secular changes in economic performance
5. the effects of road pricing on different impact groups
6. the dynamics of acceptability over time and the particular role of referenda in testing and promoting acceptability
7. the overall question of the extent to which results in one city can be transferred to another.

## APPENDIX A: DESIGNING CORDONS

### A-1 MOTIVATION

As a result of interest in the development of integrated transport strategies where policy instruments are combined to complement each other and to achieve improved performance against a set of policy objectives, May *et al* (2005) applied an optimisation procedure to identify optimal strategies for packages of urban transport improvements to achieve various policy objectives. One of the conclusions of this study was that well performing strategies for a given set of European cities tended to include peak period cordon charges to enter the city centre. These cordon charges charge traffic for crossing the boundary into the charged area and this boundary serves to separate the charging area from the rest of the network.

The performance of any road pricing cordon or boundary will be affected by the combined effects of a reduction in traffic entering the area and an increase in traffic bypassing it. While congestion will be reduced within the area, it might well be aggravated outside it. Since these conflicting impacts will depend on both the topology of the road network and the pattern of demand for its use, it is difficult to offer general advice on cordon location. All that is known is that the benefits of road pricing, usually measured in terms of welfare economic impacts, are critically dependent on the choice of cordon (May *et al*, 2002).

Yet it has been observed that there has actually been very little technical advice on the best location for such boundaries. Most designs are based on a mix of professional and political judgment, with little or no assessment of whether alternative locations would be more effective.

### A-2 A GENETIC ALGORITHM BASED APPROACH

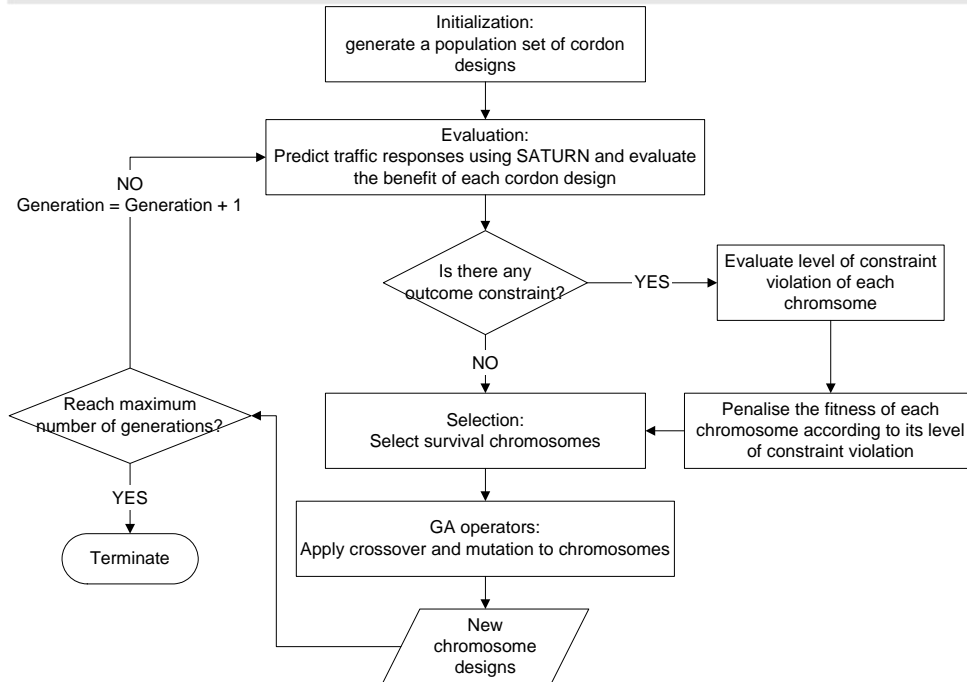
This section presents a computational method based on the concept of Genetic Algorithms (GA) for directly optimising the charging cordon design so as to maximise the scheme benefits. It summarises the method, named GA-AS, as developed in Sumalee (2004a).

The problem of cordon design is very complex, since it involves an interaction between the scheme design by the planner and the possible responses of travellers. The problem can be categorised as a Mathematical Program with Equilibrium Constraint (MPEC), which is one of the most challenging optimisation problems. In addition, the topological requirement for the charged links to form a closed cordon imposes further complexity. This combination precludes the application of a conventional gradient-based optimisation algorithm.

Instead, the concept of Genetic Algorithms (GA) has been adopted. The basic idea of the GA approach is to code the decision variables of the problem as a finite string, called a 'chromosome', and calculate the fitness (objective function value) of each string. Chromosomes with a high fitness level have a higher probability of survival. The surviving chromosomes then reproduce and form the chromosomes for the next generation through the 'crossover' and 'mutation' operators. The flowchart of the GAAS is shown in Figure A-1 below.

In this framework, the travellers' responses to the scheme have been calculated by SATURN (Van Vliet 1982), which is a steady-state equilibrium assignment model that predicts route choice and traffic flows on a road network, based on the generalised costs of travel, and takes account of delays due to capacity constraints. The output from SATURN gives the equilibrium flows, which can then be used to evaluate the performance of different scheme designs. The GA will act as a planner in this framework to improve the scheme designs so as to maximise a given objective.

For the optimal cordon problem, each chromosome in GA represents a uniform charge level for a specific charging cordon. Thus, to apply GA to the charging cordon design problem, we need to develop a chromosome scheme which represents a closed cordon and preserves its formation, even after the genetic operators (i.e. mutation and crossover) are applied.



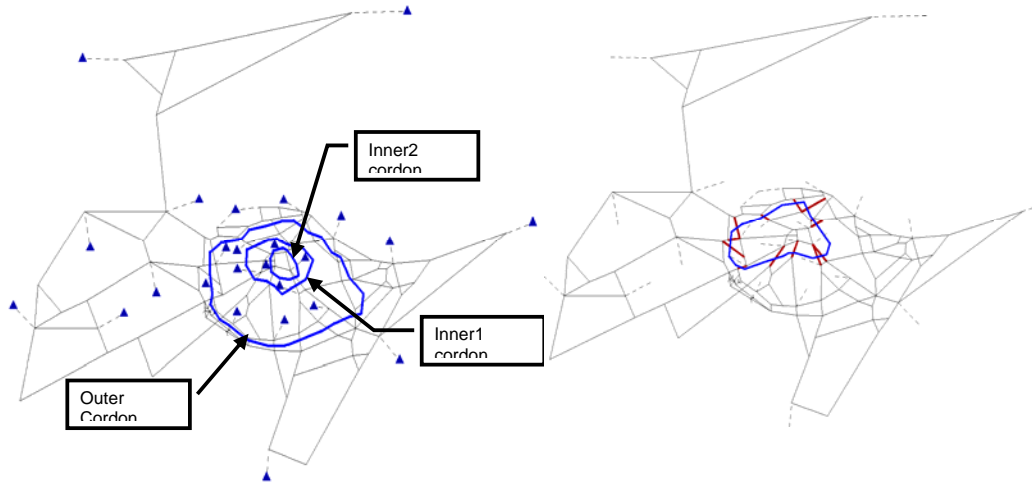
**Figure A-1 Flow Chart of GA-AS**  
 (Source Sumalee *et al* (2005))

Based on Sumalee (2004a), the concept of a “branch-tree” was used to encode a closed cordon into a chromosome format. The “branch-tree” is simply a mathematical representation of the links which form a closed cordon. The crossover operation is defined as an exchange between a valid pair of sub-branches from mated chromosomes which will automatically ensure the formation of a charging cordon for the new chromosome. The mutation is based on the branching in and branching out operations as applied to a branch-tree to reduce or widen the coverage of a particular part of that cordon.

The detail of the branch-tree structure and its associated crossover and mutation operators can be found in Sumalee (2004 a,b). This algorithm is also able to optimise the location of a double cordon scheme.

GA-AS can be extended to deal with outcome constraints (e.g. minimum desired revenue level or minimum reduction in total travel time) on the optimal cordon design problem. The mechanism used to handle the constraints is via a penalty function method which is a commonly used method to handle constraints in evolutionary computation methods. Thus the algorithm generates potential solutions without considering the constraints and then penalises those violating the constraints by decreasing the fitness of the chromosomes thereby reducing its chance of survival in the next generation (analogous to the survival of the fittest concept in Darwinian evolution theory). In this way, a constrained problem is transformed to an unconstrained problem by associating a scalar penalty with all constraint violations.

GA-AS was applied to a typical European city (Sumalee 2004a,b). In that study, where the objective was to maximise economic welfare, the benefits of the three judgemental cordons (Figure A-2) was compared with the optimal single cordon found by the GA-AS (Figure A-3).



**Figure A-2 Network with three Judgemental Cordons**      **Figure A-3 Location of the Optimal Cordon OPC**

Table A-1 summarises the benefits found. Benefits are computed net of operating cost of toll points (assuming £100 per toll point per peak hour of operation). Figure A-3 shows the optimal single charging cordon (named OPC) found by the GA-AS procedure. OPC is larger than the judgmental cordons and extends further to the west where congestion is more serious. The net benefit generated by OPC is £7.21k per peak hour which is 80% higher than the benefit produced by the Inner2 cordon and over three times the benefit of the other two judgmental cordons. This result clearly indicates the potential loss of scheme benefit by relying on professional judgment.

**Table A-1 Comparison of the performance of different charging regimes for the test network**

Charging regime	Optimal toll	No. of toll points	Gross welfare (£k/hour)	Social benefit (£k/hour)	Net welfare (£k/hour)	Social benefit (£k/hour)	% of benefit compared to OPC
Inner1 cordon	£0.50	9	3.00	3.00	2.10	3.00	-71%
Inner2 cordon	£0.75	7	4.69	4.69	3.99	4.69	-45%
Outer cordon	£0.75	20	3.96	3.96	1.96	3.96	-73%
OPC	£1.50	13	8.51	8.51	7.21	8.51	-
D-OPC	£1.25	38	19.08	19.08	15.28	19.08	+112%



**Figure A-4 Location of the Optimal Double Cordons (D-OPC)**

GA-AS was used in the fourth test to find an optimal double-cordon scheme (D-OPC) (Figure A-4). The benefit generated by D-OPC is £15.28k per peak hour which is more than double of the benefit from the OPC.

### A-3 A “SHORT CUT” APPROACH

While the Genetic Algorithm approach described above has been shown to be capable of generating significantly improved cordon designs, it is analytically complex, and has yet to be tested on the road networks of other cities or with other models. The UK Department for Transport was interested in providing guidance to local authorities on road pricing design (DfT, 2006), and commissioned work on a short cut method which could be applied more rapidly on a wider range of network models. The aim of the short-cut approach was to improve on the judgmental designs by using some theoretical modelling whilst reducing the number of simulations required by the GA based approach. As such it was not designed to find an optimal closed cordon design but it was expected to improve performance over the judgmental approach.

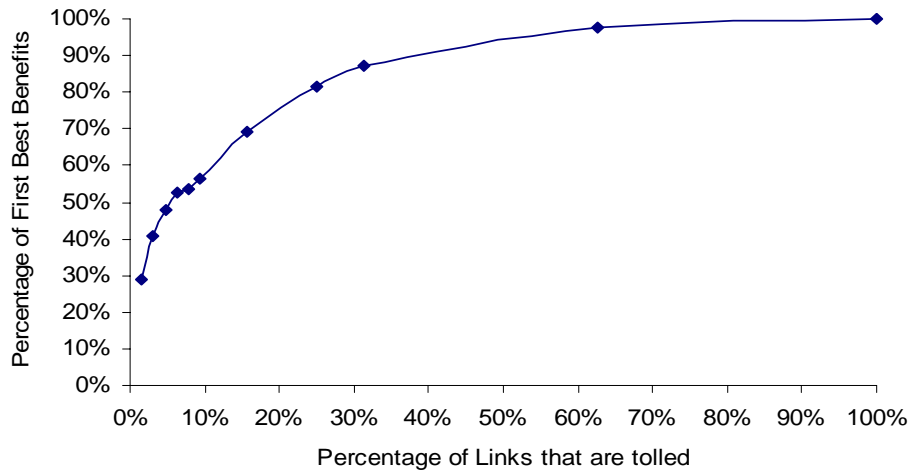
Previous work on the GA approach had included as a benchmark the system optimal or “first best” solution whereby all links were tolled to give the system optimal or maximum welfare gain (Sheffi, 1985). The top-15 links are links that have the highest marginal cost as calculated via the “first best” system.

**Table A-2 Relative performance of OPC and SLA cordons**

Cordon	Optimal toll	Cost of operation per peak hour (£k)	Gross total benefit per peak hour (£k)	% of gross total benefit compared to first-best	Net benefit per peak hour (£k)	Flow crossing top 15 links	Proportion of total flow on top 15 links	Proportion of top 15 gross benefits
Top 15 links	Varied	1.50	19.46	52.3%	17.96	66759	100%	100%
OPC	£1.50	1.30	8.51	22.9%	7.21	34389	51.5%	43.7%
SLA-single	£0.75	1.60	7.94	21.3%	6.34	51278	76.7%	40.8%
First-best condition	NA	35.00 <sup>□</sup>	37.19	100.0%	2.19 <sup>□</sup>	ALL	100%	N/A

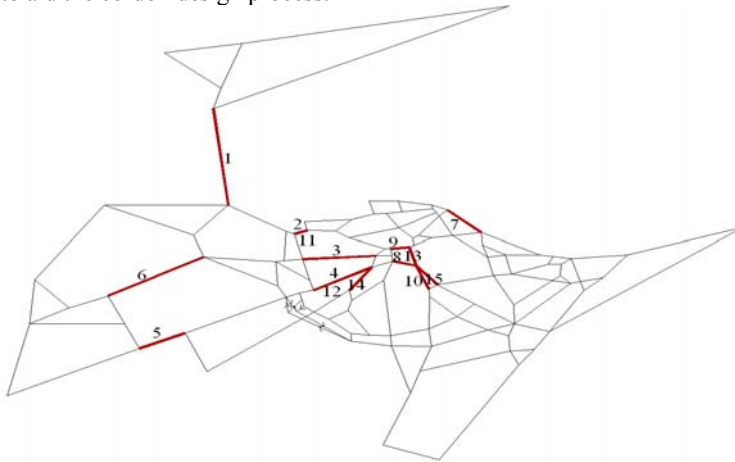
\* notional figures based on 350 links being charged

Further investigations showed that the percentage of first best benefits achieved versus the number of links tolled at the system optimal level (added in order of decreasing charges) formed a curve as shown in Figure A-5. Similar curves were also found for networks of other British cities which have many more links and many more origin-destination pairs than the test network shown here. These curves proved useful in defining how many links (the top X links) should be used in the design process. The number of links used should be manageable whilst still achieving a significant proportion of the first best benefits. In general less than 10% of the links are required to achieve around 60-70% of the first best benefits.



**Figure A-5 Percentage of first best benefits versus percentage of links tolled**

As these limited point charges on the highest charged links from the system optimum could outperform the closed cordons it was thought that using these links may prove beneficial in designing a new closed cordon. Figure A-6 shows the position of these top 15 “highest tolled” links for the test network. As can be imagined it would be difficult to find a closed cordon which is not unduly complex which passes through all these links. However, it was realised that it was not essential to include the top links in the cordon; instead the cordon charge should be imposed on the principal path flows through these high cost links. The higher the proportion of high cost flows covered by the cordon the higher the potential benefits of that cordon location. This led to the idea of using a select link analysis to aid the cordon design process.



**Figure A-6 Location of Top 15 with the Highest Marginal Cost (Numbered in Rank Order)**

Select link analysis (SLA) is available in many commercial traffic assignment packages such as EMME/2 or TRANPLAN and is an easy to use option within SATURN. Basically select link analysis shows the paths used by all flows through a set of links. First a select link analysis is performed for the top X links (in this case 15 as shown in Figure A-7). Next the path information is used to aid in the design of a new cordon on screen, trying to capture as much of the flow from the SLA as possible. A further select link analysis is performed on the new cordon and this is cross-matched with the top X links to determine the proportion of flow covered. Cordons with a high proportion of flow covered are taken to the next stage which is to run the simulation for various charge levels to optimise the uniform charge around the cordon.

This heuristic process can be summarised as follows:-

1. Compute the system optimum and calculate first-best benefits.
2. Sort the system optimal charges in descending order and apply those charges using an increasing number of links, creating a graph of relative benefits versus number of links charged.
3. Use the graph from Step 2 to select a sub-set of Top X links and produce a visual output of these links.
4. Carry out a select link analysis with these links to show, using bandwidths, where the flows come from/go to through these top X links.
5. Draw a cordon or set of cordons either on-line or off-line which “catch” a high proportion of the flows from the top X links.
6. Optimise the charge level for the cordon by plotting benefits for a set of uniform charge levels.
7. Repeat 5-7 until a satisfactory cordon design is achieved.

An example of the single cordon produced by the above approach is shown in Figure A-8. As shown in Table A-2, this single SLA cordon achieved 21% of the first best gross benefits while the GA optimised single cordon OPC achieved 22% of the same benefits. Thus the method has delivered gains in welfare which are comparable to those produced by a much more time consuming and complex approach.



**Figure A-7 Top 15 Links and Bandwidths from Select Link Analysis**



**Figure A-8 Single Cordon developed using the Select Link Approach**

More recent work for the UK Department for Transport (Shepherd *et al* 2006) has proven the method to be effective for much larger networks of other English cities. Some limitations were however found to arise from the differing ways in which buffer networks had been specified. Improved approaches are currently being developed. As well as reducing analysis time, the SLA approach has the advantage over the GA optimisation approach of involving the planner directly in drawing potential cordons, thus enabling local knowledge to be applied.

## APPENDIX B: APPRAISAL GUIDANCE IN THE UK

In this review, a brief summary is made on the guidance on the appraisal of road pricing schemes applicable to England and Wales from DfT(2006). Northern Ireland and Scotland have a separate similar version of this appraisal guidance but modified to suit local circumstances.

### *Outline of the process.*

A road pricing scheme is treated to be similar to any other transportation scheme in terms of economic evaluation requirements. The first step involves appraising the scheme's overall contribution to the Central Government objectives. In fact for "uniformity" in appraisal across the England and Wales, it is a requirement that an "Appraisal Summary Table" (AST) is completed summarising the road pricing scheme's impact five over-arching objectives for transport outlined in DETR(1998). The 5 objectives are :

- 6) Environment
- 7) Safety
- 8) Economy
- 9) Accessibility
- 10) Integration

### *Appraisal Summary Table (AST)*

To complete the AST requires information on how a charging scheme contributes to support the above 5 transport objectives of Central Government are:

- 1) Environment

English guidance requires that environmental appraisal is carried out according to the requirements of European Directive 2001/42/EC (Strategic Environmental Assessment (SEA) Directive) *on the assessment of the effects of certain plans and programmes on the environment*. This involves the assessment of the impact of the scheme on the following:

- to reduce noise
- to improve local air quality
- to reduce greenhouse gases
- to protect and enhance the landscape
- to protect and enhance the townscape
- to protect the heritage of historic resources
- to support biodiversity
- to protect the water environment
- to encourage physical fitness
- to improve journey ambience

- 2) Safety

The practice in the UK is to place a monetary value on casualties and accidents of differing severity, and to include these within a cost benefit analysis. Aside from the direct impacts such as loss of output, police time etc, property damage, an allowance is also provided for "pain, grief and suffering". In addition, absolute numbers (of killed, seriously injured and damage only) accidents are compared

between 2 scenarios. Note that safety also covers “improving the personal security of travellers and their property” but this aspect is not relevant for road user charging schemes.

### 3) Economy

The benefits on “economy” attempts to provide to some extent a measure of the economic efficiency of the system by accounting impacts through the following channels:

- Public Accounts: This is the net cost of the scheme (Investments less Revenues)
- Business and Consumer Users: This is the source of benefits from travel time savings, vehicle operating cost savings, as well as private operator revenues and public sector grants. In addition the guidance states that benefits in this front should be explicitly calculated on both an equity value of time (which is the norm in generic UK appraisal of schemes) and a segmented value of time. This segmented value of time is argued to provide a more “accurate indication of the value of such benefits in terms of transport economic efficiency (i.e. in the absence of any adjustments for equity) than an estimate based on standard appraisal values”.

Note that the above information can be generated from traffic model information fed into a standardised package TUBA (Transport User Benefit Analysis) to estimate the impacts.

However, there is no advice on the following at present:

- Reliability assessment: Impacts of road user charging on the reliability of travel times
- Wider Economic Impacts: Contribution of road user charging to the larger economic impacts

### 4) Accessibility

This objective is related to the contribution of road pricing scheme in improving access to facilities for those **without a car** and to reduce severance. Note that the objective explicitly is phrased in terms of the non-car users.

### 5) Integration

Integration: The appraisal needs to consider if the introduction of road pricing will have a significant effect on any Government policy commitments

However the AST is only one strand of the appraisal process. 3 other strands include

- an assessment of the extent to which the local and regional objectives of the study would be achieved; and
- an assessment of the extent to which the problems identified would be ameliorated; and
- supporting analyses of distribution and equity impacts, affordability and financial sustainability, practicality and public acceptability.

#### *Distributional and Equity Supporting Analysis*

This analysis is designed to consider how the road user charging scheme impacts of differing socio-economic groups. The advice states that since the impacts of road user charging schemes differ between groups, it is necessary to provide analyse the distribution of benefits across the various groups. The advice also requires the use of social research methods to generate information to feed into the Distribution and Equity Supporting Analysis for road pricing options.

#### *Affordability and financial sustainability*

The role of the Affordability and Financial Sustainability Supporting Analysis is to provide an overall assessment of the likely public expenditure impact to ensure the option under consideration is affordable.

### *Practicality and Public Acceptability*

Assessments of practicality and public acceptability should be central to the appraisal and design of road pricing options. However, this is regarded as work in progress and not much information is available on this as yet.

### *Decision making Criteria*

The guidance notes the following regarding the appraisal process of schemes:

Value for money is an important consideration in deciding between competing options. However there are other considerations that must also be factored into decisions.

It is recognised that there are a number of other issues that are important to the choice between options but that do not fit easily into the AST or considerations of value for money. It explicitly states that funding decisions are made on the basis of a series of considerations, including:

- Value for money
- Contribution to central government, local and regional objectives
- The amelioration of identified problems
- Practicality / deliverability
- Public acceptability
- Distributional and social impacts
- Affordability and financial sustainability

## APPENDIX C: CASE STUDIES ON ACCEPTABILITY

This appendix provides further information and lessons learned on acceptability from various scheme proposals.

### C-1 NORWAY

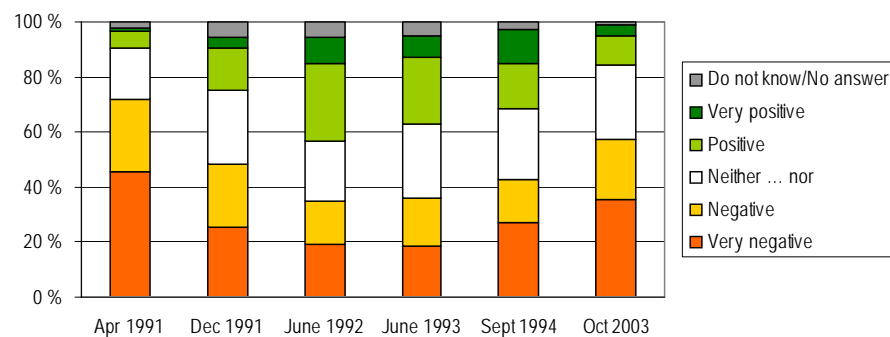
The first Norwegian urban toll ring was established in Bergen in 1986 to raise finance to accelerate the implementation of a wide-ranging programme of transport investments. Since then, a number of other Norwegian cities have adopted the scheme including: Oslo, Trondheim, Stavanger and Kristiansand (Ramjerdi *et al.*, 2004) as well as the smaller settlements of Tønsberg and Namsos (Wærsted, 2005). Both Oslo (1990) and Trondheim (1991) use automatic toll collection, made possible with modern electronic permits. In Trondheim, the tolls became differentiated by time of day, thus resembling more of a congestion charging scheme. These toll cordon schemes, especially the three major urban toll systems in Bergen, Oslo and Trondheim, have been extensively documented, e.g. Larsen (1988, 1995, 2001) Langmyhr (1999, 2001, 2003), Tretvik (2003), Ieromonachou *et al.* (2006) and Wærsted (2005). The reader is referred to these sources for a detailed description of the schemes and their implementation.

The main background for all these road toll projects was to obtain additional user funding to faster realise important main road projects than would it be possible with state funds alone. Furthermore, these schemes operated only for a limited period of time, approximately 15 years. After this period some cities such as Bergen and Oslo have introduced a second time-limited toll ring scheme referred to as package 2. In that sense these toll rings are different from congestion charging schemes. Nevertheless, their experience with low public acceptability as a main barrier to implementation may hold important lessons for other cities.

In Bergen the shift in acceptability from merely negative before the implementation to rather positive afterwards was first observed. The public was overwhelmingly against the toll scheme at the start of the project. However, at the time that the toll ring was introduced, the most important factor was to win over the local politicians and not the public. Larsen (1988) reported an opposition of 54% one month before the introduction, only 13% of the public were unreservedly in favour. Opinions started changing when the first results were apparent. Within a year 50% of the respondents were in favour and 36.5% were opposed.

Opinion polls on the attitudes to the Trondheim toll ring indicated decreased opposition during the first years after implementation as well, but the long-term trends show negative attitudes towards the RUC system increasing again (Figure C-1).

**Figure C-1 Public acceptability change of the Trondheim toll ring**



Source: (PRoGRESS, 2004)

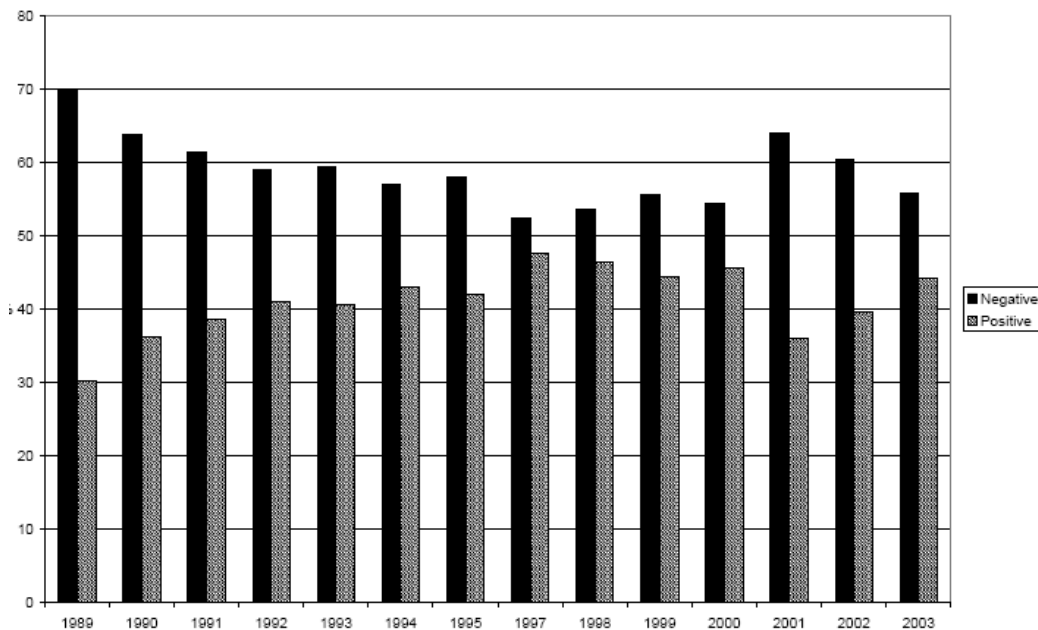
The toll ring started operating in October 1991. In April 1991, five months before the start, 72 % of people held negative views, and only 7 % were positive towards the toll ring. In December 1991, two months after implementation, the share of negative views had dropped to below 50%. In succeeding opinion polls in the summers of 1992 and 1993, the critical views dropped to around 35%, while the proponents' share increased from 19 % to 37 % in 1992, although it dipped again to 32 % in 1993. By 1994 the share of negative views had increased to 43 %, and of positive ones reduced to 29 %. This “negative” trend appears to have lasted, and in October 2004 the majority were negative (57 %), and only 14 % were still positive towards the toll system. It seems that the share of respondents being frustrated about it had grown considerably. That means, the positive level of acceptability after implementation is not guaranteed throughout the lifetime of the scheme.

The Trondheim toll ring has stopped operation at the 31st of December 2005. Politicians insisted to end the scheme, keeping in line with the promise made that any toll project would not run for more than 15 years and at the same time enhancing public trust in future political promises (Ieromonachou *et al.*, 2006).

Since 1990 road and public transport investments in the Oslo region have been partly financed by a toll ring (Oslo Package 1, in 2001 supplemented by Oslo Package 2 dedicated to investments in public transport). Odeck and Bråthen (1997, 2002) examined the changing users' attitudes towards the Oslo toll ring from 1989 to 1995 and found that users became more and more positive towards the tolls as the benefits of tolls accrued to them through better infrastructure.

A time series analysis however, also shows the changeableness of public acceptability (Kjerkreit and Odeck, 2005). The main trend was a gradual increase in public acceptability from 30% agreement before the start of the system in 1990 to 48% in 1997. This positive trend levelled off at around 45% in 1998-2000, before it dropped significantly to 36% in 2001 (see Figure C-2). This decrease is attributed to a considerable increase of the charge level introduced in 2001 (see also Tretvik, 2003). Even though in the following year public support increased again, it never reached the same level as before 2001.

**Figure C-2 Acceptability change of Oslo toll ring**



Source: Kjerkreit and Odeck (2005)

Oslo Packages 1 and 2 are generally considered to be success stories, but many important transport projects will not be financed by 2008. Furthermore dismantling the Oslo Toll Ring is in the short term calculated to increase road traffic by 8-10 %. Expected traffic growth from 2001 to 2025 without the

toll ring is around 30 %. Critical parts of the trunk road system (mainly some tunnels) may be overloaded by 2015. The Inner city is already considered to receive traffic flows near its capacity, in terms of road space and environmental conditions. On this background the politicians in the county councils of Oslo and Akershus have initiated work on a scheme for prolonged user payment beyond 2007, a possible Oslo Package 3 for which preparation are currently under way.

The successful implementation of the Norwegian schemes rests on a combination of several factors (see Langmyhr, 1999 for more details). The experience indicates that tolling with the purpose of raising funds for infrastructure investments and environmental improvements is more acceptable to the general public than tolls aimed at managing demand. Extra state funds have supplemented local user fees, thus increasing the total investment resources and contributing to local acceptance.

Furthermore, it has been important to establish a close co-operation between influential local politicians and the resourceful County Roads Offices acting as prominent road pricing promoters. During the long time-span of planning and preparations, it has been necessary to revise the scheme features according to changing political preferences. A crude road pricing scheme is better than no scheme. Some traffic management and correction of externalities can be achieved even if the official purpose is supposed to be fund raising for infrastructure investment. It is more likely to gain acceptance for a more sophisticated demand management instrument if a city has already implemented a crude toll ring.

In addition, local and national geographical features may have influenced the likelihood of acceptance. The ubiquity of ferry-crossings in Norway has provided many motorists with the experience of user fees. The distance between rival cities may be of some importance, as commercial interests are likely to object to measures that worsen the terms of competition. If a conurbation spreads across administrative borders, involvement from regional and national authorities may be necessary to settle local disputes (Langmyhr, 2003).

Since the first toll ring in Bergen 1986, the road investment bias has been decreasing in most toll ring packages. However, there are differences in degree, partly due to local political preferences. The Stavanger package, Bergen package 2, Oslo package 2 and Tromsø package 2 signify a possible new era of packages with public transport predominance. In accordance with the overall trend, extraordinary state funds for road investment have gradually been reduced. On the other hand, the possibilities to obtain state funds for the public transport part of investment packages (e.g. rail infrastructure) have increased somewhat. A revision of the Norwegian Road Act now opens up for developing the demand management side of the charging regimes (e.g., sharper time differentiation), as well as a wider range of revenue use in the transport sector (e.g. covering public transport operating costs). This opens up the possibility to develop the Norwegian urban toll rings further into congestion charging schemes.

## **C-2 LONDON**

On 17th February 2003 the Mayor of London, Ken Livingstone, launched the first major congestion charging scheme in the UK. The aim of the scheme was to

- to reduce congestion,
- to make radical improvements in bus services,
- to improve journey time reliability for car users,
- to make the distribution of goods and services more reliable, sustainable and efficient (TfL, 2003).

The charging area covers the city centre of London, 21 km<sup>2</sup>, representing 1.3 per cent of the total 1,579 km<sup>2</sup> of Greater London. Motorists are charged £5 to drive into or within the zone, or even to park in non-private spaces within the zone, between the hours of 7 am and 6.30 pm, Monday to Friday, excluding public holidays (Transport for London, 2003a). There are a number of exemptions such as taxis, motorbikes / mopeds, emergency services, disabled persons and buses. Residents are eligible for a 90% discount. The generated revenues are to be spent in public transport, mainly the bus service.

Various adjustments have been made to the scheme since it was first introduced in February 2003. For example, the charge has been increased to £8 from July 2005 onwards. Furthermore, changes in exemption and discounts have been made, fleet management has been introduced and new payment

procedures and channels such as “pay next day” have been launched (see TfL, 2005 for details). The biggest changes however will be the extension of the congestion scheme to inner city areas westwards of the current zone (referred to as western extension). The implementation is commenced in February 2007. At the same time the charging hours will be shortened by 30 minutes to 7.00am – 6.00pm.

The outcomes of the scheme so far have met or even exceeded the expectations prior implementation. Congestion in charging zone has decreased up to 26%. The overall traffic entering the charging zone has been reduced by 18%. Taking only private cars into account traffic volume has fallen about 37%. The majority of travellers has switched to public transport. Especially the bus service has considerably extended with the start of the scheme to cope with addition passengers. The number of bus passengers has increased up to 37 percent during charging hours. Around half of this was assessed to have been as a result of the scheme. Bus reliability also improved on routes in and around the charging zone after the introduction of the scheme. Excess waiting time fell by 30 percent in the first year and by a further 18 percent in the second year after the introduction of congestion charging. Although not an objective of the congestion charging positive effects have been observed for traffic safety and the environment. That means a decrease in road traffic accidents and well as emissions were measures (see TfL, 2006 for more details).

The implementation of the congestion charging scheme was prepared by the Greater London Authority (GLA) Act enacted in 1999. With this law the Government provided the legislative power to establish the office of the Mayor of London, the Greater London Authority and Transport for London (TfL), the public body responsible for managing transport in London and thus the opportunity to introduce an urban road pricing scheme in London. A possible scheme, including definition of the boundaries, technology and enforcement, would be the responsibility of the Mayor and TfL. The GLA Act requires only that the net revenues of the scheme must be invested in transport projects in London (Dix, 2002).

In March 2000, the Government Office for London published a report entitled “Road Charging Options for London: A Technical Assessment” (Dix, 2002). This report was intended to assist mayoral candidates in the understanding of the contribution that road user charging and workplace parking levies could make to the Mayor's initial Transport Strategy. It examines the sort of schemes that might be developed or introduced in the Mayor's first term. The report was prepared by an independent working group of transport professionals assisted by studies from a team of consultants under contract to the Government Office for London.

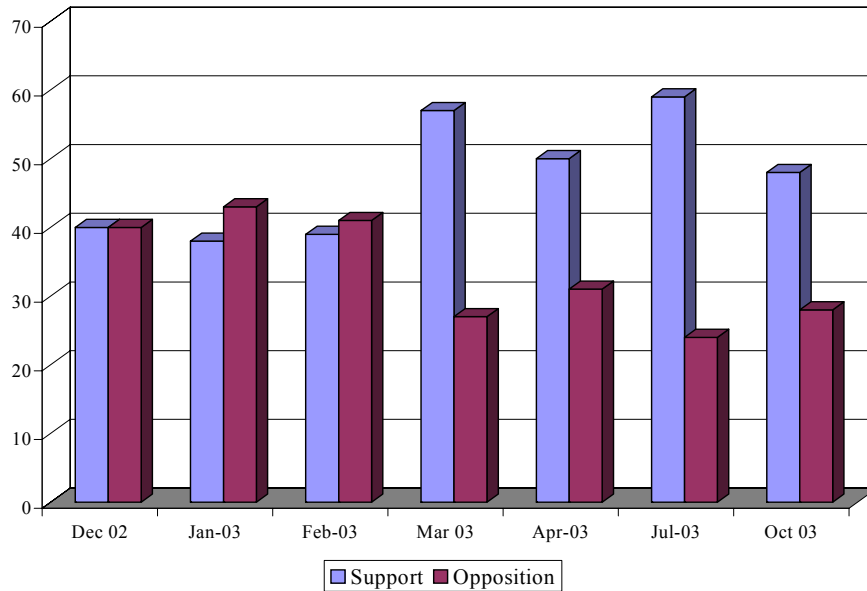
In the following election campaign the current mayor Ken Livingstone included proposals for a congestion charging scheme in his election manifesto and won the election in May 2000. Londoners voted for him knowing that he would probably implement congestion charging, as he did in 2003. Prior to the introduction an extensive public consultation process took place on the overall transport strategy including charging and the proposed congestion charging scheme itself. Within this consultation process the public and key stakeholders were given the opportunity to comment on the proposals and request changes. The final decision however was taken by the Mayor himself, in contrast to Edinburgh, where the final decision rested on a public referendum. Any further changes would go through a similar public consultation process. For example, in February 2004, TfL issued a consultation document on the expansion of the charging zone to the west. Following Livingstone's re-election in the June 2004, in August 2004 the results of the public consultation were published. In May 2005 TfL announced a further consultation period with specific proposals about the extensions. At the end of September 2005 the western expansion of the congestion charge was confirmed to come into effect in February 2007.

Figure C-3 illustrates the level of acceptability of the London Congestion Charging Scheme before and after the implementation. The level of acceptability of road user charging before the introduction was rather stable about 40%. This also holds true in comparison with other scenarios such as workplace levy schemes (GOL, 2000). After the introduction acceptability has risen above 50%. Unfortunately, no time series data is available later than October 2003 to observe any long-term trends in acceptability and the influence changes to the schemes, such as the western extension, might have. The re-election of the Mayor in June 2004 with the western extension already announced suggests that London residents accepted this change as part of their future government as well.

There are two main reasons for this rather high level of acceptability before as well as after the introduction. First, traffic levels in London had reached unacceptable levels and Londoners felt some radical measure was needed. Evidence for this is cited in the ROCOL report (2000): 90% of London

residents, polled in 1999, thought that there was too much traffic in the capital, and were concerned about its impacts on travel times and air pollution. Some 41% of a representative sample polled for the ROCOL report also felt that a congestion charge was the best way to raise money for improved public transport in London. A consultation on congestion charging carried out by TfL for the Mayor in July 2000 found that, of 400 key “stakeholders”, six times as many supported the concept of a central London congestion charge as opposed it.

**Figure C-3 Level of Support for London Congestion Charging Scheme over Time**



Source: Adapted from TfL, 2004

Second, in London the concentration of power in the hands of the Mayor meant that “local” political concerns were less important, and thus resources could be concentrated on key projects, such as the implementation of congestion charging. In doing that the TfL and the mayor himself did an excellent job of engendering trust through open communications, a clear and well-composed presentation of the problem and the proposal, and the development of first-rate communication tools, including a highly effective website. In this way consultation as well as promotion of the scheme and its benefits was achieved.

The legislation that permits the Mayor to implement congestion charging in London is also different to that which gives the same power to local authorities in Scotland (Transport (Scotland) Act 2001); and in England and Wales (Transport Act 2000). In London, the decision rests with the Mayor, without reference to a higher level of government. Another factor that might have helped is the political stability. For example, no sustained and organized opposition to the proposal has emerged. Furthermore, the fact that congestion charging was implemented early in the Mayor’s term of office gave it more chance to succeed (Rye, Ison and Santos, 2003). In summary, a high level of public acceptability together with strong political commitment made it possible to introduce congestion charging in London.

**C-3 EDINBURGH**

The congestion charging scheme proposed by the City of Edinburgh Council aimed at reducing congestion and raise revenues to improve public transport. The scheme consisted of two cordons and a £2 charge for inbound travel. The charge would have applied between Monday and Friday, during the day (7am–6.30pm) for the inner cordon and morning peak for the outer cordon (7am–10am). Vehicle exemptions included emergency service vehicles, motorcycles, local buses, Blue Badge holders

(disabled) and City Car Club vehicles. City of Edinburgh Council area residents living outside the outer cordon were exempted from paying to cross the outer cordon.

The implementation process included a comprehensive programme of consultation and market research divided into four phases followed by a public referendum prior to the start of the scheme. Phase I of the consultation strategy, conducted by the Council in 1999, aimed to determine public preferences for the basis for the future transport strategy. Significant public support for the high investment option, based around road pricing implementation, was taken as a mandate to proceed with this design (Saunders, 2005).

The Phase II exercise, conducted in 2000, started the design process. It was decided at this initial stage to divide the road pricing scheme into a series of individual design elements, providing a series of options for each one, and then assess the level of consensus in each case. Public consensus did exist on two different design elements: the charging basis (an entry permit design) and the days of operation (Monday to Friday). These elements were subsequently adopted into the scheme design (Cain *et al.*, 2001).

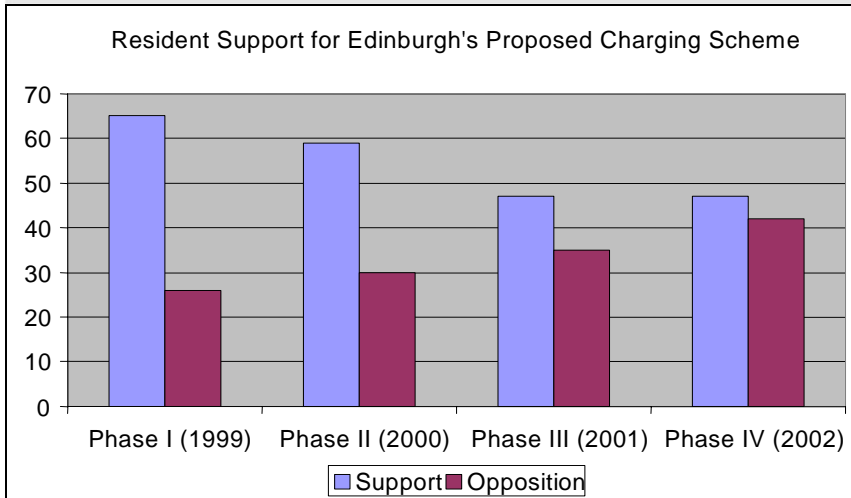
Phase III presented a series of charging scheme options, each featuring different design configurations, in order to develop an understanding of public preferences for an overall scheme design. It was found that the charge level was the major determinant of level of support, with the most popular charging options being those that minimized the charge level. Other factors in the transport strategy design, such as whether a single or double cordon is employed, the length of the charging period or the kind of transport improvement package provided, were less important in influencing respondents' overall level of support. Charging options at the £1 and £2 (around € 1.50 / € 3.00) levels both received majority support (Cain *et al.*, 2002).

The Phase IV exercise was designed as a full, open public consultation, with residents of south-east Scotland invited to comment on the proposals and state their preference between two road pricing based options and a no charging option. Setting the charge level of both options at £2 meant that other elements of the design would have a greater influence. In this case it was found that the single cordon option was much more publicly acceptable than the double cordon, with the single cordon receiving approximately equal levels of support and opposition, while the double cordon received net opposition of between 20 and 42 percent (Cain *et al.*, 2002a).

Despite the lack of public support for a double cordon design, the Council decided to base its preferred design on this option, due to this design's ability to influence city-wide congestion levels and to fund region-wide traffic improvements. Conceding that the double cordon in its current form was unacceptable, the council reduced the outer cordon charging period to during the peak periods only.

As Figure C-4 illustrates public acceptability towards the congestion charging proposals declined in Edinburgh over the four public consultation phases (PRoGRESS, 2004). In 1999, there was approximately 60% support and 30% opposition for the charging principle identified in Consultation Phase I 'Edinburgh's transport choices'. In 2002, the level of support had fallen, at the time of the Consultation Phase IV 'Have Your Say'. The option for a single, central cordon had marginal opposition amongst Edinburgh residents (43% in favour, 47% against), whereas the option for two cordons (the option presented to the public in the referendum) had stronger opposition amongst Edinburgh residents (34% in favour, 56% against). As shown by the referendum result, support for congestion charging in Edinburgh declined further after Consultation Phase IV. The referendum in February 2005 resulted in a 65% rejection of the proposed charging scheme leading to a full stop of all implementation work by the City of Edinburgh Council.

#### **Figure C-4 Level of Support for Edinburgh's Road Pricing Scheme over Time**



Source: PRoGRESS, 2004

Follow up-studies by Allen *et al.* (2006) and Brauhnoltz and Cuming (2006) have identified a number of reasons for the strong opposition and the subsequent failure of the Edinburgh congestion charging scheme. First of all, car users strongly opposed the scheme while non-car users did not exhibit equally strong support. Car users were also more motivated to vote than non-car users. Especially bus users, perhaps the groups likely to benefit most from congestion charging, did not support the scheme as expected. By the time the referendum took place, a number of transport improvements have been implemented. However it seems that by polling day these improvements had either already been forgotten about or else people thought that these improvements were not relevant to them, or did not see them as linked to the charging scheme. But also at the time of the referendum the plans for public transport improvements funded by the revenues were not well-developed and therefore quite difficult to “sell” to the public.

A second important factor were the wide held misconceptions about how the scheme would operate, the amount of charge and the specific location of the charging schemes. Only half of the respondents in the survey mentioned above were able to state the correct level of charge per day (£2). The greatest individual misconceptions were that the maximum daily charge was dependent on whether entering the charged areas more than once. Furthermore, there was a misconception that the cordons were operational in both directions (in practice they were only inbound cordons). These misconceptions therefore tended to exaggerate the level of charge and the applicability of the charge and certainly further increased the opposition.

These factors are compound by an apparent widespread distrust of the Council. Over a third of residents felt the Council is anti-car, illustrated for example by a perception that the Council’s bus priority and traffic calming measures are designed to “generate congestion” (Saunders, 2005). Only 25% of the respondents were convinced that all the revenues raised from the scheme would have been used to improve transport in Edinburgh. In addition, only a minority felt the Council is finding good solutions to the issue of traffic in Edinburgh. Furthermore low overall political support might have reinforced this negative image. “The administration’s overall majority of just two seats will have had the effect of politicising the issue, with opposition parties taking the opportunity to seek potential future electoral advantage” (Saunders, 2005).

#### **C-4 STOCKHOLM**

Road pricing has been on the political agenda for Stockholm since the late 1960s. The congestion charging field trial carried out in 2006 was the latest event in a long series. Already in 1991 politicians of at that time the three leading parties in the City and County of Stockholm reached an agreement on a comprehensive transport investment package. The so-called Dennis-package comprised road and public transport investments combined with a system of road tolls. It was finally adopted in September 1992.

However the political priorities of the three parties involved were quite diverse and all other parties opposed the agreement. Especially controversial were the toll ring and the two major road infrastructure projects. The 1994 election resulted in new political power balance in which the Social Democrats relied on support from parties opposing the Dennis-package. In the following the Dennis-agreement was terminated (Harsman, 2003).

In 2002 the National Green Party won a crucial position in the national elections. In the following coalition building process the Green and the Social Democratic party agreed on the implementation of a 'full-scale' road tolling trial in Stockholm. The government fulfilled its promise in April 2004 in a bill presenting a law on congestion taxes. The congestion charges act is general, but has a supplement regulating the terms of a temporary full-scale trial in Stockholm. It passed the parliament in June 2004. Unlike the previous Dennis agreement, where road tolls were primarily seen as instrument for infrastructure funding, the focus is now in travel demand management and congestion reduction.

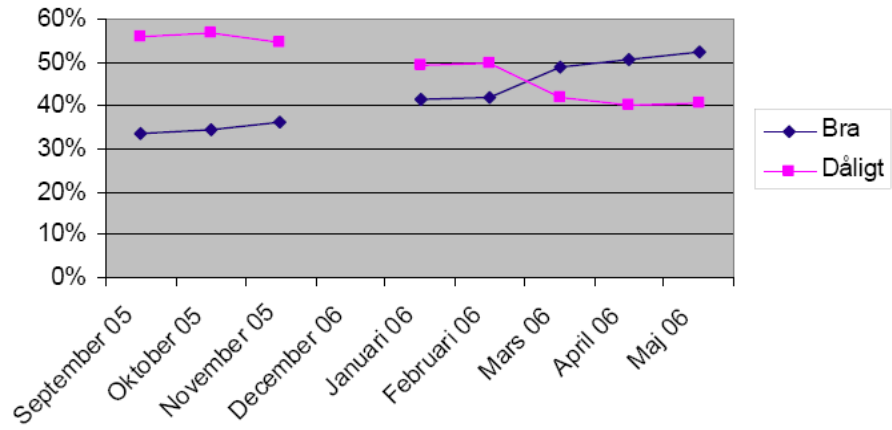
In the agreement with the Green and Left parties, the trial was described as a full-scale trial that would last for several years. However, as the Social Democratic leadership in Stockholm wanted to have this issue sorted out before the next election campaign, the city council decided to follow-up the trial with a local referendum together with the next election in September 2006. Since, the trial would have to be completed before that date, the Social Democratic, Left and Green parties agreed to conduct the trial over a 14-month period from the beginning of June 2005 to the end of July 2006. Several delays in the procurement procedure made it necessary to postpone the start. Finally, the road pricing trial in Stockholm lasted 7 month, from the 3<sup>rd</sup> January to the 31<sup>st</sup> of July 2006. The referendum whether or not the congestion charge should be permanent was held on the 17<sup>th</sup> of September on connection with the general elections (Armenius, 2006).

The road pricing system in Stockholm represents a cordon system around the inner city with 18 control points charging motorists for entering and leaving the centre of Stockholm. The charge is raised on weekdays from 7.30am to 6.30pm with no charging the evening, the weekend and on holidays. The charge is highly differentiated according to the time of travel with 2€ at peak-hours, 1.50€ at semi peak-hours and 1€ at non-peak hours. The maximum charge per day is 6€. A number of exemptions exist such as for emergency vehicles, disables persons, taxis, and vehicles using alternative fuel. A number of payment channels have been installed among others electronic payment with transponders installed in vehicles. In parallel considerable public transport improvements such as new bus lines and additional buses as well as new Park and Ride facilities have been launched already in 2005.

So far the congestion charging scheme impacts meet or exceeded similar expectations to London. Traffic volume declined between 9% and 26%. The decline was biggest during the peak-hours with the highest charges. The biggest decline of all was during the afternoon/evening peak-hour, which can be probably be partly explained by the fact that during the afternoon travel is not dictated to the same extent by time and destination as in the morning peak-hour. Traffic also declined during evenings after the charging period. Fears that bypass routes would collapse were unfounded. Subsequently positive environmental and safety effects were registered. Congestion rose at the end of April in line with the annual spring increase in traffic and it has been discussed whether this was due to the effects of the congestion tax declining over time (City of Stockholm, 2006). However, traffic counts after the trial period show an increase in traffic volume almost to the same level than before the trial. The public transport improvements lead to an increase of 6% travel in all public transport services. In the inner city the increase was around 9%. This numbers are in the range of expected demand increase of 7-8% of trips in the direction towards the inner city. However, they are not attributed to the congestion tax only, but also to the rise of petrol price sand the general economic development.

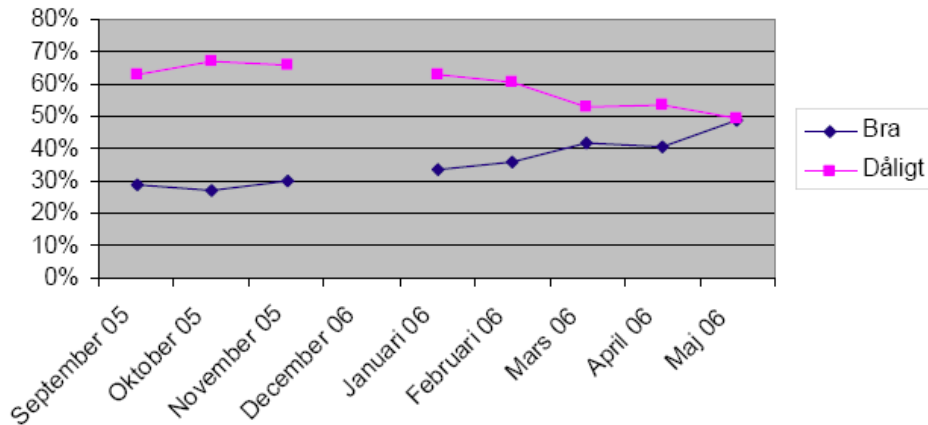
Public acceptability has been measured before and throughout the trial period. The pattern of response is quite similar to what is known from London and the Norwegian cities (see Figure C-5). Attitudes to the Stockholm Trial have become more positive during this time. In autumn 2005, about 55% of all county citizens believed that it was a "rather/very bad decision" to conduct the congestion-tax trial. Since the congestion tax was introduced in January 2006, this percentage has continuously fallen. In April and May 2006, 53% believed that it was a "rather/very good decision" while 41% believed that it was a "rather/very bad decision". Significantly, even those travelling by car to/from the inner city during the charge period in the most recent two 24-hour periods have become more positive by several percentage units. In May 2006 car driver were approximately equally for and against the road pricing trial (see Figure C-6).

Figure C-5 Attitude change towards the Stockholm road pricing trial



Source: (Söderholm, 2006)

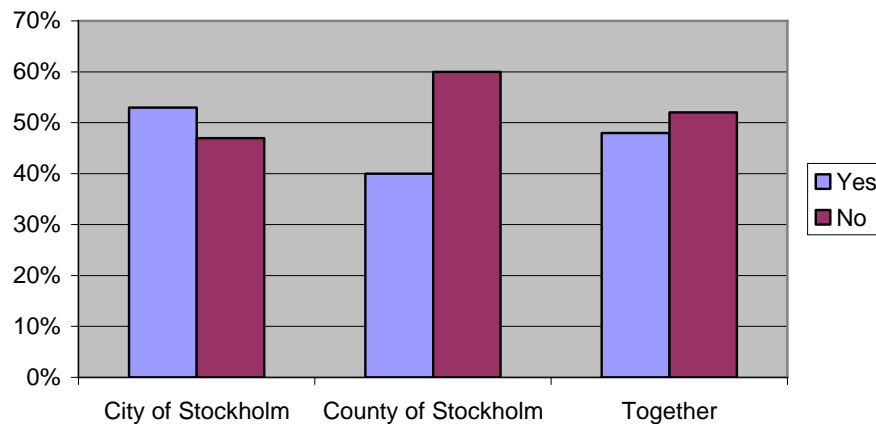
**Figure C-6 Attitude change of car drivers towards the Stockholm road pricing trial**



Source: (Söderholm, 2006)

The following referendum resulted in a 51.3% support for the charging scheme. 45.5% voted against the scheme (City of Stockholm, 2006a) Municipalities surrounding Stockholm were not satisfied with the fact that their residents were not eligible to vote. A substantial number of them travel to and from work through the congestion tax area. Therefore several of these municipalities, especially those governed by at that time opposition party have decided to hold an advisory referendum. Here the majority of residents decided against the permanent introduction of congestion charging in Stockholm (see Figure C-7). It seems that those people who benefit most from urban road pricing can be convinced if they experience in a trial the positive outcomes. However, not all municipalities held an independent referendum and the wording of the question there was different from the official Stockholm referendum. These could also be reasons for the differences in the referendum results.

**Figure C-7 Results of the Stockholm Referendum in September 2006**



After the successful referendum the future of the Stockholm congestion charge is nevertheless unclear. That is because under Sweden's constitution it cannot come into effect without approval from the national parliament, and as the ruling red-green national coalition lost its majority on the same day, confusion has reigned over whether the charge will be reinstated. The new national centre-right coalition, whose biggest party opposed the whole idea of charging, supported the advisory referenda from the surrounding municipalities and promised to take these results into account as well if they would win the election and needed to decide about the future of the Stockholm Congestion charging. Surprisingly, after the election victory they announced plans to reinstate the charge but to use the

revenue to fund the building of a controversial by-pass west of Stockholm instead of improvements to public transport, as most has expected. In addition, the new government announced that a committee reviewing the constitution will be instructed to deliver a proposal for an amendment that will pass responsibility for congestion charging from parliament to local authorities (T&E, 2006).

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