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A Road Map for Road Pricing Implementation in Thailand: Decision Making Context

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ASIAN TRANSPORTATION RESEARCH SOCIETY

902/1 9th Floor, Glas Haus Building, Soi Sukhumvit 25 (Daeng Prasert),
Sukhumvit Road, Klongtoey-Nua, Wattana, Bangkok 10110, Thailand
Tel. (66) 02-661-6248 FAX (66) 02-661-6249
http://www.atransociety.com

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A Road Map for Road Pricing Implementation in Thailand: Decision Making Context

List of Members

• Project Leader •

Assistant Professor Dr. Sittha Jaensirisak
Ubon Ratchathani University, Thailand

• Project Members •

Assistant Professor Dr. Agachai Sumalee
Hong Kong Polytechnic University, Hong Kong

Dr. Sumet Ongkittikul
Thailand Development Research Institute (TDRI), Thailand

Abstract

Most major cities around the world have been facing a growing traffic congestion problem whose impacts extend from delay in travel, economic loss, pollution problem, to degraded quality of life. The congestion problem is simply an outcome of the mismatch between available transport supply and travel demand. Transport engineers and planners have been thus far attempting to tackle the congestion problem from the supply side by increasing or providing more transport infrastructure. The outcomes of such strategies in several real world cases were, however, not long lasted in which the effect of induced travel demand, due to lower travel cost, eventually diminished the benefit of the newly added transport capacities. To this end, the idea of travel demand management has been put forward to also address the problem from the demand perspective.

Road pricing is one of possible travel demand management policies which has been widely suggested by transport economists and planners as an appropriate policy for tackling the congestion problem. The great interest in road pricing stems from its potential to control the car uses and to generate revenues for other transport projects. This potential benefit of road pricing puts it as a centrepiece of an integrated transport policy.

Several previous studies provide a fruitful lesson from both successful and failed experiences in planning and implementing road pricing schemes. This recollection of experiences helps identifying major issues to be considered during the design and implementation phases of a road pricing scheme. This research aims to unravel the key factors and their interactions which underpin the success and failure of a road pricing scheme using the international experiences and some specific case studies. The selected case studies include: Hong Kong, London, Seoul, Singapore, and Stockholm. The study identifies an overall dynamical process of these factors in each phase of road pricing policy development. The study also points out potential obstacles during the planning process of the policy, and proposes possible effective strategies to overcome them. The outcomes of this research should be useful for the decision makers and transport planners who are investigating the feasibility of a road pricing policy in their municipals.

From the literatures and case studies, we defines a life-cycle of road pricing policy and the casual relationship diagrams of different influencing factors during the initial and design phases of the scheme. A road map for road pricing development in Bangkok is then drawn from the outcomes of the study which involves the following suggestions:

(i) The national government has a responsibility to develop a clear transport strategy and legislation to support the local government.
(ii) Road pricing should be considered as a part of an effective transport strategy.
(iii) An independent expert study group should be set to formulate the effective strategy.
(iv) Effective communication should be done continuously through a two-way dialogue to raise public awareness and knowledge (mainly done by the expert study group).
(v) Road pricing revenue allocation plan is a critical issue.
(vi) Implementation plan to improve alternative transport modes should be set out clearly and convincingly in an early stage of the planning process.
(vii) Political will and leadership to commit the scheme is a key to the success of the scheme.

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However, this research report represents only the views of the authors, and does not necessarily reflect the views or approval of the interviewees and funding organisation.

Assistant Professor Dr. Sittha Jaensirisak
(Project Leader)

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List of Abbreviations

ALS ··············· Area Licensing Scheme
BRT ··············· Bus Rapid Transit
BTS ··············· Bangkok Transportation Study
CBD ··············· Central Business District
CfIT ················ Commission for Integrated Transport
CURACAO ···· Co-ordination of Urban Road-user Charging Organisational Issues
DETR ············ Department of Environment, Transport and the Regions
DOT ··············· Department for Transport
DSRC ··········· Dedicated Short Range Communication
ERP ··············· Electronic Road Pricing
GLA ··············· Greater London Authority
GLC ··············· Greater London Council
GOL ··············· Government Office for London
GPS ··············· Global Positioning System
ITE ················· Institute of Transport Engineers
ITS ················· Institute for Transport Studies
LPAC ············ London Planning Advisor Committee
NEDO ··········· New Energy and Industrial Technology Development Organization
NOK ··············· Norwegian Krone
OCMLT ·········· Office of the Commission for the Management of Land Traffic
PATS ············ Pricing Acceptability in Transport Sector
ROCOL ·········· Review of Charging Options for London
RPS ··············· Road Pricing Scheme
RZ ·················· Restricted Zone
SARS ············ Severe Acute Respiratory Syndrome
SEK ··············· Swedish Krone
SIKA ·············· Swedish Institute for Transport and Communications Analysis
SMG ·············· Seoul Metropolitan Government
TDRI ·············· Thailand Development Research Institute
TfL ················· Transport for London
TORG ··········· Transport Operations Research Group
TRL ················ Transport Research Laboratory
USD ··············· U.S. Dollar
VPS ··············· Vehicle Positioning System

CHAPTER 1 INTRODUCTION

1. Introduction

1.1 Background

Most major cities around the world have been facing a growing traffic congestion problem whose impacts extend from delay in travel, economic loss, pollution problem, to degraded quality of life. The congestion problem is simply an outcome of the mismatch between available transport supply and travel demand. Transport engineers and planners have been thus far attempting to tackle the congestion problem from the supply side by increasing or providing more transport infrastructure. The outcomes of such strategies in several real world cases were, however, not long lasted in which the effect of induced travel demand, due to lower travel cost, eventually diminished the benefit of the newly added transport capacities. To this end, the idea of travel demand management has been put forward to also address the problem from the demand perspective.

Road pricing is one of possible travel demand management policies which has been widely suggested by transport economists and planners as an appropriate policy for tackling the congestion problem. Road pricing involves charging the motorists a fee for using their vehicles within specific areas or on specific roads. The term road pricing has been used to cover any fiscal form of traffic restraint including both direct and indirect charges of road users. The great interest in road pricing stems from its potential to control the car uses and to generate revenues for other transport projects. This potential benefit of road pricing puts it as a centrepiece of an integrated transport policy.

Various governments have been interested in introducing urban road pricing in their cities, but only few of them have actually succeeded (i.e. Singapore, Sweden, Norway, and UK). In fact, there was a long history of road pricing studies before the idea became well known. In the UK, the Smeed Report (Ministry of Transport, 1964) was the first full contribution of the theory and policy implementation of road pricing, which catalysed the interests in road pricing studies. Subsequently, the first practical road pricing scheme was implemented in 1975: the Area Licensing Scheme (ALS) in Singapore. The other country which successfully implemented the policy in that time is Norway. Toll rings were installed to raise revenue for transport projects around Bergen in 1986, Oslo in 1990, and Trondheim in 1991. Following the success of the Singapore's ALS scheme, other cities have started to pay attention to the possible implementation of road pricing. In 1985 an electronic road pricing was on trial in Hong Kong. In 1988 the Netherlands Government developed a proposal for a road pricing implementation in the region called 'Randstad'. In 1991 the Swedish Government created a proposal for introducing tolls around Stockholm. In UK several local authorities, e.g. Bristol, Cambridge, Derby, Durham, Edinburgh, Leeds, and London, are interested in road pricing since the central government gave new powers to decide whether they want to implement road user charging and to provide them to use the revenue for investment (DETR, 1998).

The recent interesting implementations are London Congestion Charging scheme starting on 17 February 2003, and Stockholm Congestion Tax starting on 1 August 2007.

One of the main barriers to the implementation of road pricing is the public acceptability (Jones, 1998, 2003; Jakobsson et al., 2000; Schade and Schlag, 2000, 2003; Jaensirisak et al., 2005). This in turn leads to the political acceptability issue. Two other important issues are institutional barriers (inappropriate legislation and organisation structures, and contradictory policies elsewhere) and time dimension (the temporal development of policy from conceptualisation and planning, through decision-making, to implementation and operation) (Milne et al., 2001; Glazer et al., 2001). These are particularly more crucial for developing countries in which the political situation is less stable. Road pricing is likely be most easily implemented in a city in which the planning and transport decisions and controls are vested in a single authority. An example is the experience of London. The creation of the Greater London Authority (GLA) and Transport for London (TfL) played a crucial role in overcoming these barriers by providing a single decision-making body. Nevertheless, the institutional and time dimension barriers should not pose a serious obstacle if the road pricing scheme is acceptable to the general public, and in turn to the politicians.

The other type of constraint is that transport is directly related to other economics sectors and markets (market interaction constraints) (Verhoef, 2001). This means that the transport decision makers have to take into account the indirect effects of a change in transport prices on other markets, e.g. change in commodity price due to higher transportation costs. This interrelationship creates a constraint that should be considered seriously in setting transport prices. It should be noted that technology was a barrier to the implementation in the past. However, the Singapore electronic road pricing, London congestion charging, and Stockholm congestion tax have proved the readiness of the current electronic road pricing technology for the real-world implementation.

In summary, from the pricing theory and experiences from many countries, it is clear that road pricing is the most efficient and environmentally beneficial available for congested cities. However, the success of the implementation of this viable policy is rather limited due to a number of barriers in social, political, and constitutional contexts which obstruct its implementation.

1.2 Objectives

This research aims to unravel an implementation process of both success and failure cases to indicate the underlying factors for such outcomes which will be useful for the decision making context of road pricing development in the future.

The objectives of this research are:

i. To review road pricing policy and its role in an integrated transport strategy
ii. Based on the real cases, to review implementation plan and process of road pricing
iii. From (ii) to determine factors influencing the successful implementation
iv. Similar to (iii) to identify the main barriers to its implementation and the strategies taken to overcome the barriers in difference cases

v. To draw the suggestions on implementation of road pricing in Thailand

1.3 Methodology

The implementation of road pricing is complex and often involves not only economic aspect but also political aspect. In order to study the factors that contributed to the successful implementation of road pricing schemes at the international level, we need to look at the history of each successful or unsuccessful case, especially the process before, during, and after the implementation phase. To do this, we need to collect the data, mostly qualitative data to construct the casual relationship between decisions in the process.

The study follows the analytical framework of Ongkittikul (2006) to construct the relationship between regulatory element and technological component as an interaction with transport policy. The research methodology is based on a qualitative approach. Two theoretical considerations are deployed, namely learning and feedback, and system dynamics approaches (see Section 1.3.1 and 1.3.2). A number of transport professionals and planners in each case study (see Section 1.4) were interviewed as main information to construct the casual relationship.

Based on this approach, this research conducted interviews with transport professionals and planners. A number of issues will be raised in the interviews including e.g.:

- Influential factors for successful implementation;
- Critical factors for the failure of the implementation;
- Institutional and organizational factors of the implementation and operation;
- The detail process of planning and lobbying the implementation;
- The detail process of implementation;
- Relationship between the transport policy and pricing policy;
- Relationship between transport policy and public transport in the road pricing area.

1.3.1 Learning and Feedback

Learning is vital for an organisation in developing its capabilities/competences. The concept of learning is the way in which an individual or organisation collects information and knowledge and processes it in order to improve performance.

Learning is also a feedback process (Sterman, 2000). In the learning process, we make decisions that alter the real world; we gather information feedback about the real world and, using the new information, we revise our understanding of the world and the decisions we make to bring out the perception of the state of the system as it relates to our goals. This is called a feedback loop.

The feedback loop obscures an important aspect of the learning process (Sterman, 2000). Information feedback about the real world is not the only input in our decision-making. Decisions are the result of applying a decision rule or policy to information about the world as we perceive it (Forrester, 1992). The policies are conditioned by institutional structures, organisational strategies, and cultural norms. These are governed by our mental model. This is a fundamental idea of the System Dynamics model. Forrester (1961) stresses that all decisions are based on models, usually mental models. In system dynamics, the term 'mental model' includes our beliefs about the networks of causes and effects that describe how a system operates, along with the boundary of the model and the time horizon we consider relevant (Sterman, 2000).

There are several barriers to learning. Among them is the issue of limited information which can be considered in two manners. First, the full information is not available. Often it is the case that the information is not available or we receive estimated values which have to be measured or sampled. The act of measurement introduces distortions, delays, biases, errors, and other imperfections, some known, others unknown, and unknowable (Sterman, 2000). Second, limited information occurs from individual perceptions. This issue relates to the mental models through which we define the system, evaluate, and report. These then condition the perceptions we form. Changes in our mental models are constrained by what we previously chose to define, measure, and attend to (Sterman, 2000).

The issue of limited information has a close link to the bounded rationality. The bounded rationality or problem-solving approach, as defined by behaviourists who take their lead from the work of Herbert Simon, stress some or all of the following elements. Man's rationality is "bounded": real-life decision problems are too complex to comprehend and, therefore, firms cannot maximise over the set of all conceivable alternatives.

The two key attributes to which Simon refers are the cognitive ability and the self-interestedness of human actors. Bounded rationality – behaviour that is intensely rational but only limitedly so – is the cognitive condition to which Simon refers. 'Frailties of motive' describes the condition of self-interestedness (Simon, 1985). Moreover, the importance of organisational tasks is to formalise the dynamics of organisational evolution through models which explicitly consider the interplay between three inter-related factors, namely: (a) a cognitive representation of the problem(s) the organisation faces; (b) a mechanism of variation, which generates new solutions, new ways of doing things; and (c) a mechanism of selection, implemented through various kind of incentives and reward mechanisms (Dosi et al., 2003).

The concept of bounded rationality is also a foundation in the study of organisation theory. Simon (1997) suggests that the term organisation refers to a complex pattern of human communications and relationships. The relationship between the organisation theory and bounded rationality is that organisational behaviour is the theory of intended and bounded rationality – it is about the behaviour of humans who satisfies because they do not have the ability to maximise. While neoclassical economic man maximises (selects the best alternative among all those available to him) or looks for a course of action that is satisfactory or good enough. Economic man deals with the real world in all of its complexity, whereas organisational man perceives a drastically simplified model of the real world (Simon, 1997). The implication that the decision makers are bounded by rationality is essential to this study. They have limited information and they lack the capability to process the information that they do posses.

Limited information reduces the potential for learning and performance by limiting our knowledge of the real world (Sterman, 2000). Simon (1957) asserts that the capacity of the human mind for formulating and solving complex problems is very small compared with the size of the problem whose solution is required for objectively rational behaviour in the real world. Though we sometimes attempt to make the best decisions we can, bounded rationality means we often systematically fall short, limiting our ability to learn from experience.

We can extend this learning concept into the concept of organisational learning as well. Because all learning takes place inside individual human heads, an organisation learns in only two ways: (a) by the learning of its members, or (b) by ingesting new members who have knowledge in the organisation who previously did not have it (Simon, 1991). Thus, the process of organisational learning is not only a part of the organisational and managerial processes that we discuss in the dynamic capabilities concept, but it governs all parts of the development of competences/capabilities. Organisational learning determines organisational and managerial processes as well as firm's positions. It also evaluates the path dependencies and technological opportunities of the firm.

Ongkittikul (2006) studied the tendering case of bus transport and revealed that the public transport manager has to adopt his organisational process to the tendering process that will take place in the area. The manager needs to coordinate and integrate his knowledge from various departments of the company in order to prepare the offer. How efficiently and effectively internal coordination is achieved is crucial here. In order to prepare the bid, the company's assets must be realised. The company positions are considered here as well. Then the manager must understand the company's paths, i.e. the past investments and the company practices in the public transport services. The manager also needs to search for technical opportunities to be used in the tender. All elements, i.e. processes, positions, and paths, are developed by using the company's competence/capabilities which are built through the learning process.

This approach was a starting point to interview and analyse information from the interview of transport professionals and planners, in order to understand the policy process of the road pricing in our case studies.

1.3.2 System Dynamic Models

System dynamics models can be characterized as structural, disequilibrium, behavioural models (Radzicki and Sterman, 1994). System dynamics models seek to portray the micro-structure of a system at the operational level. The feedback loop structure of any dynamic system consists of the physical structure of the system, the flows of information characterizing the state of the system, and the decision rules of the agents in the system, including the behavioural decision rules people use to manage their affairs (Radzicki and Sterman, 1994).

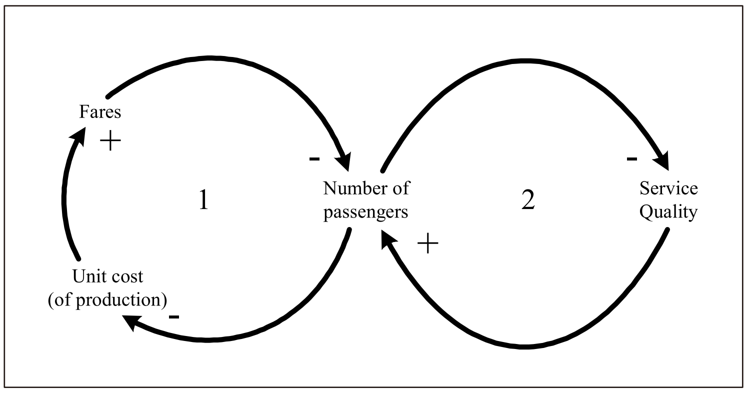
Radzicki and Sterman (1994) stress that a fundamental feature of system dynamics models is that they rest on the theory of bounded rationality (Simon, 1981, Nelson and Winter, 1982). The essence of the theory is summarized in Herbert Simon's principle of bounded rationality (Simon, 1957):

The capacity of the human mind for formulating and solving complex problems is very small *compared to the size of the problem whose solution is required for objectively rational behaviour in the real world or even for a reasonable approximation to such objectively rationality*.

The attributes described above make system dynamics modelling well suited to the study of evolutionary dynamics in human systems (Radzicki and Sterman, 1994). The flexibility of the simulation method and emphasis on empirical assessment of the decision rules of the actors means the microstructure of a system can be represented with great fidelity.

The behaviour of a system develops from its structure. That structure consists of the feedback loops, stocks, flows and nonlinearities created by the interaction of the physical and institutional structure of the system which the decision-making processes of the actors involved in the system (Sterman, 2000). The feedback loop is considered as an important element of system dynamics models. It represents the relationship between structure and behaviour of the model. There are two types of feedback loops; positive and negative. Figure 1 shows an example of these feedback loops.

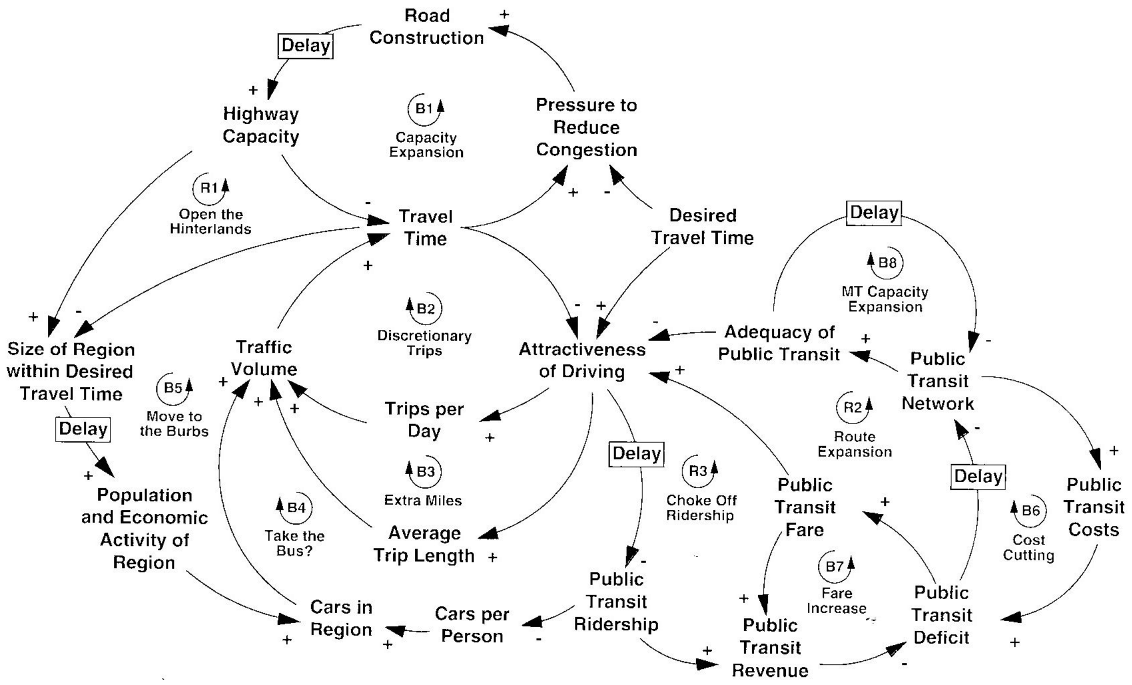
Figure 1 Example of two feedback loops



Mayo et al. (1999) give a simple example of these two feedback loops related to public transport service. Figure 1 above, adapted from Mayo et al. (1999), illustrates how such feedback loops are represented. In the positive or self-reinforcing loop on the left (1), if fares are cut, the number of passengers increases. A negative-sign arrow means that the change is in a reverse direction. An increase in the number of passengers lowers unit costs. This also presents by a negative-sign arrow. A decrease in unit costs lowers fares. This presents by a positive-sign arrow as the change is in the same direction. For this loop, it is called exponential growth; it arises from positive feedback (Sterman, 2000). The negative or balancing loop on the right (2) illustrates that the number of passengers increases, service quality problems increase if the capacity is not adequate enough to meet the increased volume of passengers. These negative loops seek balance, equilibrium, and stasis (Sterman, 2000).

For more complicated example, Sterman (2000) provides a policy analysis of the problem 'The Mass Transit Death Spiral', as shown in Figure 2. The main mechanism is that, as lower travel time caused by new roads increases the attractiveness of driving, ridership and revenue of the public transit system fall. Public transit operation's costs do not fall very much, since most of the costs are the fixed costs of providing service: buses must run whether they are full or empty. If the transit authority tries to close its deficit by cost cutting, service and quality erode. Furthermore, the adequacy of a public transit system depends not only on the scope of the network and the frequency of service but also on the size and population density of the region. As population density falls, fewer and fewer people live near a bus or subway route. Public transit becomes less and less useful, leading to more driving and lower mass transit riderships. This is just an example of a complex system where the system dynamic approach can provide a more insightful analysis to the public policy.

Figure 2 Example of Casual Loops: The high fixed cost of mass transit lead to a death spiral (Sterman, 2000)



1.4 Case Studies and Justification

The case studies in this research include:

- Singapore
- London, UK
- Stockholm, Sweden
- Seoul, South Korea
- Hong Kong

There are several underlying reasons for the selection of these particular cases. In the nutshell, each of these cases represents different key aspects of success and failure during the planning and implementation phase of road pricing policy. In addition, in some cases the local environment and circumstance can be compared to the condition in Thailand to some extent. The justification and key observation points for these cases are provided as follows.

Singapore

Singapore has been at the forefront of the development of the road pricing policy which was started by a low-tech scheme since 1970's. The case represents an ideal subject for studying the actual impact of different design or implementation aspects of road pricing. Particularly, three main points can be analyzed from this case including the impact and effect of different pricing structure (e.g. area covered and time of day), utilization of revenue in improving public transport services, and evolution process of the scheme from a simple one to a more complex system. Nevertheless, the political climate and social norm in Singapore is considerably different from the situation in Thailand. This point is well aware by the team and other cases, thus, are included in the study to supplement this part.

London, UK

There are three interesting issues for the UK case study in relation to this project. The first is the experiences from the planning and implementation of the area pricing scheme in London. This case illustrates the factors of political leadership and timing of the implementation. The political climate in London and UK in general is more similar to the condition in Thailand (as compared to Singapore). Thus, the scheme in London can provide us the details on how to handle public and political acceptability problems. For London case, there are several detailed documents and reports on the design, strategy, justification, and political discussion before, during, and post the implementation phase of the scheme. These are invaluable sources for understanding the factors for success and failure in delivering a pricing scheme. The last issue for the UK case is related to the government plan and action to promote and support the development of road pricing policy in different cities in the UK including the legislation process. On the formal side, prior to the implementation of the scheme in London, the government had to modify and approve several legislations to allow for the introduction of road pricing scheme and enable the local authority to utilize the revenues collected from the scheme in several ways. In addition, on the non-legislative part, several policies at the national level have been put forward by the government to encourage and support different cities to apply the pricing policy. For instance, the government offers an advance budget for developing major public transport infrastructures for the cities planning to implement the policy. On the technical side, a congestion charging partnership was set up to regularly promote the idea and provide information on the development and design process of the scheme.

Stockholm, Sweden

The experience in Stockholm represents a unique case for understanding the benefit of illustrating the benefit of the scheme to the public. The swing of the votes to support the scheme after the trial of the road pricing scheme in Stockholm is a key lesson for any other cities who are interested in implementing the policy. The case illustrates the benefit of a clear illustration of the objective and benefit of the scheme and the significance of open political debates on the topic. This research benefits from this case by looking at the planning and development process of the trial scheme and the communication methods between the city and the public, as well as monitoring the progress of the development of the current scheme which was transformed from the trial one.

Seoul, South Korea

The case study in South Korea is primarily on the Namsen tunnel toll in Seoul. The similarity between Seoul and Bangkok makes this case study an ideal subject for analyzing the approach to overcome public opposition (or increase public acceptability) to the road pricing policy through different planning and public participation stages. The Seoul case illustrates a different tactic of introducing the road pricing policy to the public through the introduction of toll onto existing tolled road but with different purposes. Also, the case demonstrates a great power of public understanding campaign and selection of the scheme. The justification of the scheme is clear which is due to the congestion problem on these major corridors to the Seoul CBD. It is also interesting to look at the approach taken to avoid the direct impact to many stakeholders in the same time. A form of exemption (high occupancy vehicle) is introduced to encourage shared rides and also the taxis are exempted from the toll. This form of road pricing development is particular of relevance for the development in Thailand especially in Bangkok since already having a large extensive network of tolled expressway in the city which is under different contractual agreements.

Hong Kong

Although there has not been any successful implementation of a real urban road pricing scheme in Hong Kong, the city has been developing several plans and proposal since 1970s'. The main objective for studying this case is to look at the key obstacles that prevent Hong Kong to implement the schemes including technological and political issues. It is also the intention to look at the attempt of the government to develop the proposals over the years in order to handle these issues (there were already at least three major studies on the implementation of road pricing policy in Hong Kong). There are also several similarities between Bangkok and Hong Kong particularly on the social norm, public participation, and high volume of taxis in the traffic system which should enhance the transferability of the experiences to avoid the same problem.

1.5 Outline of Report

This report is aimed for transportation policy makers and planners who are considering the application of road pricing to urban areas. It is intended to identify potential obstacles in the planning process, and to develop effective strategies to assure successful implementation, in order to assist policy makers in developing road pricing initiatives.

The report reviews in Chapter 2 the general background of urban road pricing, and in Chapter 3 reviews experiences of road pricing in various cities, both in the stage of planning process and in the stage of implementation process. The report then in Chapter 4 summarises and discusses key success and failure from selected case studies: including Hong Kong, London, Seoul, Singapore, and Stockholm. From the analysis of these cases, the casual relationships among the critical factors were constructed to explain the initial and design phases of road pricing development. Finally, through the case studies, the report provides in Chapter 5 lessons leaned and road map regarding what to do and what not to do in developing and implementing urban road pricing for travel demand management.

2. Review of Road Pricing

2.1 Introduction

The objective of this chapter is to provide an overview of road pricing and a review of relevant previous studies. It includes general background: definitions, objectives and development history in Section 2.2, and economic background in Section 2.3. Finally, the design of road pricing schemes is presented in Section 2.4.

2.2 General Background of Road Pricing

This section provides an overview about road user charging. This includes definition and objectives of the policy. Different terms have been used with the same or similar meaning as road user charging. Different goals can be set for different schemes. The development history of road pricing is also briefed in this section.

2.2.1 Definitions and Objectives

Road pricing, in general, is a transport policy for charging motorists a fee for using their vehicles within specific areas or on specific roads. The main concept of road pricing can be defined in two ways by Jones and Hervik (1992). Firstly, by traffic engineers and transport planners it refers to the imposition of direct charges on road use, with a variety of objectives. These are for managing travel demand in order to alleviate traffic congestion and to reduce the environmental impacts from traffic, and for generating revenue to finance transport services and infrastructure. Secondly, by economists road pricing is referred to as the setting of pricing equal to the difference between the social marginal cost and the marginal private cost of a journey. It is a means of achieving what economists define to be optimal.

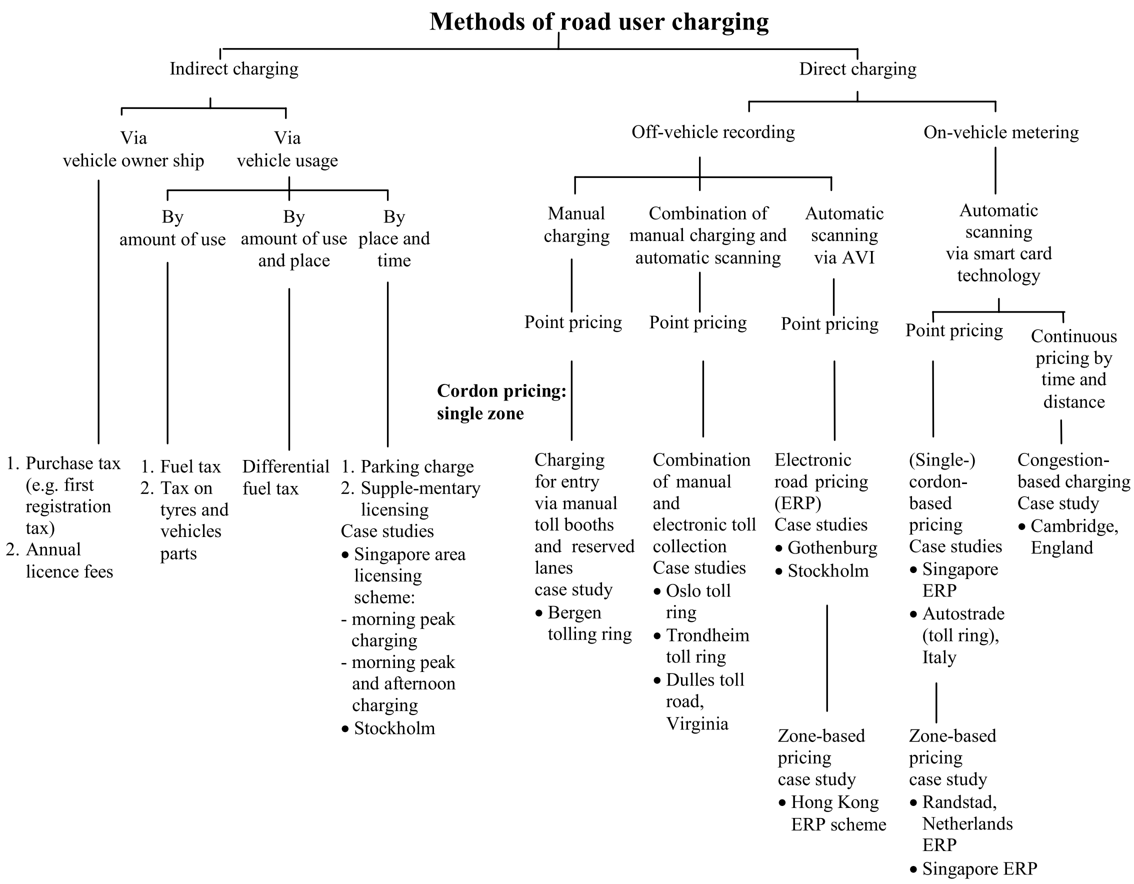
The term road pricing has been used to cover any fiscal form of traffic restraint (Thompson, 1990) including both direct and indirect charges of road users (Ministry of Transport, 1964; Lewis, 1993). However, various terms have been used in parallel with the term road pricing, e.g. road user charging and congestion charging (in UK) and congestion pricing (in USA), and the specific terms, e.g. road tolling, value pricing, variable pricing and peak period pricing.

In UK during 1990s, the term *road user charging* was widely used for specifying direct charge schemes and formally used by the government, but since 2000 it has been called *congestion charging*. In the USA, one particular form of road pricing called *congestion pricing* is only used for the objective of reducing congestion (Giuliano, 1992) by charging each motorist a fee that is directly related to the amount of congestion he or she causes in using a road; as a result motorists are encouraged to travel during less congested time, by less congested routes or by alternative modes, or not to travel at all (Gomez-Ibanez and Small, 1994). The Transportation Research Board (1994) also states that “congestion pricing would charge a premium to motorists who wish to drive during peak travel periods through strategies that could include tolls on roads or bridges, fees to enter congested areas, or changes in the structure of parking and transit pricing”. The terms *variable pricing* and *peak period pricing* are sometimes used to specify that a charge is varied by time of day, in order to shift demand from peak periods to off-peak periods or other modes.

Road tolling is defined as road tolls or charges imposed by governments or private investors to finance the construction of new roads and maintenance of old roads where the objective is to maximise revenue (Luk and Chung, 1997). *Value pricing* was first introduced by the private operators of the SR91 Express Lanes in California. The term is defined by the Institute of Transport Engineers (ITE, USA) as a “system of optional fees paid by drivers to gain access to alternative road facilities providing a superior level of service and offering time saving compared to the free facility” (cited in Orski, 1998). Road tolling and value pricing are slightly different from the concept of road pricing. They may charge motorists for financing the construction costs or for providing better service, and may not be necessarily implemented on congested roads.

There are many methods of road pricing. The Smeed Report (1964) illustrated the different methods of charging and then it was developed by Lewis (1993) as shown in Figure 3.

Figure 3 Alternative methods of road user charging



Source: Lewis, 1993

2.2.2 Development History of Road Pricing in Transport Planning

The concept of road pricing was initially mentioned in the middle of the 18th century (see Section 2.3). In the UK, the Smeed Report (Ministry of Transport, 1964) was the first full contribution of the theory of road pricing to policy implementation, which seemed to be a catalyst of interest in road pricing studies. Subsequently, the first practical road pricing scheme was applied in 1975 through the Area Licensing Scheme (ALS) in Singapore to reduce traffic congestion. Another country, which has successfully implemented road pricing, is Norway. Toll rings were installed to raise revenue for transport projects around Bergen in 1986, Oslo in 1990, and Trondheim in 1991. Many other countries are also interested in implementation of road pricing. In 1985 an electronic road pricing was on trial in Hong Kong. In 1988 the Netherlands Government developed a proposal for a road pricing implementation in the region called 'Randstad'. In 1991 the Swedish Government created a proposal for introducing tolls around Stockholm. In UK several local authorities, e.g. Bristol, Cambridge, Derby, Durham, Edinburgh, Leeds, and London, are interested in road pricing since the central government gave new powers to decide whether they want to implement road user charging and to provide them to use the revenue for investment (DETR, 1998). This led to the congestion charging initiative in London (GOL, 2000; GLA, 2001), which has been implementing since 17 February 2003. The most recent urban road pricing is in Stockholm, starting on 1 August 2007. More details of these schemes are reported in Chapter 3.

In summary, so far the only successful implementations of urban road pricing are in Singapore (which replaced the manual (ALS) system by an electronic road pricing system in 1998), five cities in Norway, London and Stockholm. Other countries are still studying road pricing and trying to gain support from the public.

2.3 Economic Background of Road User Charging

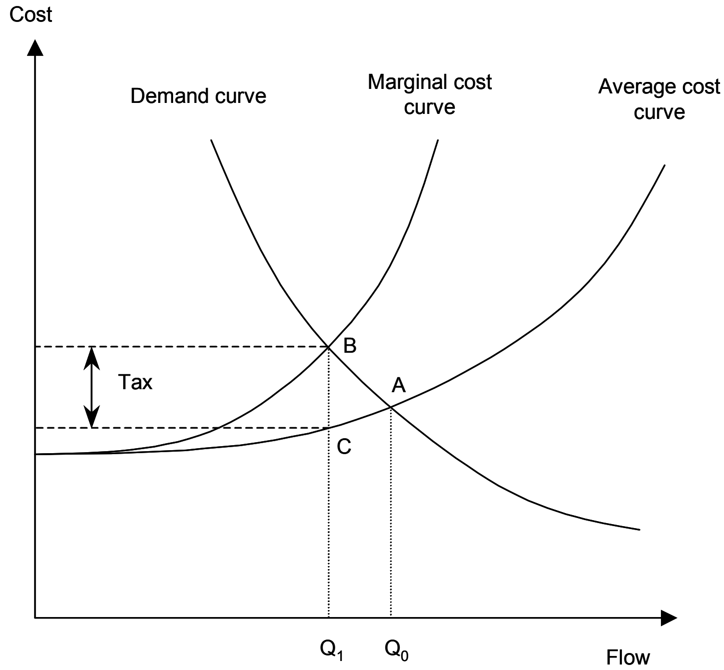
Over 200 years ago Adam Smith (1776), a Scottish economist, already mentioned the principles of efficient provision of 'public good' (e.g. roads, bridges, canals and harbours). Smith argued that services should be paid for by those who benefit from them. Dupuit (1844), a French engineer, by using a simple example of the imposition of a toll on a footbridge, demonstrated efficiency of pricing, for which the benefit to users of the bridge was greater than the revenue collected from the users.

A substantial studies of the economics of road user charging, based on the marginal pricing concept pointed out by Marshall (1890), has been led by Pigou (1920) and Knight (1924). They introduced the simple two-road example and argued that by imposing a toll-tax on a congested road, total travel time would be reduced and encourage the more efficient use of road space, so that society's welfare would be enhanced. Walters (1954) clearly suggested that "motor taxation should be levied so that the marginal private cost of vehicle operation is brought nearer to the marginal social costs and the degree of congestion on our roads is reduced". Vickrey (1955) also stated that marginal cost should be concerned in an elaboration of any scheme of prices in order to achieve the efficient utilisation of facilities. However, this has not happened in practice. He believed that in "no other major area are pricing practices so irrational, so out of date, and so conducive to waste as in urban transportation" (Vickrey, 1963).

Since the cost rises as traffic speed falls, an extra cost is imposed on the average cost of all users when an individual driver is added to a road network. The average cost is slightly higher than before the individual joined, because of increase of travel time and pressure from other vehicles. This concept was mentioned by Walters (1961), Beesley and Roth (1962) and the Smeed Committee (Ministry of Transport, 1964).

A basic representation of the concept is presented in Figure 4. The demand curve represents the decreasing flow with increasing cost. The average cost curve shows an increasing cost as flow increases. The intersection of the demand curve with the average cost curve (point A) represents the equilibrium condition where flow is Q0. The marginal cost curve illustrates the extra costs imposed on itself and other vehicles by the addition of one extra vehicle. If travel costs are increased by a road user charge CB, the flow of traffic reduces from Q0 to Q1 (optimal flow in which there is no extra cost imposed with an extra vehicle), where the demand curve intersects the marginal cost curve. With this charge, overall welfare of society would be improved, from which revenue plus benefits of those who are willing to pay for delayed-time reduction is higher than the loss of those who stop using the network.

Figure 4 The simple economics of road user charging



The marginal cost function can be related to objectives of the charge. Firstly, if the objective is concerned only with congestion, the marginal cost curve will include the extra cost of delay, which vehicles impose on each other. Secondly, the curve will be different, if the objective is also concerned with other external costs e.g. air pollution, noise and accidents. Furthermore, in the case of maximising revenue, the curve is not taken into account. The level of charge is dependent upon the elasticity of the traffic demand.

Following the development of the basic charging concept, various studies have contributed to the economic theory of road pricing; for example, by Vickrey (1969), Walter (1987), Newbery (1990), Small (1992), Verhoef (1996) and Hau (1992a, 1998). The more recent development of the fundamental analysis involves the specification of demand and supply for congested networks. One theory is that the average cost curve can be bent backward when demand exceeds the maximum capacity of the network and speed falls with flow (hypercongestion). Nevertheless, there is still an on-going debated among researchers, who have still not agreed on the fundamental analysis.

The initial analysis (see e.g. Hau, 1992a; Verhoef, 1999) used a static model with the flow-based approach to explain the several points of intersection between the demand function and the backward-bending supply function. This supply function is derived from the relationship between average network speed and traffic flow for a given time period, in order to represent performance of the network. This is based on an assumption that congestion on a network is stable with continuous demand.

The flow-based approach is criticised by Hills and Gray (2000) who believe the backward-bending curve of cost/flow over simplifies the actual traffic network, in which traffic flow performs differently across different times and segments of network. By using a micro-simulation approach, May et al. (2000) addressed the behavioural responses relating to the spatial change (route choice) and the temporal change (departure time choice), whereas the costs to users were measured by tracking individual vehicles through the network, not cutting them in a given time period (as done for the performance curve).

This issue was investigated in detail based on micro-simulations in a DETR project 'Analysis of Congested Network' (2001) carried by ITS (University of Leeds), TORG (University of Newcastle upon Tyne), John Bates' Services (Consultant) and TRL (Transport Research Laboratory). They demonstrated that the use of performance curves to estimate supply curves is unreliable, and will generally overestimate the flow levels at which congestion charging is the first justified and underestimate its benefits. They claimed that *"once demand and supply have been properly defined and the dynamic complexity of congestion properly represented in a model of a suitable specification, then the impact on supply/demand interaction of any change (whether in pricing, regulation or investment) could be analysed in the normal way"*. However, this has not been achieved. Some further interesting studies are suggested by the project, for example exploration of dynamic rescheduling and route-choice behaviour, extension of modelling to include vehicle-occupancy and other important behavioural responses (e.g. shifts in mode, destination and frequency) to changes in trip costs, exploration of more complex networks and the incorporation of different journey-purposes and multiple user-classes.

2.4 Design of Road Pricing Schemes

In this section, the design of road user charging systems is presented. This includes general criteria of design and main structure of the systems.

2.4.1 General Criteria of Design

In the UK pricing measures have been studied sine the early of 1960s. The Smeed Committee (DOT, 1964) specified the nine most important requirements of the system as following:

- Charges should be closely related to the amount of use made of the road;
- It should be possible to very prices;
- Prices should be stable and readily ascertainable by road users before they embark upon a journey;
- Payment in advance should be possible;
- The incidence of the system upon individual road users should be accepted as fair;
- The method should be simple for road users to understand;
- Any equipment used should possess a high degree of reliability;
- It should be reasonable free from the possibility of fraud and evasion; and
- It should be capable of being applied, if necessary, to the whole country.

Eight desirable features which were also considered, but not so important are as following:

- Payment should be possible in small amounts and at fairly frequent intervals;
- Drivers in high-cost areas should be made aware of the rate they are incurring;
- The method should be applicable without difficulty to road users entering from abroad;
- Enforcement measures should impose as little extra work on the police forces as possible;
- It would be preferable if the method could also be used to charge for street parking;
- The method should, if possible, indicate the strength of demand for road space in different places; and
- The method should be amenable to gradual introduction commencing with an experimental phase.

For the design of road user charging, although each city and country has its own constraints, some general criteria should be considered (Ministry of Transport, 1964; Thompson, 1990; Hau, 1992a):

- *fairness*, the charges should be perceived as fair by most travellers. This may involve basis of charge (e.g. based on quantity of road use), charged areas, time periods, and the travellers who are charged;
- *simplicity*, the charging system should be easy to understand by the public;
- *accuracy*, the charging system should always be accurate and be able to be verified by users;
- *enforcement*, the system should be capable of protecting against fraud and evasion;
- *privacy*, the system should be designed to protect users' privacy;
- *flexibility,* the system should be able to integrate with other systems, e.g. driver information system and roadside information system, etc.;
- *technology*, to achieve all above issues technologies should be appropriately applied.

These cover the four characteristics of a 'good' tax proposed by Smith (1776) in his book 'The Wealth of Nations', in which the objectives of a good tax should be considered as equity, certainty, convenience and efficiency.

Furthermore, The High Level Group on Transport Infrastructure Charging (1998), convened by the European Commission, in considering the general concept of charging, commented that "the consequence of introducing the proposed charging systems should be to reduce rather than to increase total transport related costs to the economy as a whole". This decrease of overall costs could be achieved because the charge should increase efficiency of operation and use of infrastructure, and the 'external' costs which are incurred somewhere in the economy will be paid directly by those who cause them.

2.4.2 Structure of Road User Charging System

Various road user charging features have been studied; for example, those reviewed by May et al. (1991), May (1992), Hau (1992b), Lewis (1993), Gomez-Ibanez and Small (1994), and Small and Gomez-Ibanez (1998). These show many practical features of road pricing. In addition to setting objectives of the system, there are five key issues, which need to be addressed when designing a road pricing system (Jones, 1998):

- type of traveller/vehicle to be charged;
- charged area;
- charged period;
- charging level;
- charging basis.

Type of traveller/vehicle to be charged

To classify categories of travellers to be charged, the objectives of the scheme should be specified. Jones (1998) suggests that exemption of some types of traveller or vehicle can be made; for example: of pedestrians, cyclists and drivers of electric vehicles, when pollution reduction is an objective of the scheme; of pedestrians, cyclists and public transport users, when congestion reduction is an objective of the scheme; and of disabled drivers and goods vehicles, according to 'need' to use vehicles. Moreover, occasional users, visitors, high occupancy vehicle users and residents in the charged area should also be considered when designing the system. However, designers of the system needs to be concerned that if residents in the charged area were exempt from the charge, this is likely to affect the effectiveness of the scheme.

Charged area

Evidence from road pricing studies and implementation has shown various scales of implementation that can be divided into three (Decorla-Souza, 1993; Bhatt, 1993). Firstly, single facility pricing (small scale) involves charging for use of a segment of motorway or bridge, e.g. in USA, UK and France. Secondly, area-wide pricing (medium scale) involves charging within a small area such as a city centre or a central business area. For example, this has been implemented in Singapore and Norway's cities and also researched for Hong Kong, Cambridge, Stockholm, Leeds and London. Finally regional-wide pricing (large scale) involves charging within a regional area covering urban areas and road networks; for example, studied for Randstad region (Netherlands).

The design of road pricing scales is dependent on the objectives of the scheme, and local geographical factors. For example, when the objective is to reduce congestion the scale of charged area (covering a congested area) may be smaller than when the objective is to reduce pollution (Jones, 1998). Single facility pricing may be for the objective of covering the construction costs or reducing congestion on a particular section. If the objective is to generate revenue, the scale should be adequate to prevent 'rat running' and bypassing.

Charged period

The charged period is closely related to the objectives of the scheme (Jones, 1998). Many time periods could be used. A charge could be installed 24 hours a day when revenue raising is a major issue; for example, in Oslo. It could be applied only to the daytime for reducing congestion and pollution. At weekends some reasons for having no charge are that there are fewer problems and the scheme can gain more public acceptance (MVA, 1995).

Charging level

The level of charge is dependent on the policy objectives and local circumstances (Jones, 1998). For example, a low charging level could be applied for generating revenue, e.g. in Norway's cities, while a high charging level could be used for reducing traffic and pollution, e.g. in Singapore (Small and Gomez-Ibanez, 1998), as well as social benefit optimality. The level of charge could vary by categories of user or vehicle (e.g. high charge for vehicles which cause the problem, and low or free for others), by time of day (e.g. same charge all day, charge peak time only, or charge all day with higher charges in peak times), by areas (e.g. high charge in the central area and low charge in the suburbs), and by direction of traffic (e.g. inbound only or both directions).

Charging basis

Two broad charging bases are categorised in the design: point-based and area-based (MVA, 1995; Milne, 1992; Jones, 1998). There are two types of point-based charging: cordon-based and cellular system, while there are five types of area-based charging: supplementary licence, time-based, distance-based, congestion-based and externality-based. These are described as follows.

Firstly, for point-based charging, drivers are charged when entering specific areas, defined by a single or series of boundaries. The charge is directly dependent on the number of boundary crossings made by the vehicle (Milne, 1992). Two types of point-based charging: cordon-based and cellular systems are suggested (MVA, 1995). Cordon-based systems involve one, two or more boundary lines around a specified area, and sometimes with screen lines. For example, single toll cordons have been implemented around three Norwegian cities. Cellular systems include many cells; for example, a system of hexagonal cells, each with a radius of about a mile.

Secondly, for area-based charging, many types have been considered.

- A supplementary licence system requires a licence to be purchased for and displayed on any vehicle used within a charged area (May, 1975). This system had been used in Singapore since 1975, before being replacing by an automatic point-based charging system, electronic road pricing (ERP) in 1998 (see URL: www.lta.gov.sg/erp/index.html). While the original Singapore scheme used manual enforcement, enforcement can now be achieved by video or digital camera studied for Leeds (Richards and Harrison, 1999) and London (GOL, 2000).

- Distance-based charging involves a charge calculated from the distance travelled within a charged area. This charging basis would be predictable based on route choice, and would not lead to dangerous driving behaviour (Milne, 1992; MVA, 1995).

- Time-based charging involves a charge calculated from the time spent travelling within a charged area. This charging method is perceived by the public as a fair system (Thorpe et al., 2000). However, it leads to fast driving, which in turn may induce unsafe driving behaviour (Bonsall and Palmer, 1997).

- Congestion-based (delay-based) charging is that vehicle users are charged when using their vehicles on a congested road in a charged area but they are not charged when the road is not congested. For example in the study for Cambridge, a congested road is specified as being when a vehicle using the road has four stops within 0.5 km, or when the time taken to travel any 0.5 km is above three minutes (Oldridge, 1995). The delay-based charging is related to congestion levels, so the charge tends to be difficult for users to predict. This regime also may induce unsafe driving behaviour (Bonsall and Palmer, 1997).

- Externality-based charging involves a charge linked directly to the negative impact being caused by the vehicle (Jones, 1998); for example, the charge could be related to exhaust emissions from vehicles.

2.5 Summary

This chapter presented general background, which should be useful for decision makers. Various terms relating to road user charging were explained. The development history and economic background was summarised. The general criteria and the charging system features, which are important in the design, were described.

3. Experiences of Road Pricing

3.1 Introduction

The objective of this chapter is to provide an overview of some interesting road pricing schemes, including Singapore, Norway, London, Stockholm, Hong Kong, the Netherlands and Seoul. It is also to summarise lessons learned from the experiences and a number of studies, which lead to a research gap for this study.

3.2 Road Pricing Schemes

In practice, there are some interesting road pricing cases, including Singapore, Norway, London and Stockholm, have successful introduced urban road pricing measures. They have demonstrated different objectives and system designs. Thus they have different effects on traffic and travel behaviour. Governments of some countries introduced proposals of urban road pricing schemes. Although the studies of the impacts of the schemes demonstrated that the design could achieve their objectives, they have not yet been implemented. These implemented and un-implemented cases are as presented below for example.

Singapore

Singapore was the first country to introduce urban road user charging. Initially, the objective was to restrict traffic at peak periods into the Central Business District in order to alleviate congestion. The system applied was called Area-Licensing Scheme (ALS) (Figure 5), covering most of the central area in peak morning hours. The system was paper-based, and enforcement was effected by observers posted at each of the 22 entrance-points to the Restricted Zone-RZ (over 5 kilometres square). Each vehicle entering this zone had to display an area licence on windscreen.

Figure 5 ALS boundary

As a result of the scheme, traffic volumes during the morning peak hours fell almost immediately by 45% (against the goal 25-30%) and average speeds increased from 18 to 35 km/h (Holland and Watson, 1978). Though the ALS had achieved more than the target, it was argued that the price of an ALS licence had been set too high; thus causing less than optimal use of available road space in peak hours (Wilson, 1988; McCarthy and Tay, 1993).

Initially, the charge structure was simply a flat rate charge of S$3 for travelling inside the RZ in the AM peak period (7:30-9:30 a.m.) on Monday to Saturday. However, three weeks later the charging hours was extended until 10:15am in response to the substantial increase in traffic volume entering the RZ just after 9:30am (Chin, 2002). The charge was then increased to S$4 and S$5 in 1976 and 1980 respectively. Gradually, the structure of the charge and charging period was modified to increase the effectiveness of the scheme. In 1989, the charge period was extended into the PM peak (4:30pm – 7:00pm) with a charge level of S$3. The charge period was extended again to the whole day from Monday to Friday in 1994 with the same charge level of S$3. The ALS was considered successful and it was also claimed that there were no significant impact on businesses inside the RZ (Seik, 1998).

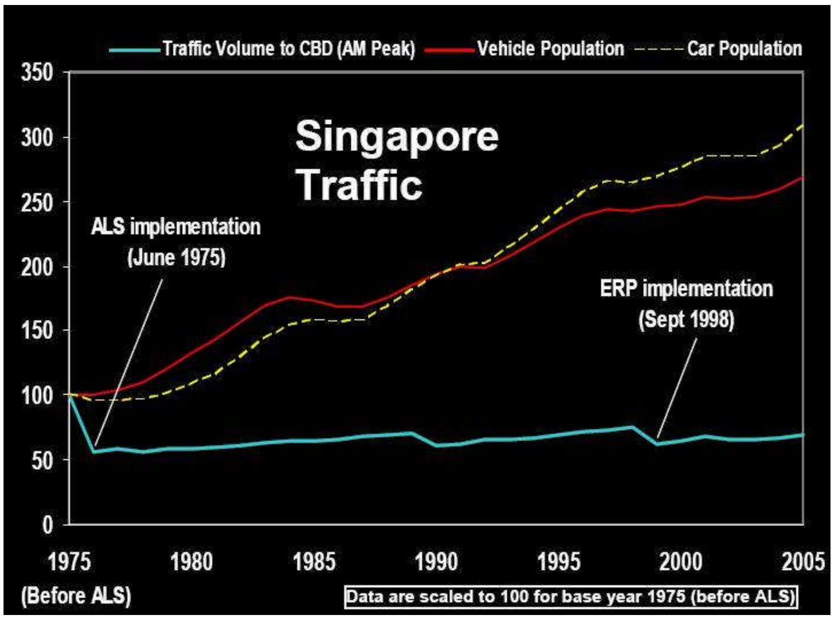
Nevertheless, the original ALS also had unintended adverse effects such as congestion on feeder roads and expressways leading to the CBD (Goh, 2002). The government decided to introduce the Road Pricing Scheme (RPS) to regulate traffic on the expressways and feeder roads in 1995. The RPS (manually operated) was implemented on the three main expressways heading to the CBD with congestion tolls to pass defined points. About 16% of motorists stopped using the expressways during the RPS operation hours (between 7:30am and 9:30am). However, the ALS and RP schemes were claimed to cause underutilisation of the roads within the CBD and not to be able to deter the congestion outside the RZ and RPS. In addition, the manual operation of both systems was too labour-intensive and not flexible enough to permit the future modification of the scheme.

In 1998 the ALS was replaced by Electronic Road Pricing (ERP) (Menon, 2000). The objective of the system was changed to improve travel speeds in the road network. Vehicles to pass through the area, during 7:30am and 7:00pm on weekdays and 7:30am and 2:00pm on Saturday, must have an electronic In-vehicle Unit in which a smartcard with positive cash balance has been inserted. The toll applying at the particular time when the vehicle passes under each of the 33 gantries is automatically deducted without the driver having to slow down. Prices applied under ERP do not fluctuate directly with actual traffic volumes, but they are subject to maintain traffic speeds of 45-65 km/h on expressways and 20-30 km/h on arterial roads. The tolls would be varied according to the average speed on the network.

Immediately after the implementation of the ERP, the traffic volume on the heavily congested roads fell by 17% from the condition during the operation of ALS. Traffic volume into the CBD decreased by 10-15% compared to the condition during the ALS operation (Chin 2002). ERP has been effective in maintaining a speed range of 45 to 65 km/hr for expressways and 20 to 30 km/hr for major roads as intended. The estimated monthly revenue from the system is S$3.4 million which is substantially lower than the revenue collected from the old ALS and RPS schemes, about S$5.8 million/month (Goh, 2002). The change of the fundamental principle of charging from ALS which allowed multiple entries for the whole day to the ERP which charges per crossing is the reason for the significant drop in the demand despite the lower charge rates. Figure 6 shows the impacts of Singapore road pricing traffic volume to CBD.

Advantages of the ERP over ALS are mentioned as being that it is more efficient, flexible, reliable and convenient, though with higher initial investment costs (Foo, 2000). From data one year after the implementation, Luk (1999) by using the short-run price elasticities showed that the scheme would be twice as effective as a petrol price increase in reducing car travel, but that they were similar in inducing mode shift to public transport. It would appear that ERP was not intended to force a transfer from cars to other modes, although some traffic reduction is measured (Menon, 2000).

Figure 6 Impacts of Singapore road pricing traffic volume to CBD



Sources: Land Transport Authority (LTA), Singapore

It should be noted from the experiences of Singapore that the road pricing scheme is successful because the system is a part of a policy package, including e.g. substantial improvement of public transport, high parking charge and additional registration fee, and vehicle quota system. Singapore can easily implement the ‘stick’ policies because there is no political problem; the government is strong and people believe in the government’s policies. Moreover, surprisingly, the restraint policies have no major negative side effect on economic growth; on the contrary, they have generated substantial funds for the improvement of social welfare (Willoughby, 2001).

Norway

In Norway, five cities are implementing cordon pricing. Bergen was the first city to introduce the scheme in 1986, followed by Oslo in 1990, Trondheim in 1991, Stavanger in 1991 and Kristiansand in 1992. The systems involve charging all vehicles entering the cities. In Bergen, the toll system operates between 6am and 10am on weekdays. In Oslo, it is 24-hours operation on both weekdays and weekends. In Trondheim, the time of charge is between 6am-5pm, with discount after 10am, on weekdays. An *'amputated'* toll ring with only two toll plazas was in operation from 1992-1996 in Kristiansand. A new package and toll charge period were recently agreed to fund the construction of the new trunk road (E18) and two tunnels through Kristiansand. In 2001 Stavanger implemented a city toll "ring". The toll will be in operation for 10 years to finance the new road and other transport projects. Table 3.1 summarises the characteristics of the schemes in these five cases.

In these cases, the main objective of the toll rings was to raise revenue to finance road projects. The scheme was not designed to reduce traffic. The cordons were designed to capture traffic heading to the central area of the city from the outside of the cordon. Thus, the cordon were designed to leave most of the population outside the charging boundary and also minimize the possibility of avoiding the tolls. The experiences of the toll rings suggest that although the demand management was not among the objectives of the schemes, some impacts on travel behaviour and traffic volume were found. To accommodate the objective of the scheme and the explicit presentation of the scheme to the public, the Norway's tolls are low, ranging from approximately $0.70 to $1.75 per entry, and do not vary much by time of day (Gomez-Ibañez and Small, 1994).

Given the original objective of raising revenues, the lower toll level in all schemes only reduced the traffic slightly, around 6-7% for Bergen, 3-4% in Oslo, and 10% in Trondheim during the charged periods (Larsen, 1995). Nevertheless, the results of before-and-after survey showed that in Trondheim about 40% of the public indicated effects on their travel behaviour, e.g. changing mode, time, route, destination and frequency, on the contrary, in Oslo and Bergen the impacts on travel behaviour were relatively small (Meland and Polak, 1993).

Originally, in Bergen the toll revenues collected were only used for road projects. A new agreement was reached in 2002 for maintaining the toll ring system until 2011 with the basic toll levels increased to 15 NOK from 2004 onwards (which coincides with the implementation of electronic collection), only 45% of the revenues will be allocated to road investment, and the scheme being refocused as a congestion charging system. In Oslo, Trondheim, Kristiansand, and Stavanger, the revenues will help finance road projects, public transport improvement, and other safety instruments.

Currently, 25% of the total annual budget for road construction in Norway comes from the road pricing schemes around the country (Odeck and Brathen, 2002). Most of the road pricing schemes impose tolls on particular section of trunk roads, tunnels, or bridges. Only five of them are urban charging cordon schemes (or toll rings): in Bergen, Oslo, Trondheim, Stavenger, and Kristiansand.

The toll ring system in Norway is currently at the crossroads. Most of the projects around the country were originally initiated to finance major local transport schemes (mostly road transport infrastructure). The agreements for many existing schemes are near to the end or already terminated (the case in Bergen). A decision on the future of the toll rings has to be

Table 1 Key characteristics of the Norwegian toll rings (May and Sumalee, 2003)

	Bergen	Oslo	Trondheim	Kristiansand	Stavenger
City population	213,000	456,000	138,000	70,000	103,000
Starting Date	Jan, 1986	Feb, 1990	Oct, 1991	April, 1992	April 2001
Number of toll stations	7	19	22	5	21
Charging regime	Uniform charge	Uniform charge	Peak and Off peak charge	Uniform charge	Peak and Off peak charge[1]
Entry charge for small vehicle[2] (NOK)	10	15	15 (for all period for manual payment[3])	10	10 for Peak 11 for Off peak
Charging period	Weekday 6am-10pm	All days All hours	Weekday 6am-6pm	Weekday 6am-6pm	Weekday 6am-6pm
Discount	Discount for monthly sub-scriptions	Discount for prepaid tickets	Discounts for users of electronic systems	Discount for monthly subscriptions	Several ad-vance payment discounts with AutoPass
Annual gross revenues (NOK millions)	156	1,046	168	95	80
Annual operat-ing costs (NOK millions)	30	103	17	20	21

1 Peak period: 7am-9am and 2pm-5pm; off peak period: other period between 6am-6pm.
2 Heavy vehicles are charged double price
3 For prepayment of 6000 NOK, 9 NOK between 6am-10am and 6 NOK between 10am-6pm; for prepayment of 3000 NOK, 10.5 NOK between 6am-10am and 7.5 NOK between 10am-6pm; for prepayment of 1000 NOK, 12 NOK between 6am-10am and 9 NOK between 10am-6pm.

made. At the national level in Norway a new law on tolling and road pricing has just been sanctioned by the Parliament. Through this law road user charging is accepted as a means both for revenue raising and for demand management, but the two objectives can never be mixed. This means that today's tolling systems must be dismantled before any urban pricing scheme can be introduced. Public acceptance of these changes is also uncertain. While 54% opposed Bergen's toll ring before its implementation, that had fallen to 37% a year later. It is not clear whether toll rings designed for congestion charging will attract such majority support.

Recently discussions have taken place concerning the modification of the current toll financing schemes to congestion charging schemes in Bergen, Oslo, and Trondheim (May and Sumalee, 2003).

London

The first proposal for London road pricing was during the 1970s by the Greater London Council (GLC). The charging system was 'supplementary licensing', in which every vehicle was required to purchase a daily licence to drive in the Inner London area. These charges were expected to reduce traffic substantially and to increase speeds by about 40% during peak period (May, 1975). However, the proposal was rejected by the GLC in 1975.

In the 1980s the London Planning Advisor Committee (LPAC) commissioned research into a number of transport strategies. This work concluded that improvement of public transport by itself was not seen as sufficient; there was a need for direct measures to restraint road traffic and to obtain a better balance between the demand and supply of road space. Various possibilities were suggested. Congestion charging was seen as the most favourable.

During the early 1990s, 'The London Congestion Charging Research Programme' was sponsored by the Department of Transport in UK (MVA, 1995). The research studied various charging systems. The simplest scheme was a single cordon charge around central London. The most complex schemes involved three cordons and screen-lines. The levels of charges were different for each cordon and screen-line and time period. The study found that the charging schemes were relatively effective in reducing car use. For example, for a single cordon charge around central London at £8 per crossing, 22% reduction of total vehicle kilometres could be expected. Nevertheless, the schemes were very much likely to be opposed by the public. At the end the systems were postponed by the government.

In 1999, the Greater London Authority Act was passed by parliament. This act gives London a unique local government structure. It also provides full powers for the Mayor to introduce congestion charging schemes in Greater London.

For London surveys in 1999, the results reported by the Government Office for London (GOL) show that a daily charge of £5 for driving within Central London and £2.50 for Inner London is supported by about a half of the respondents (53%). Also the survey by MORI (GOL, 2000) found that the scheme is supported by majority of the public, particularly when the revenue is proposed to be used for public transport improvement.

In May 2000, Mr. Livingstone was elected to be the Mayor of London on the basis of a manifesto which included a promise to introduce a congestion charging scheme in central London. Charging schemes suggested were based on the 'Road Charging Options for London' study, which was produced by an independent group of transport professionals (called Review of Charging Options for London (ROCOL) Working Group) and supported by Government Office for London (GOL, 2000).

The London congestion charging scheme was successfully introduced on 17 February 2003. The level of charge is £8 per vehicle per day (£5 before 4 June 2005). The scheme enforcement is based on the area licence enforced by using digital cameras to check number plats against the database. The charge operates between 7am and 6.30pm on weekdays within central London (21 square kilometres) (Figure 7). Some vehicles such as buses, minibuses (over a certain size), taxis, ambulances, fire engines and police vehicles, motorcycles, very small three-wheelers, alternative fuel vehicles and bicycles are exempt from the charge. Residents of the zone are eligible for a 90% discount.

Transport for London (TfL) reported the impacts after six months operation that the average number of cars and delivery vehicles entering the central zone was 60,000 fewer than the previous year. Around 50–60% of this reduction was attributed to transfers to public transport, 20–30% to journeys avoiding the zone, 15-25% switching to car share, and the remainder to reduced number of journeys, more traveling outside the hours of operation, and increased use of motorbikes and bicycles. Journey times were found to have been reduced by 14%.

Figure 7 London congestion charging area

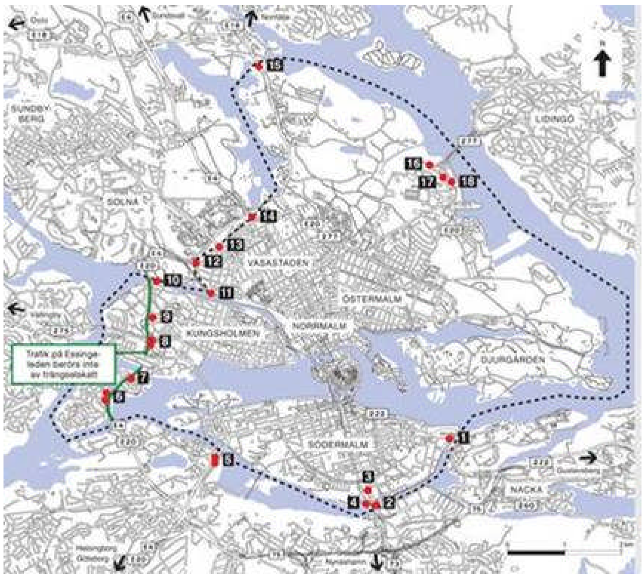
Stockholm

The road pricing system for Stockholm was proposed in 1991. The objective was primarily to reduce air pollution, traffic noise and congestion. The charging system was based on pre-purchased licences. The charge would have operated on weekdays by using £30 monthly cards or £2.50 daily cards (May et al., 1991). These have been predicted to reduce traffic by 10% and 6-8%, respectively. However, in 1997 the proposal was suspended by the government because of political problems and opposition by the business community (Ahlstrand, 2001).

In 1999, a new study of road pricing for Stockholm was carried out by the Swedish Institute for Transport and Communications Analysis (SIKA), a governmental agency. It was claimed that road pricing would be able to reduce the number of private cars struck in the morning peak period by 90-95%, compared to the current situations, and to decrease car traffic in the Stockholm region between 1998 and 2010 by 9% in the morning peak time (Ahlstrand, 2001).

On 2 June 2003 the Stockholm City Council passed a decision to conduct a trial implementation of environmental charges in the Stockholm inner city zone, about 47 square kilometres (Figure 8). On 28 April 2004, the Swedish Government submitted the Congestion Tax Bill to Parliament. The bill was approved by Parliament in June 2004 and the Congestion Tax Act was issued on 17 June 2004. In an appendix to the Act it was stated that the trial implementation of a congestion tax in Stockholm would start on a date to be decided by the Government and continue until 31 July 2006. Thus, the full-scale trial in Stockholm began on 22 August 2005, when public transport services were expanded. The trial congestion tax applied for seven months, between 3 January and 31 July 2006.

Figure 8 Stockholm congestion tax area



A referendum was held in September 2006 (about two months after the end of the trial period). In the referendum the residents of Stockholm municipality voted "yes" (more than 50% of voters) and in 14 other municipalities voted "no" to implement it permanently. However, on October 1, 2006, the leaders of the winning parties in the 2006 general election, declared they would implement the Stockholm congestion tax permanently. The parliament approved this on 20 June 2007, and the congestion tax came into effect on 1 August 2007.

The primary purpose of the congestion tax is to reduce traffic congestion and improve the environmental situation in central Stockholm. The charge operates between 6.30am and 6.00pm on weekdays. The amount of charge is 10-20 SEK (about 1.5-3 USD) depending on time of the day. The charge is applied to every crossing the cordon (both enter and exit the area). However, the maximum amount of tax per vehicle per day is 60 SEK. The vehicles passing the control points are identified through automatic number plate recognition. The equipment, consisting of cameras, laser detectors, antennas, and information signs are mounted on a set of gantries at each control point.

As results of the tax, traffic entering the inner Stockholm decrease about 20%, and 10-14% less emissions in the inner city. Public support has increased after the implementation.

Hong Kong

In 1982, the Hong Kong government decided to adopt fiscal controls to contain traffic. Particular measures introduced were trebling the annual fee for private cars and doubling the fuel tax and the registration fee for new cars. As a result of the vehicle ownership restraint, private vehicle ownership decreased from 211,000 in 1981 to 170,000 in 1984. However, the level of congestion was only reduced in the least congested (low income) areas and in the same time rose in the most congested areas (Dawson and Brown, 1985). Private car and taxi use still remained high, particularly during peak periods (Lewis, 1993).

In response to this failure, the first Hong Kong pilot of Electronic Road Pricing System (RRP) was undertaken between 1983 and 1985. The Hong Kong chose not to adopt a low-tech option like the ALS in Singapore on the basis that it would be too liable to fraud and require a considerable amount of enforcement (Borins, 1988). The system was based on the automatic toll collection, billing and enforcement. Three schemes with different levels of charge, number of zones and geographical coverage were tested. Vehicles' owners would receive a bill with details of their use of the network at the end of each month (Catling and Harbord, 1985).

The effects of the schemes were predicted (by a traffic simulation model) to reduce total daily car trips by 9-13% and peak-period trips by 20-24% (Harrison, 1986). Economic evaluation found that net benefits of the schemes were satisfactory (Gomez-Ibanez and Small, 1994). Nevertheless, the schemes were not implemented. One of the main reasons was the public concern about the potential intrusion of privacy by 'big brother', in addition to political and economic problems (Hau, 1992b).

After the failure of the attempt, in 1994, the Hong Kong government revived the idea of tackling traffic congestion by road pricing. The government commissioned a major feasibility study, which began in March 1997, with the objective of examining the practicality of implementing ERP in Hong Kong. Various technological alternatives were considered including the DSRC system as currently operated in Singapore and the Vehicle Positioning System (VPS) based on Global Positioning System (GPS). A cordon-based charging scheme was still the preferred alternative for the charging regime. Similarly to the scheme design in 1983, the charging zone would cover the most congested areas of Hong Kong and be operated on a directional and time period basis. The initial suggestion was that the peak period charge would be from 8:00am to 9:00am and from 5:30pm and 7:00pm. A slightly lower charge would be applied during the inter-peak hours. The charge rate would be set to maintain a target speed on 20km/hr. It was estimated that the implementation of this proposed ERP scheme would reduce car trips entering the charging zones by up to 50%, with 40% diverting to public transport and 10% changing travel time. In order to rectify the failure of the first proposal, there was a well-planned public consultation programme to allow public input into the development of the scheme.

Technology trials were conducted in late 1998 with both DSRC and VPS technologies. The results showed that both DSRC and VPS could be adopted in Hong Kong and the privacy issue could be overcome. However, in 2001 the government concluded that based on the feasibility study report in 1999 there were no transport and environmental grounds to justify electronic road pricing (Legislative Council, 2001). Therefore, the government decided not to pursue the implementation of the ERP scheme, despite the promising results of the technological trials. Although the technological barrier in relation to the privacy issue has been overcome, the question of the political and public acceptability of ERP still remains.

Most recently, after 2003 economic has been growing, so there is an increase of congestion and pollution, as well as an increase of public awareness in particularly air quality. To address the problem, the Council for Sustainable Development in Hong Kong offers a series of options and suggestions to tackle the problem in the "Clean Air and Blue Skies – the Choice is Our" report in 2006. One option suggested is road pricing. Currently, this option is under discussing in Hong Kong.

Netherlands

During the late 1980s, the Dutch government developed a road pricing proposal for the Randstad region. This covers four big urban areas (over 2,000 square miles) including Amsterdam, Rotterdam, Hague and Utrecht. The objective was to manage travel demand and raise revenue to finance transport project. The plan involved charging points every 10 km based on £1 peak-period charges and 10p off-peak period charges, by using SMART card technology with infra-red or microwave communications (May et al., 1991). The scheme was expected to reduce vehicle travel by 17% during peak hours (Small and Gomez-Ibanez, 1998). Nonetheless, it was rejected in 1990 because of public concerns about technical feasibility, invasion of privacy and prevention of traffic spilling over to local streets.

In 1991, a more conventional form of road toll using toll plazas (tollpleinen) was proposed. The objective of the scheme was redefined to solely raise money for road infrastructure. However, due to the potential disruption of the traffic caused by the stop-and-go operation of the toll plazas and the amount of land required for implementation, the proposal was rejected.

In 1992, a reduced scope proposal involving a system of supplementary licensing for motorists using the main road network during peak periods (spitsvignet) was discussed. The rush hour motorists would have been charged a fixed amount toll to travel during peak hours regardless of the area. The charge would be about $2.85 per day (1992 prices) applied during the morning rush hour 6am-10am. However, the proposal was not approved after a new government was elected in 1994. Boot et al (1999) suggested that the most important reason for the failure of these earlier proposals was political acceptability.

Subsequently, in October 1994 the Dutch parliament agreed in principle and strongly proposed the implementation of a revised form of rekening rijden (referred to as 'congestion charging') which would be a system of electronic toll cordons around the four main cities in the Randstad area starting in year 2001 (Dutch Minister of Transport, 1995). The charge would be in operation during the morning rush hour (7am-9am) on weekdays. The objectives of this late proposal were to improve accessibility of the economic centres.

In 2001, new charging scheme was proposed by the Dutch Ministry of Transport, Public Work and Work Management, in 'The National Traffic and Transport Plan' proving a vision for traffic and transport in 2020. It included the mileage charge scheme, in which private cars would be charged a per-kilometre fee for using their cars in the Randstad area. This was based on the principle "the more you drive the more you pay". The charges will include environmental tax and vary with peak and off-peak periods.

The barriers to the success of the implementation of congestion charging in the Netherlands have been politics and technology. The success of the recent proposal for a kilometre charge will rely heavily on the reliability and capability of charging technology. However, the greatest barrier for further progress still seems to be political one, and closely linked to the public acceptability (May and Sumalee, 2003).

Seoul, Korea

Seoul has experienced a rapid growth in car ownership and serious congestion problem since 1980's. Several self-financed expressways were commissioned to relief the pressure on the existing road network. In particular, the Namsan #1 and #3 tunnels were constructed to serve as the main corridors linking the southern part of the city to the Central Business District (CBD). The tolls of 100 won (around 0.1 USD) were collected for 20 years until 1996 to recover the construction costs. The concession of the tunnels came to an end in 1996. After that, the Seoul Metropolitan Government (SMG) started charging the tolls of 2000 won (around 2 USD) as a congestion charging toll for both tunnels. The tolls are applied to all private vehicles occupied by less than three persons (including the driver). The tolls are collected manually at the tollbooths in which the staffs can check the number of passengers in the vehicle before applying the tolls. The objectives of this implementation are three fold: reducing low occupancy vehicle, raising revenues for transport related projects, and assessing the effectiveness of the pricing technique.

In 1996, 90% of the traffic volume passing the two tunnels was made by private vehicles in which more than 78% of the private vehicles were one person occupied. This was the highest among all the major corridors linked to the CBD. After the congestion toll operation, the number of carpooling vehicles (occupied by three of more persons) has increased substantially (more than double of the original figure). Immediately after the toll implementation in 1996, the traffic volumes on these two tunnels decreased by around 25%. However, the total traffic volume has been increasing since and the total traffic volume in 2000 exceeded the level before the toll implementation (around 96,000 vehicles during 7am – 9pm period). Nevertheless, the greater proportion of this traffic volume consisted of toll-free vehicles such as taxies and high-occupancy privative vehicles. Furthermore, the traffic speed in the tunnels increases by 70% in 2000 compared to the speed before the toll implementation.

Based on the post-evaluation of the scheme mentioned earlier, it can be summarized that the Namsan tunnel tolls successfully achieved the set objective in encouraging the carpooling and increasing the efficiency of the expressway system. In particular, the tolls cause the shift in travel mode (including the use of higher occupancy vehicle) which improves the travel condition on these two tunnels. This also benefit the rest of the network by improving the travel condition all other interconnected routes.

Before the implementation, the SMG started a campaign to spread information in Seoul to raise the awareness of the congestion problem particularly in these two tunnels. The campaign also promoted participation and communication between of the public and the authority to ensure the acceptance of the new policies. It was suggested later on that the key ingredient to the successful implementation of the congestion toll was mainly credited to public hearings, information campaigns, and efforts to win media support, as well as political leadership.

3.3 Learning from Previous Studies

A number of research has attempted to explain success and failure of urban road pricing from the international experiences. For example:

Jaensirisak (2003) concluded that major issues should be concerned in implementation of road pricing schemes, in order to achieve public acceptability, effectiveness and practicability, including:

- *Existing circumstance*. Congestion and pollution must be bad enough, in order to gain support from the public.
- *Benefits and objectives* need to meet the public concern. It is found that using the scheme as a financial instrument is more easily to be acceptable than using it for demand management. Specification of the scheme's objectives needs to keep simple and straightforward.
- *System characteristics* need to be simple to understand for the public. A scheme would also be preferable if the charge can be predicted.
- *Revenue allocation* needs to meet the public preference. The most frequent suggestions are using revenue to improve public transport and reduce tax. The scheme proposal needs to specify precisely how the revenue would be used.
- *Equity issues* need to be considered. This relates to the distribution of cost and benefits. If road user charging is perceived as unjust and unfair, acceptance will be difficult to achieve. It must also not be perceived as a kind of punishment. This issue can be added by revenue distribution.
- A*lternative means of travel* need to be available. This must be part of a policy package, which can compensate those who cannot afford the charge, as well as contribute to perception of freedom of choice.
- *Technology* needs to retain flexibility once implemented, so that it could be easily later adjusted to overcome unpredicted problems.
- *Communication and marketing strategy* can be of use to improve public understanding. It also can be used to create public awareness of the transport problems, and then to enable a scheme to be perceived as effective solution. It is important to consult with all of those who might be affected, both positively and negatively, by the scheme.

May and Sumalee (2003) found that where proposals fail, the barriers to progress include: lack of political commitment reinforced by limited public acceptance and specific concerns over equity, economic impacts and, to a lesser extent, technology.

AECOM Consult (2006) explored the use of road pricing in various cities. The experiences from both successful and unsuccessful of international urban road pricing initiatives were revealed. This study summarised the key reasons why road pricing initiatives have failed to be implemented:

- Inadequately describing the rationale for the program and the consequences of inaction.
- Failing to anticipate, understand, or address public opposition to the initiative, (especially those groups who fail to understand how the scheme could benefit them and perceive they will only be disadvantaged by the scheme).
- Trying to please every interest group by making exceptions and discounts that defeat the intent of the program or make it overly complex.
- Over-emphasising revenue generation as the principle reason for road pricing.
- Not clearly stating how the proceeds from the road pricing scheme will be used.
- Public distrust of the agency responsible for program implementation and administration.

On the other hand, the most common features of successful road pricing initiatives:

- Having strong political champion(s) with the determination and longevity to see the program developed, implemented, and refined. (However, this does not guarantee success, especially if the political party supporting the scheme is voted out of office.)
- Clearly defining the goals of the road pricing initiative and the benefits expected to be received by the travelling public in terms of:
  - Congestion relief;
  - Reduced air pollution;
  - Improved alternative transport services; and
  - Expedited projects to expand existing transport network capacity.
- Dedicating at least a portion of the net revenues from the scheme to improve public transit infrastructure and/or services.
- Continuously monitoring and adjusting the road pricing scheme over time as the conditions and requirements for congestion relief and the need for revenues to support infrastructure development change.
- Using interoperable transponders for multiple jurisdictions implementing road pricing schemes within the same country.

Importantly, the study suggested several key strategies to address the obstacles, including:

- Identify congestion problems and their severity;
- Identify how the project will address these congestion problems as well as the estimated consequences of inaction;
- Introduce the road pricing scheme as part of a larger congestion relief initiative that includes both capital and operational elements;
- Identify both the benefits and costs of the road pricing scheme relative to the status quo;
- Implement a continuous public outreach and communication program;
- Anticipate through public and business outreach the major challenges that will face the project and their severity throughout the planning process; and
- Demonstrate how equity and privacy concerns will be addressed and mitigated.

A recent European project named CURACAO (Co-ordination of Urban RoAd-user ChArging Organisational issues, 2006-2009) aims to coordinate research and monitor the results of the implementation of road user charging as a demand management tool in urban areas. The project attempts to identify the barriers to road pricing implementation, and provide evidence on ways of overcoming those barriers. This project addresses a series of themes which relate to road pricing design and implementation. The issues include:

- the possible objectives of road pricing schemes;
- the ways in which road pricing schemes can be designed to meet those objectives;
- the technologies available to support such scheme designs;
- the Business Systems affecting the technology choice and operation of the scheme;
- techniques for predicting the effects of road pricing schemes;
- techniques for appraising/evaluating the effects of road pricing schemes;
- specific evidence of impacts on the economy;
- environment;

- equity;
- factors affecting the acceptability of road pricing schemes; and
- the potential transferability of experience from one city to another.

These suggestions obviously attempt to gain public and political acceptability, which is the key barrier of road pricing implementation. Although the general acceptance level tends to be low, it does exhibit considerable variation. There are a number of possible causes of this variation.

Acceptability was found to be large differences in according to system features, e.g. charging level, charging method, area of charge (e.g. Cain et al, 2002, Jaensirisak et al., 2005). There is a preference for simple systems (Bonsall and Cho, 1999), although Schlag and Schade (2000) found little difference between distance based, congestion based and cordon pricing.

Numerous studies illustrate the critical impact of hypothecation on acceptability (Schlag and Teubel, 1997; Jones, 1998; PATS Consortium, 2001; Güller, 2002; Tretvik, 2003). The need for revenue hypothecation and its use to benefit as many as possible so that opposition to the scheme is minimised has long been recognised (Goodwin, 1989, Jones, 1991, Small, 1992). Increases in acceptability when hypothecation of the revenue was specified were also apparent in several other studies (CfIT/MORI, 2000, 2001; GOL, 2000; NEDO, 1991; Thorpe et al., 2000). Some have found that the greatest impact is obtained from spending on improved public transport (Jones, 1991; GOL, 2000; Schlag and Schade, 2000; CfIT/MORI, 2001; Thorpe et al., 2000; Hårsman, 2001) whilst in others it is investment in the road network (Larsen, 1995; PATS Consortium, 2001) and in yet others it is reduction in taxes (CfIT/MORI, 2000; Harrington et al., 2001; Lex, 2002).

Acceptability has been found to be influenced by attitudes to transport problems and the perceived effectiveness of the scheme (Bartley, 1995; Sheldon et al., 1993; van der Loop and Veling, 1994; Luk and Chung 1997; Schlag and Teubel, 1997; Rietveld and Verhoef, 1998; PATS Consortium, 2001; Jaensirisak et al., 2005). It is also influenced by attitudes relating to the environment and towards the hazards of car traffic (Jones et al, 1996; Verhoef et al., 1997; Nilsson and Kuller, 2000; Güller, 2002).

Other attitudinal aspects of acceptability relate to perceptions of freedom and fairness (Baron, 1995; Jones, 1998; Jakobsson et al., 2000; Golob, 2001; PATS Consortium, 2001) and concerns over equity issues (Giuliano, 1992, 1994; Langmyhr, 1997; Teubel, 1997; Hårsman, 2001). Nonetheless, Rienstra et al. (1999) recognise that social concerns do influence preferences toward road pricing whilst Schade and Schlag (2000) identified social norms to be important.

The importance of the communication process to acceptability has been highlighted (Sheldon et al., 1993; Schade and Schlag, 2000; Hårsman, 2001), making clear the main objectives, addressing public concerns and spelling out the benefits. Frey (2003) claims that the key barriers to public acceptance are: misunderstanding of the role of prices in allocating scarce resources; aversion to price as a means of allocating resources as inherently unfair; mistrust of government intervention; and distributional concerns. He concludes that a fundamental change in decision making in the form of local referenda offer the potential to overcome resistance.

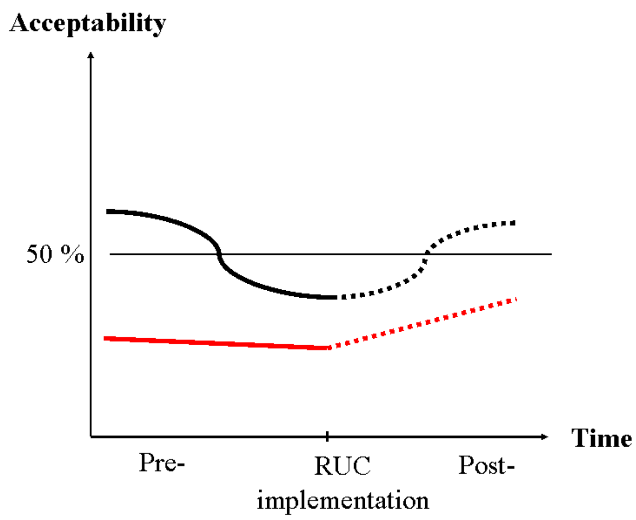
The scheme benefits that will influence acceptability are the time savings and environmental improvements. However, it is uncertain that travel time reduction and environmental improvement are perceived by the public to be worthwhile enough to compensate for the charge (Giuliano, 1992; Harrington et 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.

Politicians obviously can influence the implementation process. CURACAO project (2008) found that the factors influencing political acceptability are somehow similar to those that have been found to be important for public acceptability; therefore, in this situation a political champion or figurehead, who takes ownership of the congestion charging concept, clearly facilitate the implementation process.

CURACAO project (2008) also mentioned an importance of business community and the media in the implementation process. The business community is one stakeholder which opinion counts in the introduction process due to the fact that they are important local taxpayers and politicians fear relocation of important business sectors. The media, by choosing the topics and the way of presenting it, can influence not only the public opinion, but also the opinion of all relevant stakeholders considerably.

This knowledge on factors affecting on acceptability is very useful in road pricing implementation process. However, acceptability is not a static factor within the implementation process, but it may be highly dynamical throughout the pre-, the decision- and the post-implementation phase (Schade, Seidel and Schlag, 2004). Figure 9 show possible developments of attitudes towards road pricing. Acceptability decreases the closer and

Figure 9 Possible developments of attitudes towards road user charging (RUC)



Source: Schade, Seidel and Schlag, 2004

more concrete the proposal gets. In addition, the higher the initial ex-ante acceptability the stronger should be the decrease of positive attitudes in the course of the implementation process. After implementation, support increases again. However, the reasons for these changes need to be further validated.

3.4 Conclusions

This chapter presented an overview of some interesting road pricing schemes, including Singapore, Norway, London, Stockholm, Hong Kong, the Netherlands and Seoul. It also summarised lessons learned from the experiences and a number of studies. This provided major issues which should be concerned in design and implementation processes of road pricing schemes, in order to achieve acceptability. The issues involve economic, political, and social aspects. As can be imagined, the implementation process of road pricing would be rather complex. However, the previous findings and suggestions do not show complexity or interaction among the issues. Once we attempt to tackle the issues at the same time, without concerning the relationship, effects of such attempt may cancel each other. On the other hand, if the interaction is taken into account, we would be able to design effective instruments, which their effects are synthesised, to overcome the barriers of road pricing implementation. Therefore, this hypothesis leads to a research gap for this study.

CHAPTER 4 LESSONS LEARNED FROM THE SELECTED CASE STUDIES

4. Lessons Learned from the Selected Case Studies

4.1 Introduction

From the experiences reviewed in Chapter 3, we know that the implementation of road pricing is very complex. In order to study the factors that contributed to the successful implementation of road pricing schemes, we need to look at the history of successful or unsuccessful cases. To do this, this research selects some interesting case studies including: Singapore, London, Stockholm, Seoul, and Hong Kong. There are several underlying reasons for the selection of these particular cases (see Section 1.4). These cases represent different key aspects of success and failure during the planning and implementation phase of road pricing policy. In some cases the local environment and circumstance can be compared to the condition in Thailand to some extent.

The study collected the data, mostly qualitative data to construct the casual relationship between decisions in the process. Two theoretical considerations were deployed, namely learning and feedback, and system dynamics approaches (see Section 1.3.1 and 1.3.2). A number of transport professionals and planners in each case study were interviewed as main information to construct the casual relationship. Nevertheless, prior to the data collection, the secondary data was reviewed (in Chapter 3, particularly Section 3.3) in order to form a structure of discussion during the interviews.

This chapter presents, in Section 4.2, lessons learned from selected case studies, and in Section 4.3 the analysis result of casual relationship among key factors in the development of road pricing.

4.2 Lessons Learned from Selected Case Studies

4.2.1 Stockholm

Section 3.2 already provided an extensive background of the development and implementation of the road pricing scheme in Stockholm. Apart from this background information, we also conducted in-depth interviews with those who were working closely with the Stockholm city during the design and implementation phases. Several aspects and barriers of the implementation of the policy are similar to other cases including acceptability, political leadership, adverse impact alleviation, etc. However, one of the key outcomes that we can learn from the Stockholm scheme lies in the revelation of the system dynamic of social responses to the proposal and plan of the road pricing scheme. As shown in Figure 9, the dynamic of acceptability, as defined by Schade et al (2004), was actually observed during the whole planning and implementation phases of the scheme in Stockholm.

Three phases of public opinion on the policy can be identified: initial phase, planning and implementation phase, and post-implementation phase. The experience from the Stockholm case illustrates that during the initial phase the public may not express such a strong opposition toward the idea put forward by the city council or politician. However, the public opposition will become more serious after the authority approves or commissions a study on the feasibility or starts to discuss about the possible plan for the scheme. Then, the swing of the public support can be observed after the implementation and trial of the scheme.

There are two underlying factors of this social dynamic: (i) **perception of likelihood** of the scheme and (ii) **uncertainty** of the outcome of the scheme. During the initial phase the public may not really pay close attention to the on-going discussion since it is still a far reality. In addition, the outcome or impact of the scheme is still very uncertain. Consequently not many oppositions or stakeholders will come out to strongly criticise the policy. However, after the city council or the government really decide to pursue the idea to the study and consultation phase, the perception of likelihood and inevitability of the scheme gradually builds up. Under this circumstance, we can observe strong oppositions or even campaigns against the scheme from different stakeholders. This may be exacerbated by a clearer picture of the impacts of the scheme on different areas and stakeholder groups. Most cities (including Hong Kong, London in the past, Stockholm in the past, and other cities which had attempted to implement road pricing policy) abandoned the schemes at this phase to avoid the public confrontation and political damage.

However, this Stockholm scheme was pushed forward but with the trial phase of the scheme. After the trial phase, the scheme entered its post-implementation phase in which the public perceived the scheme as “inevitable” and the benefit of the scheme, as well as its impacts were revealed during the trial phase. In this case, the scheme performed extremely well during the trial delivering what the city promised to the public in terms of congestion alleviation and environmental improvement. It should be noted that before the scheme trial bus services as an **alternative to car** were significantly improved.

In addition, the city also introduced different measures to relieve some of the adverse impacts caused by the scheme on different stakeholder groups. As a result, we can observe the swing of the public opinion toward supporting the scheme. Thus, during the initial phase it is important to **raise the awareness of the public** about the congestion and environmental problems.

Furthermore, it is critical to inject the **knowledge** and discussion about possible solution and potential advantage of road pricing at this early stage since it will be less meaningful to attempt this after the initial phase. Thus, in this initial phase and study phase a good and accurate **communication** between the authority in charge and the public can help the smooth transition of the scheme development. For example, the objectives and benefits of the scheme to reduce congestion and environment problems in the city centre were clarified and promoted. **Revenue allocation plan** was clear and approved by the public. This was one of the key factors to achieve public acceptability.

To avoid the failure of the policy during the study phase the government or city should prepare to allow for further evaluation of the scheme, i.e. trial of the scheme. In the Stockholm case, this is the critical decision made by the political party in charge in that time to allow for the trial before making the final decision about the scheme. In this way, the public's anxiety about the potential impacts can be reduced. However, this option or practice also comes with a trade-off in which the trial of the scheme may require as high budget as the actual implementation. Furthermore, the success of the trail scheme critically underpins the final decision of the project.

Finally, it was found that the Stockholm city ensured these critical issues by carefully designing and evaluating the schemes. The term "**common-sense**" is not so common when it comes to design and plan the (trial) scheme. The city put great efforts in the detailed modelling studies and evaluations. The scheme is rather flexible to adjust to ensure that the scheme design can deliver its promises.

4.2.2 Hong Kong

Hong Kong has been trying to discuss and plan a road pricing scheme for several decades but without any success yet. This series of unsuccessful delivery of the policy provides us a good case to study the barriers of road pricing implementation.

The initial period of the attempt to discuss and implement the policy back in 1980's was failed due to the **inappropriate timing**. There was on-going uncertainty about what would happen to Hong Kong after the hand-over (was due in 1997) in which the political regime and authority would be changed completely. Under the uncertainty circumstance, such an aggressive and provocative policy as road pricing could not be discussed. Nevertheless, the Hong Kong government in that time managed to commission a detailed study on the feasibility and options for the road pricing implementation in Hong Kong. The idea was raised again in 1990's but was eventually halt due to the **economic downturn** of the region. A similar circumstance also occurred in 2003 when the economy of Hong Kong was seriously damaged by the SARS and the bird-flu breakout.

These series of events highlighted the influence of "**good timing**" for involving the public in the discussion about the road pricing policy. The good timing can be viewed as the period when the **congestion level** in the city reaches its peak in which it can naturally be associated with the period with stable growth of economy. The timing can also be related to **political stability** in the city which is slightly different from the issue of political leadership. The political stability can be viewed as a situation where there exists a clear direction of the authority and policy of that city as well as a clear legislation procedure to approve or dis-approve such a proposal.

From a more detailed perspective, the experience from the Hong Kong case reveals the importance of the **first impression** of the scheme. When the policy was originally proposed back in 1980's, the technology in that time did not allow such a seamless vehicle detection and transfer of the payment. Thus, the original proposal involved the detection technology which was alleged to violate the privacy of the drivers. Currently, there exists a new proven technology which will no longer infringe the drivers' privacy. Nevertheless, the issue of privacy and technology of the vehicle detection and charging mechanism have always been raised as one of the reasons to object the pricing policy. This issue is also related to the

design of the scheme. From the beginning, the proposed designs for the Hong Kong scheme were considerably more complex compared to the scheme in Singapore which was implemented in the same period back in 1980's. The complex design may be able to offer a higher potential benefit. However, it also requires a much more complicated charging technology and may be difficult to explain and convince the public.

The other experience learned from the Hong Kong case (also from London and Stockholm) is that road pricing initiative needs to establish **coalition** rather than opposition when such scheme is first introduced to the public, particularly with the key stakeholders. In these cases, one of the key stakeholders is public transport operators, e.g. taxi, minibus, or bus. The authority should engage them in the negotiation and discussion as early as possible to ensure their supports and to provide appropriate **exemption of the scheme**.

Despite a long history of failures to deliver the real scheme, the possibility of the road pricing implementation in Hong Kong has been revived again recently with the aim to tackle one of the fastest growing problems in Hong Kong, the urban pollution. In the recent study, the majority of the respondents to the questionnaire survey conducted by the environmental activist group suggested that most of people would accept the idea of road pricing on the environmental protection and improvement ground. This coincides with the on-going debate about the pollution problem in Hong Kong which needs to be addressed sooner rather than later. Thus, the change in **social norm** and rise in **awareness of environment problem** can also be a good catalyst to the implementation of road pricing in Hong Kong.

4.2.3 Seoul

The case of Seoul is included in our case study for the reasons that the pricing scheme was implemented on existing toll roads and the city and local condition is similar to Thailand (compared to other cases). This case illustrated a good transition in which an existing tolled road, Namsen tunnel toll, (mainly for financial reason) was converted to a congestion pricing corridor. The Seoul scheme is relatively small in size in which it aims to tackle the congestion particularly on the tolled corridor.

The oppositions of the scheme was minimised because the scheme was converted from the existing toll roads from financial purpose to congestion alleviation purpose (**clear benefit and objective**), as well as the **size of the scheme** was small.

In addition, this scheme was planned and implemented during the period in which the concept of **social justice** or environmental protection was at the peak in Seoul. The strong **political leadership** of the city Mayor in that time leveraged the public's view toward the city development with a strong focus on environmental protection.

Nevertheless, other underlying factors for the success of the toll implementation include (i) **involvement of the public** during the planning stage to discuss possible alternative and arrangement of exemption, (ii) **integration with other policies** (e.g. BRT development), and (iii) the clear link of the proposed scheme to the set objective in reducing traffic congestion along that corridor.

4.2.4 Singapore

The success of the Singapore road pricing scheme can be credited to its early decision to embark such an aggressive policy. This obviously can only be done in the case of a strong **political stability** and **leadership**, as well as **government creditability**. Nevertheless, this is not the only sole reasons for the success of the scheme. The early **scheme design** was relatively simple and easy to operate which avoided the operational and technological issues. The **revenue** from the scheme has been injected directly to the development and improvement of the mass transit and other public transport systems. This has been the ideal example of the role of road pricing in the **integrated transport policy**.

Although the success of the pricing scheme in Singapore can be viewed as a separated and rather exceptional case given its political and urbanisation condition back in 1980's, the city has been rapidly growing since then credited to the stable and strong economic development of the city. Thus, the authority also have been modifying the scheme to respond to this growth in which additional complex scheme designs have been introduced including peak-load pricing, quarterly updated charge, and extension of the pricing zone. All these efforts represent the need for the city to view the road pricing implementation as an **evolutionary process**. The simplicity of the early scheme as in Singapore ALS allows the city to implement the policy but it may not be the most effective one. The city then has to modify and evaluate the scheme over time to ensure its effectiveness. This is one of the key lessons learnt from this case which will be particularly useful for the long term plan of the scheme implementation.

4.2.5 London

London has started to discuss and study about the feasibility and benefit of road pricing policy since 1960's. It took London more than 40 years to have a successful implementation of the policy. During the past 40 years there is a large collection of knowledge and studies about the best way to pursue the scheme. Although there was not any success in delivering the real project, the discussion and commutation process between the authority and public started back then in which the concept of road pricing has become well known by most Londoners before its actual implementation in 2003. This represents the **accumulation of the knowledge** and understanding of the objective, effect, and potential benefit of road pricing.

After this long discussion process the fulfil ingredients are: (a) **legislations** to support road pricing scheme, and (b) the **political will** and leadership to commit the scheme to election campaigns.

In 1999, the Greater London Authority Act was passed by parliament. This act gives London a unique local government structure. It provides full powers for the Mayor to introduce congestion charging schemes in Greater London (also in other local government if they are interested). It also enables the local authority to utilize the revenues. This issue attracts a number of cities. Without the legislation and support from the central government, the road pricing scheme in London would never have been realised.

In May 2000, Mr. Livingstone was elected to be the Mayor of London on the basis of a manifesto which included a promise to introduce a congestion charging scheme in central London. It was remarkable that he was eventually elected as the London Mayor and in fact the promise to implement the road pricing scheme was one of the supporting factors for his victory.

What would make a politician to commit himself to such an aggressive and provocative policy? Two supporting factors we envisaged include (i) **supporting evidence** of the effectiveness and benefit of the scheme with a **clear implementation plan** in hand and (ii) the personality of the politician.

The first item was provided by the pile of previous studies as well as the recent detailed implementation plan prepared by ROCOL in 2000 (GOL, 2000) (this was prepared by an independent expert group, and was independently from the London's Mayor election). The **independent expert study** group which is supported by the government can work independently from the politics which then allows a great continuity and in-depth evaluation on the most appropriate plan. This plan also allows great inputs from other stakeholders without political biases and influences. The basis of this plan, so called "plan-led approach", can then be delivered to any politician who will be elected to the office. This process can help to avoid **political instability and distrust of the public** on the government.

The second was provided by the Mayor Livingstone in that time. These two components together with the **clear understanding** of the Londoners on the policy and **seriousness of the congestion and pollution** problems in London enabled the implementation of the policy in 2003.

In more detail, the proposed plan and negotiation game between the Mayor and the stakeholders also support the progress of the scheme in which the design of the scheme intentionally tries to **avoid the direct oppositions** from the affected groups, particularly **business community**. To reduce the pressure, exemptions and discounts are provided for some particular groups. Exemptions are for some vehicles such as buses, minibuses, taxis, motorcycles, bicycles and emergency service vehicles. Residents of the zone are eligible for a 90% discount.

In addition, prior to the implementation the **improvement of alternative transport modes** was critical here. The government offered an advance budget for developing alternative modes (major on public transport infrastructures).

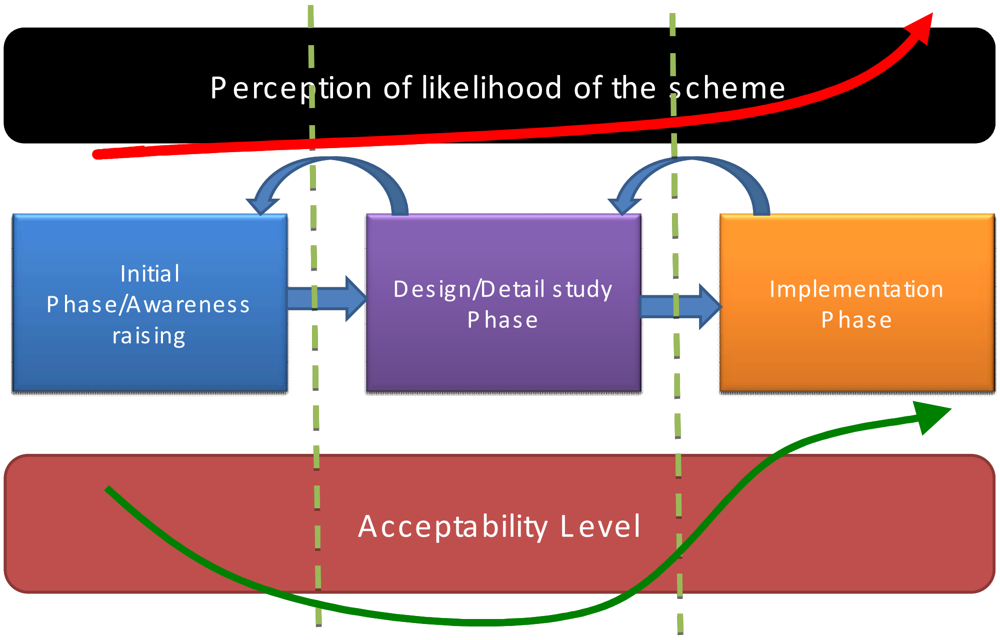
4.3 Casual Relationship of Road Pricing Development

The lessons learnt from the past development of road pricing schemes (presented in Chapter 3 and Section 4.2) help us to identify the lifecycle and critical factors to be concerned in the planning and implementation phases of a road pricing scheme.

Figure 10 shows the life-cycle of road pricing policy development. Before the implementation phase, there are two prior phases: initial phase and design phase. The initial phase is to raise the awareness of the public on road pricing. The design phase is mainly to study the detail of the system design.

Once a city council or the government suggests or raises road pricing as a possible solution for the city, the lifecycle of the policy moves from the initial phase to design phase which also gradually increases the perception of the likelihood and inevitability of the scheme. During the initial phase the public may not really pay a close attention to the on-going discussion since they may perceive this as an idea which is far from reality. Thus, the opposition level and acceptability problem may not be so high (but also no strong support). When the process moves to the design phase, if the outcome or impact of the scheme is still uncertain, many oppositions or stakeholders will eventually come out to strongly criticise and oppose the policy. Consequently, the acceptability level will decrease rapidly. Many cities in the previous cases abandoned the scheme at the initial or design phases to avoid the public confrontation and political damage. London and Stockholm had been back and forth between in these two phases a few times before the successful implementations.

Figure 10 Life-cycle of road pricing policy development

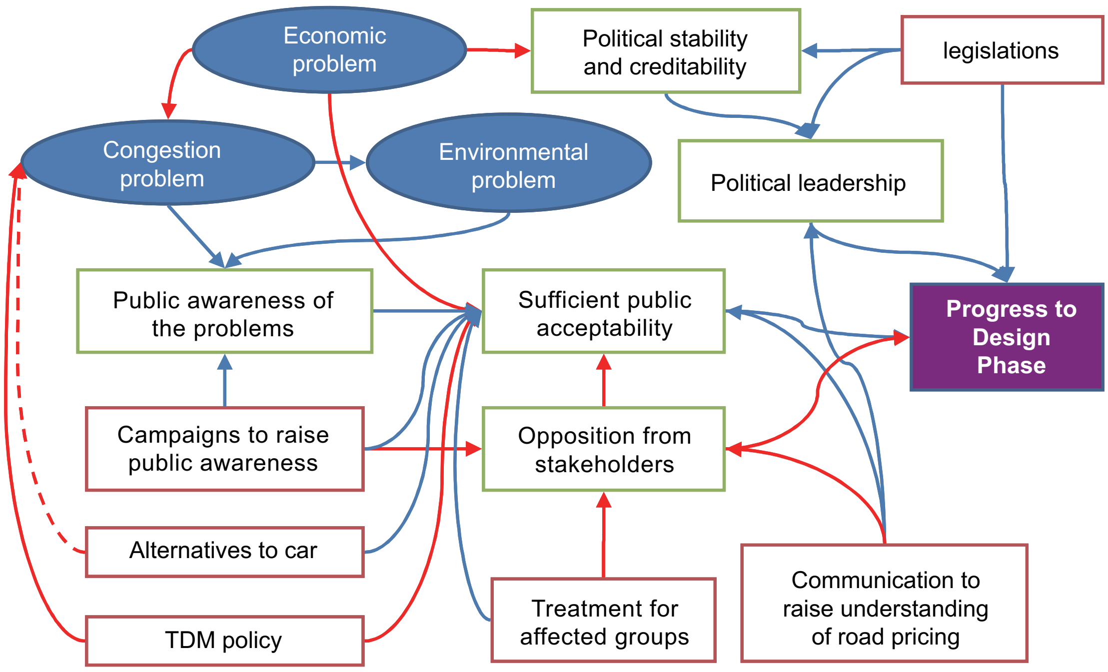


Based on the qualitative system dynamics approaches, analysis results of the interactions among the critical factors can be illustrated by the casual relationship[4] for the initial process (Figure 11), and the design phase (Figure 12).

Figure 11 illustrates the casual relationship of initial phase of road pricing development. From the initial phase prior to the design phase, there are four key factors: ***public acceptability***, ***opposition from stakeholders***, ***political leadership***, and ***legislations***. Public acceptability of road pricing relates to several conditions. If there is an economic problem

[4] Note that: Factors in the ovals represent local circumstances; factors in Green boxes represent latent variables, which can be influenced by measures in Red boxes. Blue lines show positive loops which reinforce or amplify changes. Red lines show negative loops which counteract or oppose changes. Dash lines show uncertain effect whether positive or negative.

Figure 11 The casual relationship of initial phase of road pricing development



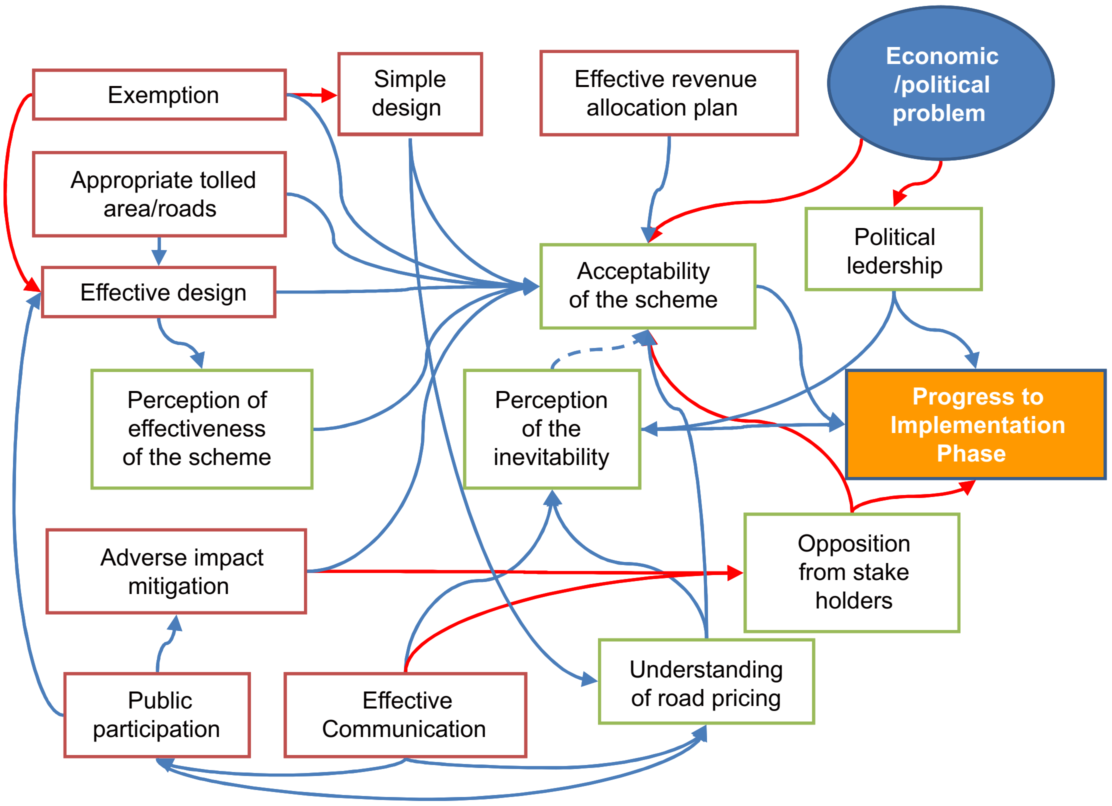
(e.g. high inflation rate), the public is likely to disagree with road pricing (e.g. the case in Hong Kong). Acceptability also relates to the public awareness of congestion and pollution, which can be influenced by campaigns through the media (i.e. the cases in London and Stockholm). Furthermore, acceptability of road pricing relates to whether alternatives to car are available, and how many other stick measures to control car use have been in place (i.e. the cases in Singapore and Seoul). If there exist some demand management measures, road pricing is unlikely to be accepted.

The opposition from the stakeholders depends on their level of the impacts and benefits they perceived during the development process. The authority should engage them in the negotiation and discussion as early as possible to ensure their supports and to provide them appropriate exemptions of the scheme and other impact alleviation measures. Communication with all stakeholders, particularly business community and the media, should be done continuously to provide sufficient knowledge about potential advantage of road pricing. More importantly the policy should be presented to the public and media as a part of the policy package which involves other measures to provide alternative to case uses. The involvement of the public is essential to understand the concerns of the public, pressure groups, politicians and the media (CURACAO, 2008).

Obviously, the progression to the design phase can occur with a strong political stability and government creditability (e.g. Singapore and Seoul). In the case of political instability (e.g. Stockholm and London), modification of or new legislations can provide power to support political champions to facilitate the design process.

Figure 12 illustrates the casual relationship of design phase of road pricing development. The general factors in the design phase to progress to the implementation phase are rather similar to the factors in the initial phase. They are (i) ***acceptability of the scheme***,

Figure 12 The casual relationship of design phase of road pricing development



(ii) ***political leadership***, and (iii) ***opposition from stakeholders***. An additional factor is the ***perception of inevitability***. However, the factors affecting the acceptability in this stage are different from the factors in the initial phase.

Figure 12 illustrates the casual relationship of design phase of road pricing development. The general factors in the design phase to proceed to the implementation phase are rather similar to the factors in the initial phase. They are acceptability of the scheme, political leadership, and opposition from stakeholders. An additional factor is the perception of inevitability. However, factors affecting the acceptability in this stage are different from the factors in the initial phase.

The acceptability of the scheme in this stage mainly relates to system design. The scheme needs to be simple and effective in an appropriate area. Importantly, it is perceived by the public as effective to achieve its objectives. Exemptions and discounts can increase the acceptability but may also make the scheme to be more complicated, more costly (e.g. the scheme in Stockholm), and less effective if the majority is exempted (e.g. if the Hong Kong scheme provides an exemption for taxis).

The acceptability is also influenced by the revenue allocation plan, adverse impact mitigation, and understanding of road pricing. These issues can be managed through the public participation and effective communication.

During the design phase the public may pay attention to the scheme. The perception of likelihood and inevitability of the scheme gradually builds up. Consequently we may face strong oppositions or even campaigns against the scheme from different stakeholders. Thus, under this circumstance, we really need effective communication strategies to deal with all stakeholders, particularly business community and the media.

Finally, as in the initial phase, strong political leadership is one of the key success factors. This is depended on the economic and political situations. However, it does not mean that without political leadership the scheme will always be abandoned. The progress to implementation phase can also be success if an effective scheme, designed by an independent expert study groups, is perceived as effective to solve the transport problems, and is acceptable by the public. In the instability political situation, the designed scheme can be put in a referendum process (e.g. in Stockholm).

4.4 Summary

This chapter unravelled implementation process in success and failure cases with the process to indicate interaction among the key factors for decision making context. It also identified obstacles in the planning process, in order to develop effective strategies to assure successful implementation. The selected case studies include Hong Kong, London, Seoul, Singapore, and Stockholm. From the analysis of these road pricing experiences, the life-cycle of road pricing policy development and the casual relationship of initial and design phases were constructed to show the interactions among the critical factors. This qualitative system dynamic provided a framework to analysis the situation in Thailand, in order to draw a road map for road pricing implementation in Thailand in the next chapter.

5. Lessons for Thailand

5.1 Road Pricing in Thailand

Road pricing was first mentioned in Thailand more than three decades ago. In 1971, the German Agency conducted the first comprehensive transport study in Bangkok, called “Bangkok Transportation Study (BTS)” (Kocks, 1975). Major recommendations were the development of mass transit and expressways with the restriction of car use (road user charging), as well as polycentric developments around the city. Unfortunately, only expressway has been done very well, and mass transit has improved slowly, while road pricing has been rarely mentioned again.

In 2001 the study of Traffic and Transportation Development Master Plan for the 9th National Economic and Social Development Plan 2002-2006, carried out by the Thailand Development Research Institute (TDRI), suggested that road pricing should be used in Bangkok for managing demand of car use (TDRI, 2001).

The study on Urban Rail Transportation Masterplan (OCMLT, 2001) proposed a rail transit network in Bangkok for the Office of the Commission for the Management of Land Traffic (OCMLT), Minister of Transport of Thailand. It also recommended that road pricing and a new taxation scheme should be combined to support this rail development. However, currently the government is only considering approval of the rail network as an independent measure, i.e. decoupling it from the pricing scheme.

Although there are a few suggestions on road pricing in Bangkok, the politicians have never showed their interest (in the public) in implementing such the scheme. Recently, in May 2007 many mayors including Bangkok Governor Mr. Apirak Kosayodhin attended the “Large Cities Climate Summit” in New York. In the session of “Beating the Congestion and Surviving Your Next Election”, London Mayor Mr. Ken Livingstone acknowledged the success of London Congestion Charging. The Bangkok Governor mentioned that he wanted to introduce the charge as well, but Bangkok does not have a proper mass transit system. He also asked whether Bangkok needs to have the mass transit system in place first or road pricing could start now in the inner city. Livingstone’s advice was to improve the bus system because subways take a long time to construct. He said in the case of London, the number of buses increased from 6,000 to 8,000 along with the introduction of new routes, and the private sector played a key role in helping with the expansion finance (The Nation, 2007).

Most recently in early 2008, Mr. Apirak Kosayodhin mentioned to the public in Bangkok that the idea of road pricing should be plausible in Bangkok because of the increasing cost of fuel. The governor said the idea comes primarily from London and Singapore, where congestion pricing is already in place on urban roads; however, adjustments will be made to ensure it is suitable for Bangkok. However, his idea received a strong criticism by the public who are afraid that the policy would make their living harder in times of economic difficulty (Bangkokpost, 2008).

Concerning the issue of public acceptability of road pricing in Bangkok, a study on travelers' attitude on introducing area licensing scheme (Pruttiphong et al., 2006) found that more than half of public responses revealed a positive attitude towards a concept of limiting automobile use in the business area; this is because the public perceive that air pollution is the major problem in the area. However, it also found that two third of automobile users perceived some difficulty in reducing their car trips, this is because of lack of alternatives.

In summary, road pricing has been suggested in Thailand over three decades by transport planners. Politicians and decision makers recently show their interest of the implementation. When the economic situation is normal, public tend to agree with the scheme because their perceptions of congestion and pollution are very serious (from the survey results in 2006). But when the economic is slow down and fuel price rapidly increases, road pricing is not acceptable by many stakeholders (the responses to the Mayor in 2008).

5.2 Analysis of Road Pricing Development in Bangkok

Analysing the situation in Bangkok with the casual relationship of road pricing development (see Section 4.3, Figures 11 and 12), Bangkok road pricing development is still in the initial phase (other cities have not yet been in this stage).

Lately, although the economic has been slow down and fuel price has rapidly increased during a couple of years, congestion and pollution problems in Bangkok are still very serious. In addition, the political situation in Thailand is extremely unstable and abnormal. Thus, the current circumstances show that road pricing should not be discussed and implemented in the near future. Nevertheless, this does not mean that the planning process of road pricing should be on hold.

On the public related issue, the public awareness of congestion and pollution problems is high. However, road pricing is still not considered as a solution by the public mainly due to the fear of change in cost of living, lack of alternative travel modes, and lack of understanding of the potential benefit of the scheme. Opposition to road pricing from stakeholders is still high, particularly car user groups and business communities.

The current communication and dialogue among the politicians, the decision makers, the media and the public mainly focuses on the mass rapid transit provision (supply-side policy) due to its popularity to the public. Travel demand management (demand-side policy), particularly road pricing, is rarely mentioned in the public, so the public understanding of road pricing is relatively low. Most people probably understand that road pricing is simply an implementation of road tolls like the expressway system on public roads. The key stakeholders, particularly business community and the media, have not been clearly informed. These are the reasons that public and political acceptability of road pricing is not sufficient.

Moreover, once a politician who has political leadership keens on introducing the scheme, but the political situation is not stable (both local and national levels) and the trust of the government (creditability) by the public is not so high, any approval of related legislation and implementation by the parliament and local council is not unlikely.

Therefore, based on our evaluations and outcomes from this study it is unlikely that the road pricing development in Bangkok at its current standing cannot progress to the design phase.

5.3 Suggestions for Bangkok

From the analysis of road pricing experiences and local circumstances in Bangkok in Section 5.1 and 5.2, based on the casual relationship presented in Section 4.3, some broad strategies can be suggested as follows, in order to help Bangkok moving from the initial phase to the design phase.

(i) The national government has a responsibility to develop a clear transport strategy and legislation to support the local government.

Without the legislation and support from the central government road pricing scheme would never have been realised. The legislation should provide powers for the Mayor to introduce congestion charging schemes and also enables the local authority to utilize the revenue. The national government should also provide advance budget for developing alternative modes.

(ii) Road pricing should be considered as a part of an effective transport strategy.

Road pricing should not be considered and mentioned independently. The development of road pricing scheme should be determined as a part of strategy formulation, in which the overall strategy is determined first. This will help to demonstrate whether road pricing is needed, and also help to identify those complementary policy instruments which are needed to integrate with road pricing scheme.

(iii) An independent expert study group should be set to formulate the effective strategy.

An independent expert study group which is supported by the government should work independently from the politics. They will be allowed a great continuity and in-depth formulation on the most appropriate plan. This plan also allows great inputs from other stakeholders without political biases and influences. This process can help to avoid political instability and distrust of the public on the government.

(iv) Effective communication should be done continuously through a two-way dialogue to raise public awareness and knowledge (mainly done by the expert study group).

Effective strategy to communicate with the public in general and all stakeholders, particularly business community and the media, should be done continuously through a two-way dialogue. This should be a responsibility of the expert study group (who generally has higher creditability than the politicians). This process is to raise public awareness on transport related problems, and to provide knowledge about potential advantage of road pricing. The involvement of the public is essential to understand the concerns of the public, pressure groups, politicians and the media (CURACAO, 2008).

(v) Road pricing revenue allocation plan is a critical issue.

Road pricing revenue allocation plan is critical to determining the acceptability and effectiveness of the scheme. Revenue use should be committed to the development and improvement of the mass transit, other public transport systems, and other alternative modes, e.g. walking and cycling. The revenue can also be used to compensate the losers.

(vi) Implementation plan of improvement of alternative transport modes needs to be clear and convincible to the public in the early stage of planning process.

Lack of alternative transport modes is the key factors of the scheme opposition. The public usually claim that there is no appropriate alternative to cars. Thus an implementation plan of improvement of alternative modes needs to be clear and convincible to the public.

(vii) Political will and leadership to commit the scheme is a key success of the scheme.

It was found that a lack of strong political commitment acts as a benchmark for other stakeholders, their attitudes may become more negative as well (CURACAO, 2008). This contributes to a slower or even stopped introduction of the scheme. Thus, a political champion, who takes ownership of road pricing scheme, clearly facilitates the implementation process. However, politicians may fear of losing elections by promoting road user charging. One way of divorcing the road pricing issue from elections is to hold a referendum on the strategy formulated in (ii) and (iii), rather than on only the road pricing scheme.

References

AECOM Consult (2006) International Urban Road Pricing, Federal Highway Administration (FHWA), U.S. Department of Transportation, USA.

Ahlstrand, I. (2001) The politics and economics of transport investment and pricing in Stockholm, Journal of Transport Economics and Policy, Vol. 32, No. 3, 437-485.

Bangkokpost (2008) “Zone-fee plan under study to reduce road congestion”, Bangkokpost (daily newspaper) 23 May 2008, Bangkok, Thailand.

Baron, J. (1995) Blind justice: fairness to groups and the do-no-harm principle. Journal of Behavioral Decision Making, 8, 71-83.

Beesley, M.E. and Roth, G.J. (1962) Restraint of traffic in congested areas, The Town Planning Review, Vol. 33, No. 3, Reprinted in 1963 by Department of Applied Economics, University of Cambridge (Reprint Series No. 195).

Bhatt, K. (1993), “Implementing congestion pricing: winners and losers”, ITE Journal, 63(12), 33-37.

Bonsall, P.W. and I. Palmer (1997), “Do time-based road-user charges induces risk-taking? - Results from a driving simulator”, Traffic Engineering and Controls, 38(4), 200-204.

Bonsall, P. and Cho, H.-J. (1999) Travellers’ response to uncertainty: the particular case of drivers’ response to imprecisely known tolls and charges. Proceedings of European Transport Conference: Seminar F, UK.

Boot, J., Boot, P. and Verhoef, E.T. (1999) “The long road towards the implementation of road pricing: the Dutch experience”, The ECMT/OECD workshop on managing car use for sustainable urban travel, Dublin, Ireland.

Borins, S.F. (1988) “Electronic road pricing: An idea whose time may never come”, Transportation Research Part A: General, 22(1): 37-44.

Cain, A., Celikel, N. and Jones, P. (2002) Incorporating public participation into the detailed design of a congestion charging scheme for Edinburgh. Paper presented at the 34th UTSG Annual Conference, 3-5 January 2002, Transport Research Institute, Napier University, Edinburgh, UK.

Catling, I. and Harbord, B. (1985) Electronic road pricing in Hong Kong: 2. technology, Traffic Engineering and Control, 608-615.

CfIT/MORI (2000) The CfIT Report: Public Attitudes to Transport in England, Commission for Integrated Transport, UK. (available from www.cfit.gov.uk).

CfIT/MORI (2001) The CfIT Report 2001: Public Attitudes to Transport in England, Commission for Integrated Transport, UK. (available from www.cfit.gov.uk).

Chin, K.K. (2002) “Road pricing Singapore’s experience”, IMPRINT-EUROPE Thematic Network: “Implementing Reform on Transport Pricing: Constraints and solutions: learning from best practice”, Brussels, Belgium.

CONCERT-P Project (1998), Pricing & Restraint Strategies: Guidelines for European Policy Development, Deliverable 6: Guidelines for European Policy Development v. 1.0.

CURACAO project (2008), Deliverable D2: State of the Art Review, Coordination of Urban Road User Charging Organisational Issues, http://www.curacaoproject.eu/

Daniel, J.I. and K. Bekka (2000), "The environmental impact of highway congestion piecing", Journal of Urban Economics, 47, 180-215.

Dawson, J.A.L. and Brown, F.N. (1985) "Electronic Road Pricing in Hong Kong 1. A Fair Way to Go?", Traffic Engineering and Control, 26(11): p522-5.

Decorlar-Souza, P. (1993), "Congestion pricing: issues and opportunities", ITE Journal, 63(12), 27-32.

DETR (1998) Breaking the Logjam: the Government's consultation paper on fighting traffic congestion and pollution through road user and workplace parking charges. Department of Environment, Transport and the Regions, U.K.

DETR project 'Analysis of Congested Network' (2001), carried by ITS (University of Leeds), TORG (University of Newcastle upon Tyne), John Bates' Services (Consultant) and TRL (Transport Research Laboratory), unpublished.

Dosi, G., Levinthal, D.A. & Marengo, L. (2003) Bridging contested terrain: linking incentive-based and learning perspectives on organizational evolution. Industrial and Corporate Change, 12, 413-436.

Dupuit, J. (1844) On the measurement of the utility of public works, Annual des Ponts et Chaussees, 2ed series, Vol. 8, translated by R.H. Barback, International Economic Papers, 2, 83-110, 1952. Reprinted in D. Munby (ed.), Transport: Selected Reading, Penguin Books, London, 1968.

Dutch Minister of Transport (1995) Contours of implementation of congestion charging (Rekening Rijden), Abstract of a Letter to Parliament from the Minister of Transport.

Edinburgh City Council (2000), New Transport Initiative: Technical Report on Phase 1.

EPA (1997), Opportunities to Improve Air Quality through Transportation Pricing Programs, U.S. Environmental Protection Agency, Washington (available from http://www.epa.gov/oms/market/pricing.pdf).

Foo, T.S. (2000) An advanced demand management instrument in urban transport: electronic road pricing in Singapore, Cities, Vol. 17, No. 1, 33-45.

Forrester, J.W. (1961) Industrial dynamics, Cambridge, Mass., M.I.T. Press.

Forrester, J.W. (1992) Policies, Decisions and Information-Sources for Modeling. European Journal of Operational Research, 59, 42-63.

Frey, B. S. (2003) Why are efficient transport policy instruments so seldom used. In J. Schade & B. Schlag (Eds.), Acceptability of Transport Pricing Strategies (pp. 63-76). Oxford: Elsevier.

Giuliano, G. (1992) An assessment of the political acceptability of congestion pricing. Transportation, 19, 335-358.

Giuliano, G. (1994) Equity and fairness considerations of congestion pricing. Curbing Gridlock: Peak-Period Fees to Relieve Traffic Congestion, Special Report 242, Volume 2, Transportation Research Board, National Research Council, USA.

GLA (2001), The Major's Transport Strategy, Greater London Authority (GLA), UK (available from www.london.gov.uk/mayor/strategies/transport/index.htm).

Glazer, A., Link, H., May, A.D., Milne, D. and Niskanen, E. (2001) Barriers to transport pricing, paper presented at IMPRINT-EUROPE Seminar, 21-22 November 2001, Brussels.

Goh, M.,(2002) "Congestion management and electronic road pricing in Singapore", Journal of Transport Geography, 10(1): 29-38.

GOL (2000) Road Charging Options for London: a Technical Assessment. ROCOL Report, Government Office for London, UK. (available from www.go-london.gov.uk).

Gomez-Ibanez, J.A. and Small, K.A. (1994) Road pricing for congestion management: A survey of international practice. NCHRP Synthesis 210, National Cooperative Highway Research Program.

Harrington, W., Krupnick, A.J. and Alberini, A., (2001) Overcoming public aversion to congestion pricing. Transportation Research Part A, 35, pp.87-105.

Harrison, B. (1986) Electronic road pricing in Hong Kong: 3. estimating and evaluating the effects. Traffic Engineering and Control, 13-18.

Hårsman, B. (2001) Urban road pricing acceptance. Paper presented at IMPRINT-EUROPE seminar, Brussels, Nov 21-22, 2001. See also www.imprint-eu.org

Hau, T.D. (1992a) Economic Fundamentals of Road Pricing: a Diagrammatic Analysis. World Bank working paper WPS 1070 (available from http://www.worldbank.org/html/fpd/transport/publicat/pub_tran.htm, Report No. TWU1).

Hau, T.D. (1992b) Congestion Charging Mechanisms for Roads: an Evaluation of Current Practice. World Bank working paper WPS 1071 (Available from http://www.worldbank.org/html/fpd/transport/publicat/pub_tran.htm, Report No. TWU2).

Hau, T.D. (1998) Congestion pricing and road investment, In K.J. Button and E.T. Verhoef (eds.), Road Pricing, Traffic Congestion and the Environment. Edward Elgar, USA.

High Level Group on Transport Infrastructure Charging (1998), Final Report on Pricing Principles, available from http://transport-pricing.net.

Hills, P. and Gray, P. (2000) Characterisation of congestion on an urban road network subject to road-use pricing – a fundamental review. Proceedings of IATBA 2000, the 9th International Association for Travel Behaviour Conference at Gold Coast, Queensland, Australia, 2-6 July 2000.

Holland, E.P. and Watson, P.L. (1978) Traffic restraint in Singapore, Traffic Engineering and Control, Vol. 19, No. 1.

Hwang, K.Y., Son, B. and Eom, J.K. (1999) Effect of congestion pricing at the Namsan tunnels in Seoul. Journal of the Eastern Asia Society for Transportation Studies, 3(4).

Jaensirisak, S. (2002) Road User Charging: Acceptability and Effectiveness, PhD Thesis, Institute for Transport Studies, University of Leeds, UK (unpublished).

Jaensirisak, S. (2003), “Urban road pricing: from theory to practice”, paper presented at the EASTS Conference, 29 October – 1 November 2003, Fukuoka, Japan.

Jaensirisak, S., May, A.D. and Wardman, M. (2002) Designing acceptable and effective road user charging schemes, Traffic Engineering and Control, Vol. 43, No. 7, 278-282.

Jaensirisak, S., A.D. May and M. Wardman (2003), “Acceptability of road user charging: the influence of selfish and social perspectives”, in J. Schade and B. Schlag (eds.) Acceptability of Transport Pricing, Elsevier Science, UK.

Jaensirisak, S., M. Wardman, and A.D. May, (2005) “Explaining variations in public acceptability of road pricing schemes”, Journal of Transport Economics and Policy, 39(2), 127-154.

Jakobsson, C., Fujii, S. and Gärling, T. (2000) Determinants of private car users’ acceptance of road pricing. Transport Policy, 7, 153-158.

Jones, P. (1991) Gaining public support for road pricing through a package approach. Traffic Engineering and Control, 32(4), 194-196.

Jones, P. (1998) Urban road pricing: public acceptability and barriers to implementation. In K.J. Button and E.T. Verhoef (eds.), Road Pricing, Traffic Congestion and the Environment. Edward Elgar, USA.

Jones, P. (2003) “Acceptability of Road User Charging: Meeting the Challenge” In Schade, J. and Schlag, B. (Eds). Acceptability of Transport Pricing Strategies. (pp. 27-62). Oxford: Elsevier.

Jones, P. and Hervik, A. (1992) Restraining car traffic in European cities: an emerging role for road pricing, Transportation Research A, Vol. 26, No. 2, 133-145.

Knight, F.H. (1924) Some fallacies in the interpretation of social cost, Quarterly Journal of Economics, Vol. 38, 582-606.

Kocks, KG.FH. and Rhein-Ruhr-Ing.-Gmbh Consulting Engineers (1975) Bangkok Transportation Study (BTS). Final Report, Vol. II, September, Bangkok.

Langmyhr, T. (1997) Managing Equity: The Case of Road Pricing. Transport Policy 4(1), pp.25-39.

Larsen, O.I. (1988) The toll ring in Bergen, Norway: The first year of operation. Traffic Engineering and Control 29, pp.216-221.

Larsen, O.I. (1995) The toll cordons in Norway: an overview. Journal of Transport Geography, 3(3), 187-197.

Legislative Council (2001) Electronic road pricing, Legislative council, Hong Kong.

Lewis, N.C. (1993) Road Pricing: Theory and Practice. Thomas Telford, UK.

Luk, J. (1999) Electronic road pricing in Singapore, Road & Transport Research, Vol. 8, No. 4, 28-40.

Luk, J. and Chung, E. (1997) Public Acceptance and Technologies for Road Pricing, Research Report (ARR 307), ARRB Transport Research Ltd, Australia.

Marshall, A. (1890) Principles of Economics, MacMillan, UK.

May, A.D. (1975) Supplement licensing: an evaluation. Traffic Engineering and Control, 16(4).

May, A.D. (1992) Road pricing: an international perspective. Transportation, 19(4), 313-333.

May, A.D. and D.S. Milne (2000), "Effects of alternative road pricing systems on network performance", Transportation Research Part A, 34(6), 407-430.

May, A.D., Hopkinson, P.G., Marler, N.W. and Sherwood, N. (1991) Road Pricing: the Potential for Comparative Monitoring: A Report to the London Planning Advisory Committee. Working Paper 329, Institute for Transport Studies, University of Leeds.

May, A.D., P. W. Bonsall and P.J. Hills (1998), "The impacts of different road user charging systems", in Proceedings of the International Conference on Transportation into the Next Millennium, Nanyang Technological University, Singapore, 9-11 September 1998.

May, A.D., Shepherd, S.P. and Bates, J.J. (2000) Supply curves for urban road networks, Journal of Transport Economics and Policy, Vol. 34, No. 3.

May A.D. and Sumalee, A. (2003) One step forwards, two steps back? An overview of road pricing application and research outside the US (Resource paper), Proc. of the TRB International Symposium on Road Pricing, Key Biscayne, USA.

Mayo, D.D., Pott, J.D. & Dalton, W.J. (1999) A system dynamics perspective on the risks and benefits of public transport restructure: case study of London Underground. The 53rd Union Internationale de Transport de Publique International Congress. Toronto, Canada.

McCarthy, P. and Tay, R. (1993) Economic efficiency VS traffic restraint: a note on Singapore's Area License Scheme, Journal of Urban Economics, Vol. 34, 96-100.

Meland, S. and Polak, J. (1993) Impact of the Trondheim toll ring on travel behaviour: some preliminary findings, Proceedings 21st PTRC Summer Annual Meeting: Seminar F, 103-115.

Menon, A.P.G. (2000) EPR in Singapore-a perspective one year on, Traffic Engineering and Control, Vol. 41, No. 2, 40-44.

Milne, D. (1992), Pricing Methods, Working Paper 405, Institute for Transport Studies, University of Leeds.

Milne, D., Niskanen, E. and Verhoef, E. (2001) Legal and Institutional Framework for Marginal Cost Pricing in Urban Transport in Europe. VATT Research Report No. 76, Project AFFORD funded by the European Commission, 4th Framework Transport RTD.

Ministry of Transport (1964) Road Pricing: The Economic and Technical Possibilities. HMSO: London.

MVA (1995) The London Congestion Charging Research Programme: Principal Findings. The MVA Consultancy, HMSO: London.

NCSR, 2000. British Social Attitudes: the 17th Report 2000, National Centre for Social Research, Sage Publication, UK.

NEDO (1991) A Road User Charge? Londoners' View, National Economic Development Office, UK.

Nelson, R.R. & Winter, S.G. (1982) An Evolutionary Theory of Economic Change, Cambridge, Harvard University Press.

Newbery, D.M. (1990) Pricing and congestion: economic principles relevant to pricing roads, Oxford Review of Economic Policy, Vol. 6, 22-38.

Nilsson, M. and Kuller, R. (2000) Travel behaviour and environmental concern. Transportation Research Part D, 5, 211-234.

O'Mahony, M., D. Geraghty and I. Humphreys (2000), "Distance and time based road pricing trial in Dublin", Transportation, 27, 269-283.

OCMLT (2001) Mass Transit: Urban Rail Transportation Master Plan, Office of the Commission for the Management of Land Traffic (OCMLT), Bangkok, Thailand.

Odeck, J. and Brathen S. (1997) On public attitudes toward implementation of toll roads - the case of Oslo toll ring. Transport Policy, 4(2), 73-83.

Odeck, J. and Brathen, S., 2002. Toll financing in Norway: The success, the failures and perspectives for the future. Transport Policy, 9(3): 253-260.

Oldridge, B. (1995), "Congestion metering in Cambridge City, United Kingdom", in B. Johansson and L. Mattson (eds.), Road Pricing: Theory, Empirical Assessment and Policy, Kluwer Academic Publishers, USA.

Ongkittikul, S. (2006) Innovation and Regulatory Reform in Public Transport: Innovative Capabilities and Learning in the Public Transport Organisations, TRAIL Thesis Series, The Netherlands.

Opiola, J. (1998), "Mobility – the role of the private motor car electronic road pricing in Hong Kong", in Proceedings of the International Conference on Transportation into the Next Millennium, Nanyang Technological University, Singapore, 9-11 September 1998.

Orski, C. (1998), "Value pricing: paying a premium for congestion-free travel", Traffic Technology International, Aug/Sept 1998, 37-38.

Orski, C. (2000), "Paying for the use of roads that offer a premium level of service", Innovation Briefs, 11(3), May/June 2000.

PATS Consortium (2001) Recommendations on Transport Pricing Strategies. Final Report of the PATS Project. European Commission, Brussels. See also www.tis.pt/proj/pats/pats.html

Pigou, A.C. (1920) Wealth and Welfare. MacMillan, UK.

Pruttiphong, T., Narupiti, S. and Choocharukul, K. (2006) "Travelers' Attitude and Acceptability on Introducing Area Licensing Scheme in Bangkok", paper presented at the 11th National Convention on Civil Engineering, April 2006, Thailand.

Radzicki, Michael J. & Sterman, John D. (1994) Evolutionary Economics and System Dynamics. In England, Richard W. (Ed.) Evolutionary Concepts in Contemporary Economics. Ann Arbor, University of Michigan Press.

Raux, C., O. Andan and C. Godinot (1998), “The simulation of behaviour in a nonexperienced future: the case of urben road pricing”, in J. Ortuzar, D. Hensher and S. Jara-Diaz (eds.), Travel Behaviour Research: Updating the State of Play, Chapter 5, 67-86, Pergamon, UK.

Richards, M. and B. Harrison (1999), Road Pricing in Leeds, MVA, U.K.

Rienstra, S.A., Rietveld, P., Verhoef, E.T. (1999) The Social Support for Policy Measures in Passenger Transport. A Statistical Analysis for the Netherlands. Transportation Research D, pp.181-200.

Rietveld, P. and Verhoef, E.T. (1998) Social feasibility of policies to reduce externalities in transport. In Button K.J. and Verhoef E.T. (Eds.), Road Pricing, Traffic Congestion and the Environment, Edward Elgar, USA.

Schade, J. and Schlag, B. (2000) Acceptability of Urban Transport Pricing. Research Report 72, Government Institute for Economic Research, Helsinki.

Schade, J., and Schlag, B. (2003) “Acceptability of urban transport pricing strategies”, Transportation Research 6F(1), 45-61.

Schade, J., Seidel. T., and Schlag, B., (2004), “Cross-Site-Evaluation of Acceptability indicators”. Working paper. EU-Project CUPID funded by the European Commission under the 5th Framwork Programme. Dresden.

Schlag, B. and Teubel, U. (1997) Public acceptability of transport pricing. IATSS Research, 21(2), 134-142.

Schlag, B. and Schade, J. (2000) Public acceptability of traffic demand management and pricing measures in Europe. Traffic Engineering and Control, 41(8), 314-318.

Seik, F.T. (1998) “A unique demand management instrument in urban transport: the vehicle quota system in Singapore”, Cities, 15(1): 27-39.

Sheldon, R., Scott, M. and Jones, P. (1993) London congestion charging: exploratory social research among London residents. Proceedings 21st PTRC Summer Annual Meeting: Seminar L, 129-145.

Simon, H.A. (1957) Models of Man, Social and Rational: Mathematical Essays on Rational Human Behavior in a Social Setting, New York, Wiley.

Simon, H.A. (1985) Human nature in politics: the dialogue of psychology with political science. American Political Science Review, 79, 293-304.

Simon, H.A. (1997) Administrative Behavior: a Study of Decision-making Processes in Administrative Organizations, New York, The Free Press.

Small, K.A. (1992) Using the revenues from congestion pricing, Transportation, Vol. 19, 359-381.

Small, K.A. and Gomez-Ibanez, J.A. (1998) Road pricing for congestion management: the transition from theory to policy. In K.J. Button and E.T. Verhoef (eds.), Road Pricing, Traffic Congestion and the Environment, Edward Elgar, USA.

Smith, A. (1776) The Wealth of the Nations, with an introduction by A.S. Skinner (1974), Penguin Book, UK.

Smith, J.C. and R.S. Burton (1998), "Initial findings from the Leicester environmental road tolling scheme", paper presented at the 9th International Conference on Road Transport Information & Control, IEE, 21-23 April 1998, London.

Sterman, J.D. (2000) Business Dynamics: Systems Thinking and Modeling for a Complex World, Boston, Irwin/McGraw-Hill.

Stokes, G. (1996), "Getting car commuters onto public transport – a Survey in Merseyside", Proceedings 24th European Transport Forum: Seminar F, PTRC, UK.

Stokes, G. and Taylor, B. (1995) The public acceptability of sustainable transport policies: finding from the British Social Attitudes survey. Proceedings 23rd European Transport Forum: Seminar C, 69-83, PTRC, UK.

TDRI (2001) The study of Traffic and Transportation Development Master Plan for the 9th National Economic and Social Development Plan 2002-2006, Thailand Development Research Institute (TDRI), Thailand.

Teubel, K. (1997) Verteilungswirkungen von Straßenbenutzungsgebühren in einem Städtischen Ballungsraum. Internationales Verkehrswesen 49, pp.97-103.

The Nation (2007), "Congestion charge for downtown Bangkok still a dream", The Nation (daily newspaper) 17 May 2007, Bangkok, Thailand.

Thompson, A. (1990) Road user charging: the current state of technology, Traffic Engineering and Control, Vol. 31, No. 10.

Thorpe, N., Hills, P. and Jaensirisak, S. (2000) Public attitudes to TDM measures: A comparative study. Transport Policy, 7(4), 243-257.

Transportation Research Broad (1994) Curbing Gridlock: Peak-Period Fees to Relieve Traffic Congestion. Special Report 242, Volume 1, National Research Council, USA.

Van der Loop, J.T.A. and Veling, I.H. (1994) Developments in the acceptance of the transport structure plan by the Dutch population and how to increase the acceptance of measures?. Proceedings 22nd PTRC Summer Annual Meeting: Seminar D, 125-134.

Verhoef, E.T. (1996) The Economics of Regulating Road Transport. Edward Elgar, Cheltenham.

Verhoef, E. (1999) Time, speeds, flows and densities in static models of road traffic congestion and congestion pricing, Regional Science and Urban Economics, Vol. 29, No. 3, 341-369.

Verhoef, E. (2001) Marginal cost based pricing in transport key implementation issues from the economic perspective, paper presented at IMPRINT-EUROPE Seminar, 21-22 November 2001, Brussels.

Vickrey, W. (1955) Some implications of marginal cost pricing for public utilities, American Economic Review, Vol. 45, 605-620.

Vickrey, W. (1963) Pricing and resource allocation in transportation and public utilities, American Economic Review, Vol. 53, No. 2, 452-465.

Vickrey, W. (1969) Congestion theory and transport investment, American Economic Review, Vol. 59, No. 2, 251-260.

Walters, A. (1954) Track costs and motor taxation, Journal of Industrial Economics, Vol. 2, No. 2, 135-146.

Walters, A. (1961) The theory and measurement of private and social cost of highway congestion, Econometrica, Vol. 29, No. 4, 676-699.

Walters, A. (1987) Congestion. In J. Eatwell, M. Milgate and P. Newman (eds.), The New Palgrave: a Dictionary of Economics, Macmillan Press, London.

Willoughby, C. (2001) Singapore's motorization policies 1969-2000, Transport Policy, Vol. 8, 125-139.

Wilson, P.W. (1988) Welfare effects of congestion pricing in Singapore, Transportation, Vol. 15, No. 3, 191-210.

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