# LAND TRANSPORT PRICING FOR NEW ZEALAND

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## AN IMPORTANT NOTE FOR THE READER

# CONTENTS


| | | |
|---|---|---|
| EXECUTIVE SUMMARY | | 11 |
| ABSTRACT | | 15 |
| PART 1. | THE CURRENT STRUCTURE AND PRICING OF LAND TRANSPORT IN NEW ZEALAND | |
| 1. | INTRODUCTION | 17 |
| 1.1 | Aims | 17 |
| 1.2 | Structure of Part 1 of Report | 18 |
| 2. | LAND TRANSPORT SYSTEM | 19 |
| 2.1 | Aims and Structure of the Land Transport System | 19 |
| 2.1.1 | Aims of the Land Transport System | 19 |
| 2.1.2 | Structure of the Land Transport System | 20 |
| 2.2 | National Land Transport Programme (NLTP) | 22 |
| 2.3 | Passenger Transport System | 23 |
| 3. | PRICING LAND TRANSPORT | 25 |
| 3.1 | Funding | 25 |
| 3.2 | The Charging System | 29 |
| 3.3 | Allocation of Road Costs | 30 |
| 3.3.1 | Driver-Imposed Costs | 30 |
| 3.3.2 | Space-Imposed Costs | 30 |
| 3.3.3 | Strength-Imposed Costs | 30 |
| 3.3.4 | Summary of Costs | 31 |
| 3.4 | Charging Methods | 31 |
| 3.4.1 | Motor Spirit Tax | 34 |
| 3.4.2 | Heavy Vehicle Charges | 34 |
| 3.5 | Summary of Relationship between Road User Charges and Highway Costs | 35 |
| 4. | POTENTIAL EXTENSIONS TO THE CHARGING SYSTEM | 38 |
| 4.1 | The Land Transport Pricing System Review | 38 |
| 4.2 | Key Issues in Land Transport Pricing System Review | 39 |

## PART 2. LITERATURE REVIEW


| | | |
|---|---|---|
| 1. | INTRODUCTION | 41 |
| | 1.1 Background to the Literature Review | 41 |
| | 1.2 Structure of the Literature Review | 42 |
| 2. | PRICING PRINCIPLES | 44 |
| | 2.1 Introduction | 44 |
| | 2.1.1 Economic Efficiency | 44 |
| | 2.1.2 Environmental Protection | 45 |
| | 2.1.3 Urban Planning | 45 |
| | 2.1.4 Equity | 46 |
| | 2.1.5 Revenue Generation | 46 |
| | 2.1.6 Evidence of Objectives | 47 |
| | 2.2 First-best Pricing Principles | 47 |
| | 2.2.1 Effect of Price | 47 |
| | 2.2.2 Effect of Competition | 49 |
| | 2.2.3 Pricing a Single Product | 49 |
| | 2.2.4 Exceptions | 50 |
| | 2.2.5 Examples for Setting Price | 50 |
| | 2.2.6 Marginal Costs | 52 |
| | 2.3 Second-best Pricing Principles | 53 |
| | 2.4 What is the Appropriate Cost Measure? | 55 |
| | 2.5 Optimal Investment | 57 |
| | 2.6 Pricing Structures | 58 |
| | 2.7 Other Issues | 59 |
| | 2.8 Road Track Costs - Charging Vehicles for Their Use of Road Infrastructure | 60 |
| | 2.8.1 Capital Charges | 60 |
| | 2.8.2 The Fourth Power Rule | 61 |
| | 2.8.3 Weathering | 62 |
| | 2.8.4 Economies of Scale | 63 |
| | 2.8.5 Other Issues | 64 |
| | 2.9 Summary | 64 |
| 3. | PRICING METHODS | 66 |
| | 3.1 Criteria for the Design of Road Pricing Systems | 66 |
| | 3.2 Alternative Charging Structures | 67 |
| | 3.2.1 Extension of Existing Charging and Taxation Arrangements | 67 |
| | 3.2.2 Supplementary Licensing | 68 |
| | 3.2.3 Cordon Tolls | 69 |
| | 3.2.4 Time-, Distance- and Congestion-Based Charging | 70 |
| | 3.2.5 Other Approaches to Charging | 71 |
| | 3.2.6 Fairness of Charging Structures | 71 |
| | 3.3 Technology | 72 |
| | 3.3.1 Systems of Payment | 72 |
| | 3.3.2 Communication Systems | 73 |
| | 3.3.3 Enforcement | 74 |
| | 3.4 Summary | 75 |

**4. PUBLIC ATTITUDES TO ROAD PRICING** 76
4.1 Introduction 76
4.1.1 Attitudes to Charging Structures 76
4.1.2 Limitations of the Review 77
4.2 Awareness of Traffic-related Problems 77
4.3 Support for Pricing and Other Externality-Reduction Measures 79
4.3.1 UK Surveys 79
4.3.2 European Surveys 80
4.3.3 Surveys in Japan and USA 82
4.4 Attitudes Towards Road Pricing 83
4.4.1 Scheme Conception 84
4.4.2 Charging Basis of the Scheme 88
4.4.3 Practical Feasibility 90
4.4.4 Views of Businesses 91
4.5 How Can Road Pricing Be Made More Acceptable? 92
4.6 Summary 95

**5. RESPONSES TO ROAD PRICING** 96
5.1 Introduction 96
5.2 Short-term Effects 96
5.3 Medium-term Effects 97
5.4 Changes in Land Use and Activity Patterns 97
5.5 Differential Impacts 98
5.6 Macroeconomic Effects 98
5.7 Distributional Impacts 98
5.8 Elasticities 99
5.9 Urban Transport 100
5.10 Inter-Urban Transport 101
5.11 Freight Transport 102
5.12 Summary 103

**6. PRICING AND OTHER POLICY MEASURES** 104
6.1 Pricing and the Objectives of Transport Policy 104
6.2 Planning Policies 107
6.2.1 Access Planning 108
6.2.2 Land Use Planning 109
6.3 The Sustainability Argument for Regulation 110

**7. OTHER DEMAND MANAGEMENT MEASURES** 112
7.1 Introduction 112
7.1.1 Measures Affecting Supply 112
7.1.2 Measures Affecting Demand 112
7.1.3 Criteria for Assessing Demand Management Measures 113
7.2 Demand Management Measures as Alternatives to Pricing Policies 114

7.3 Voluntary Measures: Car Sharing and Car Pooling 116
7.3.1 Effectiveness 116
7.3.2 Efficiency 117
7.3.3 Practicality 118
7.3.4 Fairness 118
7.4 Voluntary Measures: Rescheduling Activities119
7.4.1 Effectiveness 119
7.4.2 Efficiency 119
7.4.3 Practicality 119
7.4.4 Fairness 119
7.5 Physical Control Measures 120
7.5.1 Effectiveness 120
7.5.2 Efficiency 121
7.5.3 Practicality 121
7.5.4 Fairness 122
7.6 Regulatory Measures 122
7.6.1 Effectiveness 123
7.6.2 Efficiency 123
7.6.3 Practicality 124
7.6.4 Fairness 124
7.7 Parking Control Measures 124
7.7.1 Effectiveness 125
7.7.2 Efficiency 126
7.7.3 Practicality 127
7.7.4 Fairness 132
7.8 Summary of Demand Management Measures 132

**8. BIBLIOGRAPHY** 135

**PART 3. RESEARCH REQUIREMENTS**

**1. INTRODUCTION** 157
1.1 The Need for a Research Programme 157
1.2 Research Issues 157

**2. RESEARCH REQUIREMENTS** 159
2.1 Dimensions of a Research Programme 159
2.2 Objectives of a Research Programme 159
2.3 Structure of the Proposed Research Programme 160
2.4 Details of the Proposed Research Programme 161
2.4.1 Stage One: Preliminary Review 161
2.4.2 Stage Two: Conceptual Studies 163
2.4.3 Stage Three: Detailed Research Programme 163
2.5 Research Priorities 166
2.6 Research Timetable 168

## FIGURES

### Part 1

2.1 Planning relationships of the organisations administering the land transport system in New Zealand, under the Transit New Zealand Act 1989. 21

3.1 Central government revenue flows and inputs to the land transport system. 26

### Part 2

2.1 Loss of welfare caused by inefficient pricing. 48

2.2 Benefits of setting price equal to marginal social cost (MSC), in a congested situation. 51

7.1 Categories of demand management measures. 115

7.2 Summary and comparison of the principles of demand management measures. 128

## TABLES

### Part 1

3.1 Duties, taxes and levies on motor fuels (cents per litre, excluding GST), from 2 July 1992. 27

3.2 Summary of revenues and expenditure in the Land Transport Fund for 1991/92. 28

3.3 Percentage allocation of costs between driver, space and strength components for State Highways in New Zealand. 32

3.4 Summary of proposed National Land Transport Programme expenditure. 36

### Part 2

4.1 Effect of context on attitudinal response. 80

4.2 Views of Europeans concerning the effectiveness of different measures for improving traffic movement and the environment in city centres. 81

4.3 Views of Europeans concerning priorities of user groups in traffic planning conflicts. 81

4.4 Support for different congestion and pollution control measures in Osaka, Japan. 82

4.5 Most and least acceptable methods of road user charging in London. 86

4.6 Support (% Very Much or Somewhat in Favour) by drivers and non-drivers for different restraint/control measures in Central London. 87

5.1 Urban short-run own-price and cross-price elasticities of demand. 100

5.2 Inter-urban own-price and cross-price elasticities of demand. 101

5.3 Own-price elasticities of demand for freight transport (all commodities) in situations where shippers face a choice. 102

6.1 Quality-of-life objectives for transport. 104

### Part 3

3.1 Summary of detailed research programme at Stage Three. 167

# EXECUTIVE SUMMARY

This report deals with issues of land transport pricing in New Zealand. It has three parts:

- A description of the current structure and pricing of land transport infrastructure in New Zealand;
- A review of the literature on land transport pricing to identify the principles underlying transport pricing policies and current and proposed policies from other countries; and
- The identification of a land transport pricing research programme for New Zealand.

The current land transport system in New Zealand aims to provide an integrated planning, funding and operational structure. The basis of the system of current road user charges is recovery of the national roads budget from the several classes of vehicle in proportion to the extent to which they cause costs to be incurred. How well current charging policies and levels meet this objective needs to be established.

The review of the principles underlying transport pricing policies draws attention to the other costs associated with land transport which, to maximise efficiency, should also be incorporated in user charges. Such costs include congestion, notably in cities, accident risks to others, local environmental degradation and contributions to global pollution.

The review sets out the pricing rules to be applied to land transport to maximise efficiency:

- In circumstances where efficiency is the designated objective and other related sectors are applying similar pricing rules, and
- Where objectives other than efficiency (financial, for example) take priority and other pricing rules are applied in other related sectors.

The practical difficulties and the costs of developing charging mechanisms which successfully internalise all the costs associated with transport, allowing the defined pricing rules to be put into practice, are identified.

Criteria which charging mechanisms should meet are identified and those charging mechanisms which can be applied to private transport have been assessed against them. This assessment draws attention to the trade-off between, on the one hand, more complex charging structures more closely related to actual costs and, on the other, simpler more easily understandable charging structures.

The evidence of public attitudes and responses towards different charging mechanisms is reviewed. While vehicle and fuel taxes and tolls on new roads are well established and generally accepted, road pricing, in its more limited, congestion-related sense, is treated with more suspicion by the public. Vehicle users are more likely to be receptive to paying for safety and the environment than paying for congestion.

Congestion-related pricing is more likely to be acceptable if:

- It is apparent that the funds raised are used to alleviate problems on the transport network or environmental problems;

- It is accompanied by a well planned package of complementary measures; and

- Careful explanations are given of the inefficiency, insufficiency or inequity of current practice.

Pricing policies, as a mechanism for efficiently managing travel demands in congested conditions, are not challenged by any other policy instrument. They have advantages of:

- flexibility (the potential to vary their severity by location and by time of day),
- selectivity (bearing hardest on those trips imposing highest cost and having the capacity to discriminate in favour of high occupancy or efficient vehicles), and
- immediacy (ensuring that travel decisions are based on a full awareness of the costs of a journey).

Other mechanisms, based on physical controls, parking controls, regulation or voluntary demand management, will neither ensure that desired numbers of trips, from an economic efficiency perspective, are made nor ensure that only trips with a surplus of value over their full social cost are made.

The requirements now in New Zealand are:

- To compare the current land transport pricing system with an economically efficient pricing system (for each mode in rural, inter-urban and urban areas);

- To understand the consequences, particularly in terms of modal demands, revenues and economic benefits, of moving towards an economically efficient pricing system; and

- To understand the economic efficiency forgone by pursuing objectives other than efficiency maximisation.

To inform these requirements, a structured sequential research programme is required. This programme should include:

- Internal costs and external costs;
- Urban, inter-urban and rural trips; and
- All relevant transport modes.

Stage 1 of this programme, a preliminary review, would use current information and best estimates to meet the following objectives:

- An initial assessment of the charges per trip (by type, area, time of day) which would satisfy efficiency criteria;

- An assessment, outside urban areas, of whether existing charging mechanisms meet their currently defined objectives and whether they equate reasonably with the optimum; and

- Identification of the gaps in current information where estimates are inadequate and further research is necessary.

Stage 2 would focus on those areas covered least well in the preliminary review and would include conceptual studies to examine:

- The effectiveness of congestion pricing in the principal urban areas; and

- The non-transport benefits of the rural road network.

At this stage the implications of pursuing different pricing objectives throughout the land transport system would be established.

Stage 3 would be a detailed research programme to inform the final design and evaluation stages of a land transport pricing system and to pave the way for implementation of the preferred system.

**ABSTRACT**

As part of the management of the land transport system of New Zealand, a study of land transport pricing policies, with particular emphasis on road pricing, has been carried out. The study comprised a review of relevant literature and the development of a proposed land transport pricing research programme for New Zealand. The report of this study consists of three parts:

- A description of the current structure and pricing of land transport infrastructure in New Zealand;
- A review of the literature on land transport pricing to identify the principles underlying transport pricing policies and current and proposed policies from other countries; and
- The identification of a proposed land transport pricing research programme for New Zealand.

The proposed research programme that was identified has three stages:

- A preliminary review, based on current information and best estimates, which would derive initial estimates of costs per trip;
- Conceptual studies to assess the implications of pursuing different policy objectives particularly in urban and rural areas; and
- A detailed research programme to evaluate land transport pricing systems and to design a preferred pricing system.

# THE CURRENT STRUCTURE AND PRICING OF LAND TRANSPORT IN NEW ZEALAND 1.

# 1. INTRODUCTION

## 1.1 Aims

Under the Transit New Zealand Act 1989, Transit New Zealand is required to ensure a safe and efficient land transport system for New Zealand that maximises economic and social benefits.

As part of the management of the land transport system, a review of the New Zealand Land Transport Pricing System is currently underway. The intention is to develop a comprehensive framework for establishing a pricing and regulatory basis for the land transport system, considering all effects, costs and benefits of the system.

The three principal tasks of the review are:

- to gain an understanding of the current structure and pricing of land transport infrastructure in New Zealand; and to provide a summary of the structure of the land transport system along with details of the current approach to pricing;
- to review literature and both current and proposed policies from other countries, to identify potential improvements to New Zealand's current land transport structure and its pricing, from both theoretical and practical points of view; and
- to identify further research projects necessary to (i) quantify particular costs and benefits where existing data are not sufficiently precise, and (ii) select appropriate policy options where the best option is not obvious even following the literature review.

This report, as part of the review, is intended to define the starting point for subsequent research that will explore the applicability of other pricing and demand management techniques for New Zealand.

## 1.2 Structure of Part 1 of Report

Section 2 of Part 1 concerns the structure of the Land Transport System currently applied in New Zealand. The institutions involved in the system are briefly introduced; the Land Transport Development Programme is described; and the Passenger Transport System is reviewed.

Section 3 describes the means by which land transport is priced. The general method of funding land transport is addressed and a description provided of the basic charging system. Then, two key procedures are considered:

- The method of allocating road costs to particular categories of user; and

- The charging methods for collecting revenue from users.

Section 4 summarises a number of suggestions for extending the road user pricing programme.

# 2. LAND TRANSPORT SYSTEM

## 2.1 Aims and Structure of the Land Transport System

In September 1989, the New Zealand Parliament passed a package of new laws that fundamentally reformed the management of the New Zealand land transport system. These Acts are:

- Transit New Zealand Act 1989;
- Transport Services Licensing Act 1989; and
- Local Government Amendment Act (No. 4) 1989.

Subsequent amendments have been made to the reforms (of which the content has been incorporated into this paper) but the broad principles remain. The implications of these changes for the structure of the New Zealand Land Transport System, which includes road and rail, are outlined here.

The term "system" is entirely appropriate to the approach currently taken to the management and planning of transport in New Zealand because all the fundamental elements of a systems' method are featured in this approach. They include:

- A set of **aims** and **objectives** for the system as a whole, together with its sub-components;

- A recognition of the importance of **interactions** and **relationships** between different parts of the transport system, such as between public and private transport or between vehicle type and pavement damage, and between the modes of road versus rail;

- An understanding of the concept of a system's **boundary**, particularly when deciding which impacts of transport operations should be "internalised" in an economic analysis; and

- A recognition of the importance of **performance measures** and **control** in the monitoring and manipulation of a system's behaviour. In this case, economic performance measures and control by pricing are favoured.

### 2.1.1 Aims of the Land Transport System

The main aim of the system is to provide a fully integrated planning, funding and operational structure for land transport in New Zealand. Subsidiary to this are a number of supporting objectives, which are to:

- Integrate all aspects of land transport planning into a coherent unified system that reflects community interests;

- Improve road safety through the integration of planning and implementation of roading design and construction with traffic management, road safety education and enforcement;

- Encourage innovation in land transport management to provide transport facilities and services that match the needs of particular communities;

- Develop an appropriate partnership between local and national government in the planning, funding and management of the land transport system, with maximum possible devolution of decision making to local communities;

- Provide cost-effective transport facilities and services; and

- Clearly identify the social costs and benefits of the new system for users.

### 2.1.2 Structure of the Land Transport System

The hierarchy of the main organisations within the land transport system is illustrated in Figure 2.1, and the chief responsibilities of each agency are outlined as follows.

- **Territorial Councils** (city and district authorities) were set up in 1989 and each has to prepare a District Land Transport Programme for its area. This programme must set out all the projects planned for the following year for which funding is sought from the Land Transport Fund (LTF) (see Section 3.1). Responsibility for the analysis and appraisal of these programmes and funding applications lies with Transit New Zealand and the Ministry of Transport (MOT).

- Each **Regional Council** in New Zealand develops a Regional Land Transport Programme (mainly covering public passenger transport needs) and also produces an annual road safety report for its region. The programmes are analysed and appraised by Transit New Zealand.

A recent amendment, the Local Government Act 1992, abolished the Nelson/Marlborough Regional Council and established the three territorial local authorities in the area as **Unitary Authorities.** These have the functions, duties and powers of both territorial authorities and regional councils.

- **Transit New Zealand** is a central government agency and is primarily responsible for:

    - preparing an annual National Land Transport Programme (see Section 2.2) which is developed out of the Regional Land Transport Programmes;

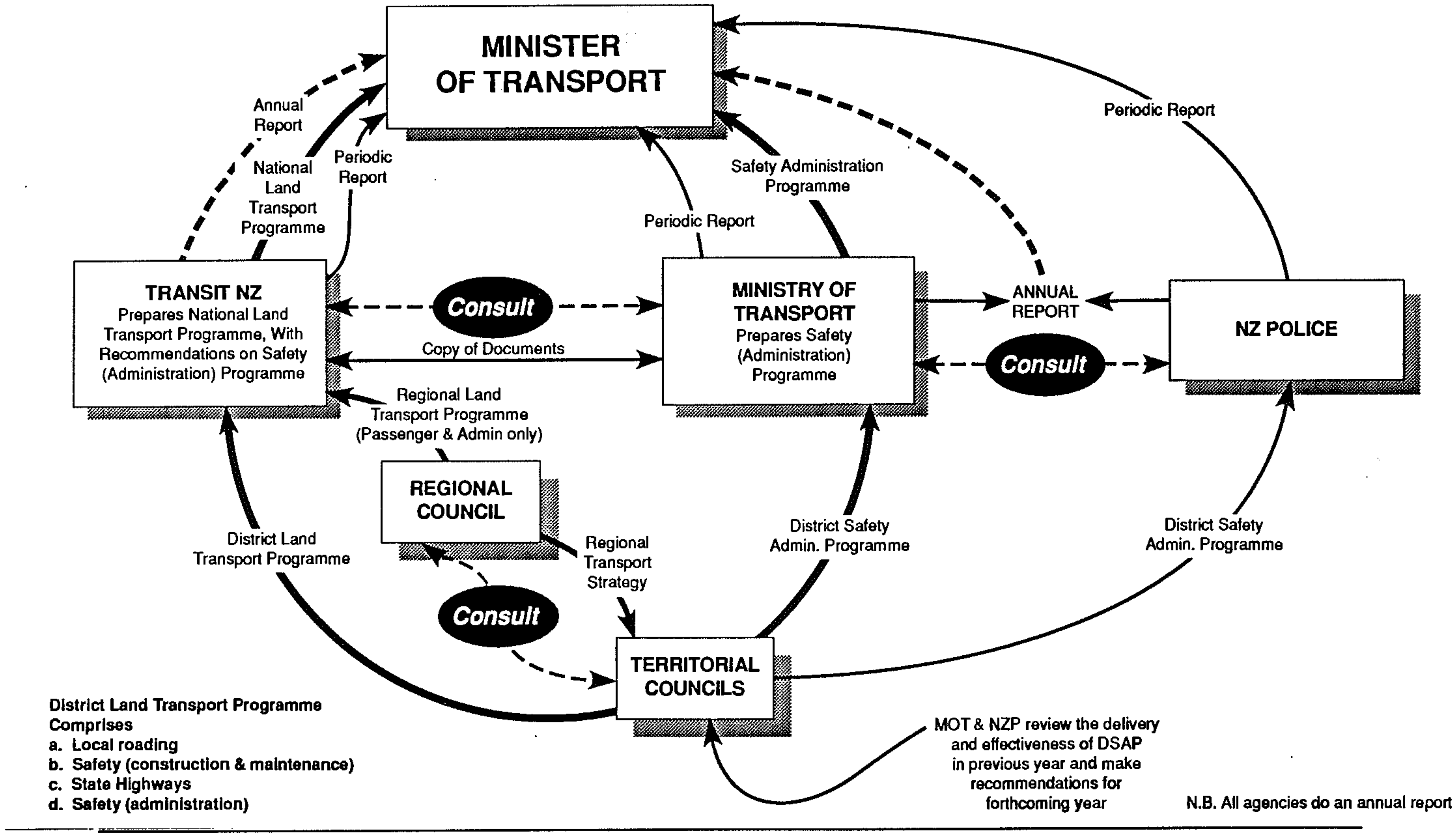


**Figure 2.1** Planning relationships of the organisations administering the land transport system in New Zealand, under the Transit New Zealand Act 1989.

- recommending to government the levels of income and expenditure from the Land Transport Fund;
- funding and auditing approved projects;
- management of the State Highway system; and
- advice, research and information on land transport systems.

• The **Land Transport Division** of the **Ministry of Transport** has overall responsibility for:

- developing safety policy and standards for drivers, vehicles and facilities;
- education and safety promotion activities; and
- monitoring and enforcement of road traffic safety (along with New Zealand Police).

Once the National Land Transport Programme has been approved (see Section 2.2), responsibility for its implementation is assumed by the appropriate organisation. The main areas of responsibility are as follows:

- State highways - Transit New Zealand retains responsibility for all work on state highways, though Territorial Councils may request that powers be delegated to themselves;
- Local roads: safety, construction and maintenance - local authorities have this responsibility;
- Safety administration - the Ministry of Transport and the New Zealand Police have this responsibility; and
- Passenger transport - Regional Councils have overall responsibility for administering competitive tendering and the allocation of subsidies.

## 2.2 National Land Transport Programme (NLTP)

The National Land Transport Programme is developed each year by Transit New Zealand and sent to the Minister of Transport for consideration and sanctioning. The Programme recommends a package of projects along with proposals for expenditure and revenue collection (including road user charges, licensing fees and government grants).

For example, the Programme for 1992/93 contains proposals under the following broad headings:

National Land Transport Programme:
- Local roads construction and maintenance,
- Safety, construction and maintenance for both local roads and state highways,
- Passenger transport,
- State highways construction and maintenance,
- Administration,
- Research.

Safety Administration Programme:
- Safety administration programme,
- Fund enforcement programme for road user charges.

New projects are recommended on the basis of an economic evaluation, with a benefit:cost ratio of two to one being required before a particular scheme is commissioned. In view of the current economic climate and shortage of capital for investment in public projects, a ratio of at least 4:1 has been proposed for projects which are to be recommended in the present Programme.

It should be emphasised that this is a project-based, rather than a system-based, approach. Moreover, environmental and social effects are not taken into account.

A minimum level of expenditure of the Programme of 90% of the previous year's budget is guaranteed by the government. Proposals for expenditure beyond this level are individually considered.

## 2.3 Passenger Transport System

The new Passenger Transport System aims to integrate all public transport modes, including rail, ferry and taxis, into a simple management unit to provide the most appropriate and cost-effective services for passengers.

A key characteristic of the system is that the planning of services and their operation are to be separate. Planning is now the responsibility of the Regional Councils and operation is the responsibility of the private sector and the territorial authorities.

The system is administered by the Regional Councils who prepare a Regional Passenger Transport Plan. It is not compulsory that they do so but, if they do not, all passenger transport services within the region would be supplied by private operators on a purely commercial basis. No facility would exist for subsidies to be provided for socially desirable but (financially) non-viable services.

Where a Regional Council does decide to prepare a Plan, then it can specify service requirements for some or even all public transport routes in the region. Services may be specified in terms of:

- route to be operated,
- capacity,
- frequency,
- fare levels,
- integration with other modes,

or any other characteristic considered to be important, with the exception of the mode of transport.

Operators within a region must notify the Regional Council and register all services they wish to run. These may be services set out in the Plan, or others considered to be a worthwhile venture. If a service specified in the Plan is commercially viable then the Council has no further involvement except that it may decline to register other services that may affect the financial viability of a contracted service. If a specified service cannot be commercially provided, the Region may invite competitive "reverse bids" from operators to supply a subsidised service.

Only those services specified in the Regional Passenger Transport Plan can be contracted out and subsidised.

Local authority-operated public transport services are now corporatised and by July 1994, Regional Councils must divest themselves of all operations.

The passenger transport system incorporates all modes of public passenger transport, including rail, ferry and taxis. Rail passenger services are currently provided by NZ Rail Ltd, a government-owned company that is to be privatised (as at March 1993). However, it is expected that NZ Rail or its counterpart will continue to contract with Regional Councils to provide passenger transport services.

# 3. PRICING LAND TRANSPORT

## 3.1 Funding

Approximately NZ$750 million (M) will be spent on land transport over the coming year (1992-1993) by central government. This sum does not include indirect costs or externalities (e.g. congestion and accident costs). Around NZ$1,300M will be raised through various transport taxes, road user charges and licence fees.

A further NZ$300M (approx.) will be funded by local government from local taxes for expenditure on local roads.

The Local Government Amendment (No. 2) Act 1992 gives the regional councils that include the major urban areas the power to levy a regional petrol tax of up to 2 cents per litre over a designated tax area for the three years ending in June 1995 for the purposes of funding passenger transport. It should also be noted that the Regional Councils no longer receive any contributions from Local Authority Petrol Tax.

Revenues from transport users have two principal destinations:

- the **Land Transport Fund**, for re-allocation specifically to transportation expenditure; and

- the **Crown Account** (or national exchequer) for general expenditure.

Some fuel excise tax revenue is also allocated to territorial authorities for their own purposes. Figure 3.1 shows the main revenue flows and inputs to the system.

Table 3.1 summarises the various types of fuel tax levied. Only the Land Transport Fund excise (item b) is specifically destined for expenditure in the transport sector.

The main sources of revenue for the Land Transport Fund are as follows:

- motor spirit excise tax (9.4c/l for petrol and methanol in 1992);

- road user charges, collected from heavy vehicle operators; and

- licence fees collected from motor vehicle registrations.

The Government may also transfer money to the Fund from general revenue sources (Crown Account) as considered necessary.

Expenditure from the Land Transport Fund is directed to the following three areas:

- Land Transport Account managed by Transit New Zealand, which funds the approved National Land Transport Programme;

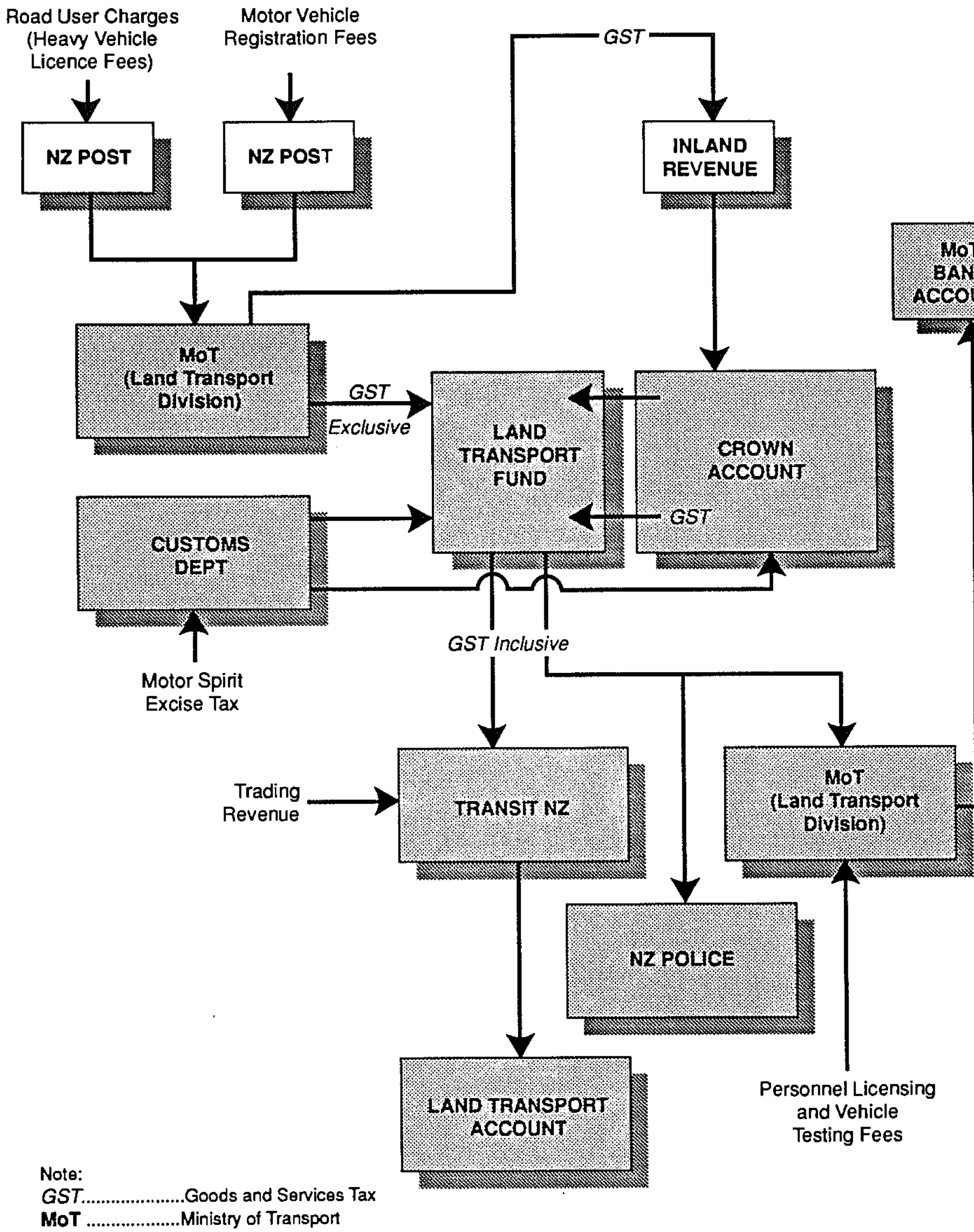


**Figure 3.1** **Central government revenue flows and inputs to the land transport system.**

## Table 3.1 Duties, taxes and levies on motor fuels (cents per litre, excluding GST), from 2 July 1992.

| Type of Fuel | Type of Revenue | | | | | | | | | Regional Petrol Tax | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | d | e | f | g | h | i | ARC | WRC | WNRC | CRC | ORC |
| Leaded 96 RON | 20.8 | 9.4 | 30.2 | 2 | 0.0 | 0.025 | 0.66 | 2.8 | 35.685 | 0.95 | 0.2 | 1.5 | 0.62 | 0.5 |
| Unleaded 91 RON | 20.8 | 9.4 | 30.2 | 2 | 0.0 | 0.025 | 0.66 | 0.0 | 32.885 | 0.95 | 0.2 | 1.5 | 0.62 | 0.5 |
| Automotive diesel | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.025 | 0.33 | 0.0 | 0.355 | | | | | |
| LPG | 0.0 | 8.4 | 8.4 | 0 | 1.1 | 0.0 | 0.00 | 0.0 | 9.5 | | | | | |
| CNG | 0.0 | 11.0 | 11.0 | 0 | 1.6 | 0.0 | 0.00 | 0.0 | 12.6 | | | | | |

**KEY:**

| Type of Revenue | | Regional Petrol Tax | | Tax Area |
|---|---|---|---|---|
| a | Consolidated Fund excise | ARC | Auckland Regional Council | Auckland City Area |
| b | Land Transport Fund excise | WRC | Waikato Regional Council | Hamilton City |
| c | Total excise (a + b) | WNRC | Wellington Regional Council | See Note |
| d | Accident Compensation Corporation levy | CRC | Canterbury Regional Council | Christchurch City |
| e | Energy Resources levy (ERL) | ORC | Otago Regional Council | Dunedin City |
| f | Petroleum Fuels Monitoring levy | | | |
| g | Local Authorities Petroleum Tax | Note: | WNRC tax is 1.5 cpl for Wellington, Porirua and the Hutt Valley, and 0.5 cpl for the Kapiti Coast | |
| h | Lead Tax | | | |
| i | Total of volume-based duties and taxes (c+d+e+f+g+h) | | | |

**Notes:**
- The lead tax is levied at the rate of 8.0 cents/gram of lead added. Since 1/1/91 lead has been added at the rate of 0.35 grams/litre.
- Diesel is not subject to excise because diesel vehicles are all subject to road user taxes, which help to fund Transit New Zealand.
- The total taxes figure for CNG is based on per litre petrol equivalent. The ERL is charged at 45 cents/gigajoule.
- The Land Transport Fund applied to CNG is $3.17/gigajoule. These figures have been converted to cents/litre petrol equivalent on a straight energy basis, i.e. 34.6 MJ/litre (premium).

GST Goods and Services Tax

- Safety Administration Programme, administered by the Ministry of Transport and the Police; and

- Enforcement of road user charges, and vehicle registration and licensing requirements, carried out by the Ministry of Transport.

The National Land Transport Programme (see Section 2.2), which is prepared each year by Transit New Zealand, recommends a package of proposals for both expenditure and revenue collection. This includes proposed levels of transport excise duty, road user charges, motor vehicle registration and licensing fees along with proposals for appropriations to the Fund from general Government revenue to finance the expenditure programme. Approval for these proposals is required from the Minister of Transport before they can be implemented.

The current sources and (approximate) levels of revenues and expenditure are summarised in Table 3.2 which shows that approximately 50% of the costs of improvements and maintenance to local roads are derived from the Land Transport Fund with the remaining 50% being raised locally. In fact, 43% of local expenditure on roads is guaranteed by Transit New Zealand. Poorer authorities (with lower earning power) may qualify for in excess of 50% of the costs. Local Authorities can also raise funds through loans to supplement rates income for investment in particular transport projects.

**Table 3.2 Summary of revenues and expenditure in the Land Transport Fund for 1991/92.**

| REVENUES | | EXPENDITURE | |
|---|---|---|---|
| LAND TRANSPORT FUND | | | |
| Road user charges | $300M | Road Maintenance | |
| | | • State | $250M |
| | | • Local | $250M |
| Motor spirit tax | $350M | Road Improvements | |
| | | • State | $50M |
| | | • Local | $50M* |
| Licence fees | $100M | Road Safety & Enforcement | $100M |
| Accident levies | $100M (for health care) | Public Transport Support | $50M |
| Fuel excise | $600M (to Crown Account) | | |

* Approximately the same amount also is provided from local rates

Territorial Councils determine requirements for highways-related investment while Regional councils decide on the level of subsidy for public transport. Although both authorities are able to collect rates to cover this expenditure, in practice the Territorial Councils sometimes take responsibility for collecting the two categories together.

The depressed state of the New Zealand economy along with the strict control over public spending is currently constraining the availability of funds for capital projects. This is prompting the government and Transit New Zealand to explore alternative means of financing new schemes (see Section 4) including greater private sector involvement in the design, construction and operation of highways. It is also stimulating research into economic methods for assessing the most efficient pricing mechanisms and levels of charge and of investment levels in the transport sector.

## 3.2 The Charging System

The basis of the system of current road user charges is recovery of the national roads budget from the several classes of vehicle in proportion to the extent to which they cause costs to be incurred. It imposes a tonne-kilometre charge on vehicles that are either heavy (more than 3.5 tonnes) or diesel-powered, and a fuel tax on all other vehicles. The system has been in operation since 1978 and, although it has undergone minor amendments, it has not been significantly altered to date (1992).

The system accommodates both a road funding policy and a vehicle taxation policy. The amount raised from user charges is not necessarily related to the costs of road maintenance and construction. The amount allocated to these costs annually is determined as part of the annual budget process in preparation of the NLTP.

The main steps in establishing the annual level of charges are identified below. It should be noted that this represents the prescribed procedure but, in practice, charges have not been reviewed or amended for the last five years. The procedure is:

- Determination and approval of the roads budget;
- Preparation of the detailed cost estimates specifically categorising the types and extent of works to be undertaken (see Section 3.3);
- Cost allocation of the various categories of work to the defined classes of vehicle user in the total vehicle population (see Section 3.3);
- Establishment of a unit charge for (i) private vehicles; and (ii) goods vehicles, based on the estimated allocated annual costs of each vehicle category (see Section 3.3); and
- Levy charges through fuel tax (private vehicles) and licence fees (goods vehicles) (see Section 3.4).

## 3.3 Allocation of Road Costs

The procedure at the core of the charging system is that of allocating the total roads budget to the main categories of road user. This requires that first the roads budget is broken down under a number of headings (general maintenance, bridges, reconstruction, etc.) for the three classes of roads: state highways; urban local roads; and rural local roads. The cost incurred under each heading is then attributed to three basic parameters (Sections 3.3.1 - 3.3.3):

- Driver-imposed costs;
- Space-imposed costs; and
- Strength-imposed costs.

Research carried out over the past 15 years has provided the basic information required to allocate costs in this way. Table 3.3 illustrates the percentage allocation of costs between the driver, space and strength components for state highways. A similar breakdown of costs also exists for country (rural) roads and municipal roads.

Costs are separately estimated for 15 classes of vehicle. Cars and light vehicles represent one class, and the remaining 14 concern various heavy vehicles and their trailers. Thus, for each category of vehicle, costs are expressed in terms of the Driver, Space and Strength resources that each consumes. The sum of these costs is equivalent to the annual roads budget.

### 3.3.1 Driver-Imposed Costs

Driver-imposed costs are those which result from the need to provide resources for motorists themselves, irrespective of the type of vehicle being driven. They include:

- signs;
- roadmarkings; and
- landscaping.

The same unit "driver" cost is allocated to all powered vehicles, while unpowered vehicles (trailers and semi-trailers) are zero weighted. Costs are expressed in terms of vehicle-kilometres in order to allocate annual costs in an equitable manner among the various categories of vehicle.

### 3.3.2 Space-Imposed Costs

Space-imposed costs relate to the average area of road space occupied by a particular vehicle type. These costs are expressed as a function of vehicle weight, so that light vehicles (with a gross weight of under 1 tonne) have a value of unity, while a mean value of 3.0 is given to heavy vehicles as a group.

### 3.3.3 Strength-Imposed Costs

Strength-imposed costs are estimated as a function of the axle loads imposed by particular vehicle types. The "fourth power" relationship between axle load and pavement wear is used as the basis for estimating these costs. This is explained further in Part 2 (Section 2.8.2).

### 3.3.4 Summary of Costs

The breakdown of costs between the above three categories for 1986 is illustrated below:

| Category | $M | % |
|---|---|---|
| Driver | 133.0 | 30.0 |
| Space | 161.4 | 36.4 |
| Strength | 148.6 | 33.6 |
| **Total (1986)** | **443.0** | **100.0** |

A distinction is made between the categories of powered and unpowered vehicles because of the significant contribution to total revenues that is derived from the trailer component of the vehicle population. The following illustrates the 1986 revenues collected from powered and unpowered vehicles:

| Category | $M | % |
|---|---|---|
| Cars and light vehicles | 229.0 | 51.7 |
| Powered heavy vehicles | 151.1 | 34.1 |
| Unpowered vehicles (Trailers) | 62.9 | 14.2 |
| **Total (1986)** | **443.0** | **100.0** |

A method has also been developed for dividing costs imposed by vehicles into their fixed and variable components. This, in theory, would enable fixed costs to be collected through some annual standing charge per vehicle, while variable costs could be collected in proportion to vehicle use. However, separate collection of fixed and variable costs has not yet been introduced into the system.

## 3.4 Charging Methods

The maintenance and construction costs which are allocated to each category of vehicle are collected from highway users broadly in accordance with their level of road use. For light petrol-powered vehicles, road user charges are collected through a fuel tax. For heavy vehicles powered predominantly by diesel and for diesel-powered cars, a tonne-kilometre charge is levied via special licences which each operator must purchase.

**Table 3.3 Percentage allocation of costs between driver, space and strength components for State Highways in New Zealand.**

| Item | Description | Combined % of Item | % of Item to Driver | % of Item to Space | % of Item to Strength |
|---|---|---|---|---|---|
| **1.** | **General Maintenance** | | | | |
| (a) | Pavements | 52 | 3.1 | 3.1 | 45.8 |
| (b) | Shoulders | 16 | - | 13.6 | 2.4 |
| (c) | Drainage | 8 | 3.2 | - | 4.8 |
| (d) | Verges | 24 | 24.0 | - | - |
| | | 100 | 30.3 | 16.7 | 53.0 |
| **2.** | **Reseals** | | | | |
| (a) | Surface Texture | 30 | - | 30.0 | - |
| (b) | Cracking | 60 | - | - | 60.0 |
| (c) | Ageing | 10 | 5.0 | 5.0 | - |
| | | 100 | 5.0 | 35.0 | 60.0 |
| **3.** | **Shape Correction** | 100 | 6.0 | 6.0 | 88.0 |
| **4.** | **Bridge Repairs** | 100 | 100.0 | - | - |
| **5.** | **Traffic Services** | 100 | 100.0 | - | - |
| **6.** | **Accommodation and Depots** | 100 | 100.0 | - | - |
| **7.** | **Landscape Maintenance** | 100 | 100.0 | - | - |
| **8/12.** | **Reconstruction** | | | | |
| (a) | Incremental Pavement | 29 | - | - | 29.0 |
| (b) | Balance | 71 | - | 71.0 | - |
| | | 100 | 0 | 71.0 | 29.0 |
| **9/14.** | **Bridging** | | | | |
| (a) | HMV Loading | 18 | - | - | 18.0 |
| (b) | Balance | 82 | - | 82.0 | - |
| | | 100 | 0 | 82.0 | 18.0 |

**Table 3.3 Percentage allocation of costs between driver, space and strength components for State Highways in New Zealand.** *continued*

| Item | Description | Combined % of Item | % of Item to Driver | Space | Strength |
|---|---|---|---|---|---|
| **10.** | **Land Purchase** | | - | 100.0 | - |
| **11.** | **Motorway Construction** | | | | |
| (a) | Capacity Items | 56 | - | 56.0 | - |
| (b) | Furniture | 2 | 2.0 | - | - |
| (c) | Pavement | 5 | - | 1.0 | 4.0 |
| (d) | Structures | 37 | - | 30.3 | 6.7 |
| | | 100 | 2.0 | 87.3 | 10.7 |
| **13.** | **Seal Extension** | | | | |
| (a) | Pavement Structure | 20 | - | - | 20.0 |
| (b) | Balance | 80 | - | 80.0 | - |
| | | 100 | 0 | 80.0 | 20.0 |
| **15.** | **Miscellaneous Works** | 100 | 100.0 | - | - |
| **16.** | **Surveys and Investigations** | 100 | 100.0 | - | - |

### 3.4.1 Motor Spirit Tax

All vehicles under 3.5 tonnes gross vehicle weight using petrol pay a motor spirit tax on each litre of fuel purchased. The total annual revenue to be collected from this category of vehicle is known from the cost-allocation procedure, as is the charge rate per vehicle-kilometre. Furthermore, the average annual consumption of fuel is known from Customs Department records of previous years.

This information enables a tax rate/litre to be set which, over the year, will recover the required portion of the roads budget. In 1992, the level of motor spirit tax dedicated to the National Land Transport Fund was 9.4 cents per litre.

The tax is not collected at the point of sale, but from the wholesalers or distributors to whom the fuel is released from storage. The wholesalers make a weekly declaration of fuel received and as a result there is a weekly cash flow of funds.

Not all motor spirits are used in transport on the public highway and a refund procedure operates to take account of off-road usage. Most off-road users are in the farming sector and these must submit a claim for refunds based on a declaration of vehicle usage. The opportunity for fraudulent claims exists here, although claims can be checked to some extent against established "norms" of farm vehicle usage.

### 3.4.2 Heavy Vehicle Charges

As with light vehicles, the cost-allocation process for heavy goods vehicles (and diesel-powered cars) determines the total revenue to be collected and a charge rate per tonne-kilometre. A difference exists, however, because there can be a range of licensed weights for any class of vehicle.

Heavy vehicle owners must license their vehicles for the coming year by type and by the maximum gross weight expected to be carried. Licences are available in multiples of 1000km for each weight class, and supplementary licences may be purchased for excess loads or additional distances. As an example, the annual charge per 1000km for a 22 tonne GVW (gross vehicle weight) three-axled rigid truck was NZ$286 in 1986. An equivalent charge for a two-axled 5 tonne GVW rigid truck was NZ$23.

Heavy Vehicle Licences, like light vehicle licences, are available from post offices where operators purchase the required weight and distance quantities for specific vehicles, and where a cross-check is made against the original registration document. This is to ensure that the declared information on the licence is compatible with the vehicle specification.

When licensing for a particular weight to be carried, the onus lies with the transport operator to declare the correct information. Police roadside checks are used to enforce the system and these are reinforced by the deterrent effects of heavy fines for overloading and for carrying more than the licensed weight.

The calculation and setting of the charges for each class of vehicle requires an assumption to be made on the average loading of the vehicle. The calculation is based on the following assumptions:

- the nominated gross weight will be achieved for 50% of the distance travelled;

- for the remainder of the distance travelled, the vehicle is represented by a load ranging between its tare weight and the nominated gross weight; and

- the gross weight being carried is spread to individual axles in a manner which approximated to the minimum pavement wear for that loading.

Hubodometers are fitted to all vehicles over 3.5 tonnes to record the distance travelled. Enforcement of compliance with weight and distance limits is carried out through roadside checks. In addition, all purchases of licences are recorded on a computerised database, which ensures a continuity of hubodometer readings for individual vehicles and trailers.

One problem with this system of road user charges concerns the different load factors common to particular categories of goods vehicle operations. At the one extreme, the inter-regional operators are advantaged by their ability to backload, so that a vehicle may achieve its nominated gross weight for the total distance travelled on a return trip yet incur charges for only 50% of this distance. At the other extreme, the rural operator tends to have a more one-sided delivery system with little or no opportunity for backloading.

The authorities recognise this problem but have taken the decision that to add another dimension to the charging system for percentage loading would be administratively impractical.

## 3.5 Summary of Relationship between Road User Charges and Highway Costs

The National Land Transport Programme for 1992/93 recommends a budget of $739M, consisting of:

- $619M for the National Land Transport Programme; and
- $140M for the Safety Administration Programme.

Table 3.4 gives more detail of the recommended expenditure programme in which the budget is seen to cover all state road-related costs, though not external costs related to, say, congestion, environmental degradation or accidents.

This budget can be fully accommodated from the existing (1991/92) levels of road user fees and charges, comprising (approximately):

- Fuel excise (motor spirit tax) - $300M;
- Vehicle licences - $140M;
- Heavy vehicle user charges - $300M.

**Table 3.4 Summary of proposed National Land Transport Programme expenditure.**

| OUTPUT CLASS | APPROVED 1991/92 NLTP (NZ$M) | RECOMMENDED 1992/93 NLTP (NZ$M) |
|---|---|---|
| Output I Local Roading | 188.69 | 201.0 |
| Output II Safety (Construction and Maintenance) | | |
| • Local Roading | 31.56 | 31.0 |
| • State Highways | 46.68 | 50.1 |
| Output III Passenger Transport | 44.53 | 38.1 |
| Output IV State Highways | 271.84 | 272.8 |
| Output V Administrations | 23.58 | 23.7 |
| Output VI Research | 2.27 | 2.3 |
| Balance | 5.63 | - |
| Subtotal National Land Transport Programme | 614.78 | 619.0 |
| Safety Administration Programme | 120.00 | 140.0 |
| Fund Enforcement Programme | | |
| **TOTAL EXPENDITURE (GST exclusive)** | **NZ$ 734.78M** | **NZ$ 739.0M** |
| **TOTAL EXPENDITURE (GST inclusive)** | **NZ$ 826.63M** | **NZ$ 831.4M** |

GST = Goods and Services Tax
M = millions

On the basis of cost breakdowns from previous years, the budget of the National Land Transport Programme ($619M) can be broadly allocated in the following ways:

- Driver charges - $186M (30%);
- Space charges - $225M (36%); and
- Strength charges - $208M (34%).

Moreover, the budget can be allocated (again, approximately) to the following general vehicle categories:

- Cars and light vehicles - $322M (52%);
- Powered heavy vehicles - $210M (34%); and
- Unpowered trailers - $ 87M (14%).

These costs and revenues relate directly to the road maintenance and construction budget. Other fiscal revenues from road users are allocated to the Crown Account and are regarded as general government revenue rather than as road pricing revenue. Thus they are effectively outside the road pricing system.

# 4. POTENTIAL EXTENSIONS TO THE CHARGING SYSTEM

## 4.1 The Land Transport Pricing System Review

The review of the New Zealand Road Pricing System is currently underway. The intention is to develop a comprehensive framework for establishing a pricing and regulatory basis for the land transport system, considering all effects, costs and benefits of the system.

As a part of the review, this study comprises a review of relevant literature and the development of a land transport pricing research programme for New Zealand. The three principal tasks of this study are:

- to gain an understanding of the current structure and pricing of land transport infrastructure in New Zealand;
- to review literature and both current and proposed policies from other countries, to identify potential improvements to New Zealand's current land transport structure and its pricing, from both theoretical and practical points of view; and
- to identify further research projects necessary to (i) quantify particular costs and benefits where existing data are not sufficiently precise, and (ii) select appropriate policy options where the best option is not obvious following the literature review.

The existing charging system, described in Sections 2 and 3, is clearly a good start to developing an economic basis for pricing road transport. However, it has drawbacks:

- it is only concerned with recovering the costs associated with the provision and maintenance of the road infrastructure (i.e. the internal road costs); and
- the allocation of road charges to particular groups of users may not be entirely equitable or efficient.

To develop the optimal conditions for an efficient land transport system, it is important that current external costs (environmental effects, congestion, accident costs) be internalised. That is, the private costs borne by road users should be equivalent to all the social costs which they impose. In addition, the costs imposed by individual motorists should, so far as possible, be reflected in the charges that they are compelled to pay for a particular trip.

## 4.2 Key Issues in Land Transport Pricing System Review

A number of key issues have been identified by Transit New Zealand, the Ministry of Transport and the Ministry for the Environment in designing the scope of the pricing review. These issues include the following which, with related issues, are addressed in Parts 2 and 3 of this report:

- **Valuation of external impacts**: what methods exist to place economic values on factors such as congestion and pollution?

- **Road pricing instruments**: these need to be cost-effective and also may require extending beyond the current taxes and annual licences to enable charges to be more precisely targeted.

- Alternative or complementary **demand management methods**: pricing is just one of several approaches to demand management and improved efficiency.

- The **distribution and incidence** of effects, costs and benefits associated with land transport activities.

- **Methods of incorporating** the effects, costs and benefits of land transport activities into users' decisions; for example, through regulation, pricing, planning mechanisms, education or institutional reform.

- Availability of different **types of technology** for land transport pricing.

- **Cost-allocation methods**: techniques are required for allocating the external costs imposed by traffic to individual vehicle categories, perhaps in terms of vehicle-km or tonne-km.

- **Marketing** any change in the pricing system to the general public: it is important that people understand the rationale behind any change, and that a consensus be developed to ease implementation and operation of the programme.

- **Funding of infrastructure**: introduction of a comprehensive road pricing system has implications for the funding of new transport projects, particularly as it is likely to significantly increase the availability of finance for new schemes.

# LITERATURE REVIEW 2.

# 1. INTRODUCTION

## 1.1 Background to the Literature Review

The aim of this Part 2 of the report is to review the literature relevant to the pricing of land transport, with a particular emphasis on road pricing. The review of land transport pricing currently being undertaken by Transit New Zealand mirrors similar reviews being undertaken by many countries, including - in the case of major cities at least - Great Britain.

The reason for the high degree of interest in transport pricing is clear. In most countries, predicted growth of road traffic will lead to serious problems of congestion in cities, local environmental degradation and contributions to global pollution. The question being asked, therefore, is whether existing transport prices fully cover the costs of these problems. For if they do not then trips will be made where the value to the trip maker is less than the costs imposed on other people. In other words, economic efficiency is being reduced. An economically efficient price on the other hand will cover all the costs imposed on the rest of society as a result of a trip.

Two counter arguments to this view are worth dealing with first. One says that the congestion imposed by extra road users is a cost imposed on themselves in that they themselves experience the resulting delays. This is an elementary confusion, which fails to recognise that in congested circumstances an extra vehicle does not simply suffer congestion itself but also adds to the journey time of all other vehicles on the road. In other words there is a genuine externality imposed by each road user on all others, which needs to be reflected in the charges if road traffic is to be at an efficient level.

A second argument is that these externalities are not charged for in many other sectors, so why should they be in transport. At its most sophisticated this is a form of the second-best argument discussed in Section 2. If it is true that other prices are generally below optimal as a result of a failure to charge for externalities, this might mean that the optimal transport price would be somewhat less than the sum of all the costs imposed. However it is highly unlikely that this would lead to more than a marginal modification to the optimal transport price because the transport sector is unusually prone to the creation of external effects, both from congestion and environmental effects. Only if these effects were equally important and uncharged for in most other sectors, would there be a case for ignoring them in transport.

The term "road pricing" has been criticised as an inaccurate description of systems to which it is applied (Thompson 1990), and there is some inconsistency regarding the extent of charging policies which are to be included. A liberal definition of the term could cover any fiscal measure which applies to the use of road vehicles. Using this definition, road pricing already exists worldwide through taxes imposed upon the purchase and licensing of vehicles and through fuel taxation. The extension of conventional taxation arrangements has been used as part of road pricing strategies in both Hong Kong and Singapore (Dawson and Brown 1985, LPAC 1991).

However, the essence of most road pricing work has been to replace and supplement these existing charges, which do not discriminate by time, location or amount of vehicle use, with charging structures which are directly related to these issues. For this reason the descriptions road-use pricing, congestion pricing and road user charging are sometimes preferred. Some recent texts have attempted to impose a narrower definition for road pricing, in which only charging systems relating directly to the time and distance travelled are included (CIT 1992). For the purposes of this review it is appropriate to apply the broadest definition, to cover all forms of pricing for the use of roads.

## 1.2 Structure of the Literature Review

Pricing principles, with an emphasis on pricing for economic efficiency, is considered in Section 2. Pricing for economic efficiency requires that each transport user pays the costs he or she imposes on the rest of society. Examples of such costs include additional costs imposed on providers of transport services, delays imposed on other transport users, residents, workers or shoppers affected by noise or fumes from vehicles, anyone affected by the global pollution imposed by transport systems.

Measurement and valuation of all these items gives a "first-best" transport price. For public transport, this first-best price will almost inevitably involve a subsidy. For roads this depends on the circumstances whether it involves a subsidy or a surplus. It is recognised however that the budgetary implications of this may be seen as either inefficient if there are efficiency costs involved in raising the finance for such subsidies, and/or unfair if it is believed that transport users should pay the total costs of the facilities they use.

If such arguments hold, then it is important to obtain the additional revenue in the way which costs the least in terms of inefficiency. This involves the use of Ramsey pricing which, in simple terms, charges what the market will bear until sufficient revenue has been raised, i.e. disproportionately large charges are raised on those parts of the market which are least price sensitive.

Efficiency prices for transport services will vary widely by time and place. It is only worth imposing a pricing system which does so if the costs of implementing it are less than the benefits. Section 3 considers the practical problems of designing pricing systems able to vary in this way, with particular reference to road pricing and to the experience of those countries which have introduced such a system or have carried out detailed studies.

Efficiency pricing clearly would involve a high charge to motorists entering congested areas in the peak period, and such a charge is widely seen as unpopular. Section 4 looks at a wide range of surveys that have been undertaken to examine public attitudes to congestion pricing, and the degree to which it is seen as acceptable when regarded as part of a package of measures designed to deal with the problems of congestion and environmental degradation in urban areas.

Efficiency pricing will only offer advantages over a simpler form of pricing if people change their behaviour in response to it. Moreover, given the widespread presence of externalities in the urban economy, it is possible that some of the responses to efficiency pricing, for instance by further decentralisation of activities, could impose costs in other respects such as the provision of other forms of public infrastructure. Thus to estimate the benefits of moving towards efficiency pricing it is important to understand the nature and extent of the behavioural response to its introduction. Section 5 considers the rather limited evidence on the responses to road pricing currently available.

Section 6 considers the relationship between pricing, investment and the management of transport systems as a whole. Given the costs of introducing efficiency pricing, clearly it may be preferable, in some circumstances at least, to introduce physical or other rationing which approximate to the effects of efficiency pricing but are cheaper to implement. These are considered in detail in Section 7. An assessment of the general effectiveness of pricing and of other measures is also given.

# 2. PRICING PRINCIPLES

## 2.1 Introduction

Transport pricing may have a wide variety of objectives, but the five principal categories are:

- Economic efficiency,
- Environmental protection,
- Urban planning,
- Equity,
- Revenue generation.

Evidence of the objectives is also discussed.

### 2.1.1 Economic Efficiency

This is the usual starting point for any consideration of pricing systems and was the basis of the Smeed Report (MoT 1964). Smeed estimated that, at a speed of 21 km/hr, each additional driver on a road network imposes time losses upon others equal to his own travel time, and that this rises to time losses that are double to his own travel time at 16 km/hr (Smeed 1968). Subsequent work has suggested that this analysis may be too simple, as it ignores the effects of queueing (Button and Pearman 1983), and fails to consider the effects on drivers travelling later in the congested period (Smith and Ghali 1991).

These arguments relate principally to the levels of charges which would be required to secure maximum efficiency, and do not detract from the basic concept that there is a discrepancy between the marginal private cost perceived by the road user and the marginal social cost, i.e. the true cost of a journey which includes the additional costs imposed on other users.

Failure to correct this discrepancy leads to a situation in which it would be possible, in principle, to make some road users better off without making anyone worse off, since what some road users would be willing to pay to reduce congestion would exceed the compensation required by other road users to stop imposing delays on them.

In practice, economic efficiency requires also that:

- the resources required to operate a charging system should not exceed the benefits achieved by it; and

- where pricing measures cover only a discrete area, the resources required should include any provisions which are necessary beyond the system boundaries caused by transfer of traffic.

Where congestion costs are high, the economically most efficient solution is often to provide more capacity. The case for this should be justified by cost-benefit analysis. Where capacity cannot be increased to satisfy demand, there may be a loss in potential overall economic efficiency if charges are not applied.

### 2.1.2 Environmental Protection

Traditionally, environmental impacts of transport have been viewed as local issues and have focused upon the following concerns:

- Noise and vibration;
- Primary pollutants (e.g. carbon monoxide);
- Visual intrusion;
- Severance; and
- Danger and accidents.

Increasing worldwide environmental concerns have extended the geographical area of concern to include impacts from transport across national boundaries, such as secondary pollutants (e.g. ozone and acid rain), and at the global level, the contributions of traffic to emissions of carbon dioxide. In principle, to the extent that these factors inflict disbenefits on people, they would be included in the economic efficiency criterion. The reason that they are often seen as a separate issue reflects the problems in measuring and valuing them. Nevertheless, some countries, such as Sweden, do value at least some of these costs explicitly when in assessing the marginal social cost of road use for transport pricing decisions (Hansson and Nilsson 1991).

Charging has been identified as a means of reducing all these impacts, but the charging system appropriate for tackling local impacts may be very different to those required at regional and global levels. The concept of a "carbon tax", administered through fuel prices, has been the centre of recent debate (Pearce et al. 1989). This would attempt to produce the significant overall reduction in fuel use, independent of time and location, that is required to address the regional and global pollution issues.

By contrast, reduction of the environmental impacts of transport at the local level would require measures that reduce traffic levels at specific sensitive locations, during particular times of day, and may target individual classes of user, such as heavy commercial vehicles. Therefore, a direct charge upon vehicle use would be more appropriate.

As local impacts are closely related to prevailing levels of congestion, local environmental charges could be levied in the same way as those designed to improve traffic efficiency on the network.

### 2.1.3 Urban Planning

Road pricing policies may be beneficial to other urban planning goals by improving accessibility and helping to revitalise urban areas. Traffic growth and congestion has, over time, reduced urban accessibility and, alongside its associated adverse impacts on the local environment, contributed to the decentralisation of industry, commerce and residential sectors away from inner and central city areas.

On the other hand, imposing an efficiency price will inevitably raise the generalised cost of travel in urban areas overall, even if travellers whose value of time is high may benefit, as well as the environment. Land use planning objectives of increased urban investment will depend upon the effects of road pricing measures on accessibility, the local environment and, perhaps most importantly, upon the general image of local transport policy. The fear that this image will be negative and will offset other benefits, exacerbating existing decentralisation trends, has also been expressed.

The relevance of these arguments may vary by location, dependent upon general urban planning policy and other specific planning and road pricing objectives. For example, a package of measures incorporating the provision of an alternative public transport option could be designed to increase accessibility across all travel groups and have a very positive effect upon both public and business perceptions of local transport policy if successfully marketed.

### 2.1.4 Equity

Whether efficient pricing is fair depends heavily on the view of what constitutes fairness. If it is seen to be fair that transport users pay the costs that they impose on the rest of society, then obviously efficiency prices will be seen to be fair. Why this view should be considered unfair in transport is hard to see, when it is seen to be fair for most other products that are sold in the market place.

Another view is that transport is seen as an essential which should not be priced in this way. Or it may be seen as appropriate to redistribute the transport costs and benefits in a more just manner than under present conditions. In practice, implementing efficiency pricing would involve both benefits and disbenefits to equity in this sense. It is popular to propose road pricing as a means of redistributing road space more equitably between private cars and road-based public transport and in relation to need, based on values of time.

It has also been suggested that any assessment of equity issues should be disaggregated by user type (including non-road users, such as residents), location, income group, journey purpose and need, to distinguish significant equity issues affecting particular groups which are offset by more general trends. On the other hand, road pricing is likely to benefit better-off motorists at the expense of poorer ones.

A major issue is obviously how the revenue is used. Consequently it is not possible to say whether road pricing will be equitable or not but there is, however, little doubt that the size of the revenues will be sufficient to compensate all "losers".

### 2.1.5 Revenue Generation

A major motive behind transport pricing is to raise revenue to cover the costs of the transport system and other government expenditure. Meeting government budgetary needs in the least damaging fashion when they require a divergence between efficiency pricing and actual prices is considered separately below.

### 2.1.6 Evidence of Objectives

Objectives for implementing and proposing electronic road pricing schemes to recover revenue shows considerable variation (LPAC 1991). The reduction of congestion was the principal objective in both Singapore and Hong Kong, while environmental benefits were the principal focus in Holland and Stockholm. Early work in London relating to supplementary licensing was principally concerned with congestion, but also acknowledged the potential environmental improvements (May 1975). By contrast in Melbourne, the financial inequities of existing transport taxation between urban and rural road users have been identified as the principal justification for urban road pricing (Howie 1991).

More recent studies have tended to acknowledge the whole range of potential objectives, but revenue has been the driving force behind the Norwegian toll rings and, although congestion is the clear focus of the congestion metering system proposed in Cambridge, related proposals to use revenue to develop a new public transport system identify this as a second important objective. A recent study for Edinburgh (May et al. 1992) has proposed road pricing as part of a package of measures designed to achieve a wide range of benefits.

The specific role of road pricing within such a policy may be seen as providing revenue to fund other measures and reinforcing incentives for private car users to switch to public transport.

If economic efficiency were the only criterion, the definition of what prices would be forns a useful starting point for any consideration of pricing policy, as the cost is then seen in terms of efficiency of pursuing other objectives.

Efficient pricing principles in the transport sector are dealt with in the rest of this section, starting with a consideration of the basic pricing rule to follow in a first-best world, and demonstrating how to correct for market failure in an optimal manner (Section 2.2). Second-best rules which apply when, for example, there is a budget constraint or market failure in a related market are covered in Section 2.3.

## 2.2 First-best Pricing Principles

### 2.2.1 Effect of Price

A **perfectly operating market system** achieves a set of prices equal to marginal cost without government intervention. **Price** is the mechanism by which scarce resources are allocated efficiently between competing uses. For consumers, price encourages a purchase if the benefits of making the purchase exceed the benefits of alternatives.

For producers, prices provide incentives for resources to move to those uses which people value most highly by informing firms how much to produce, which products to produce, when and where to sell the products, and when, where and how much to invest.

Essentially, in a perfectly operating market, the "right" prices should lead to the "right" amount of the "right" goods being sold to the "right" consumers. The question which must be resolved is however: how do we ensure that the "right" prices are those which prevail?

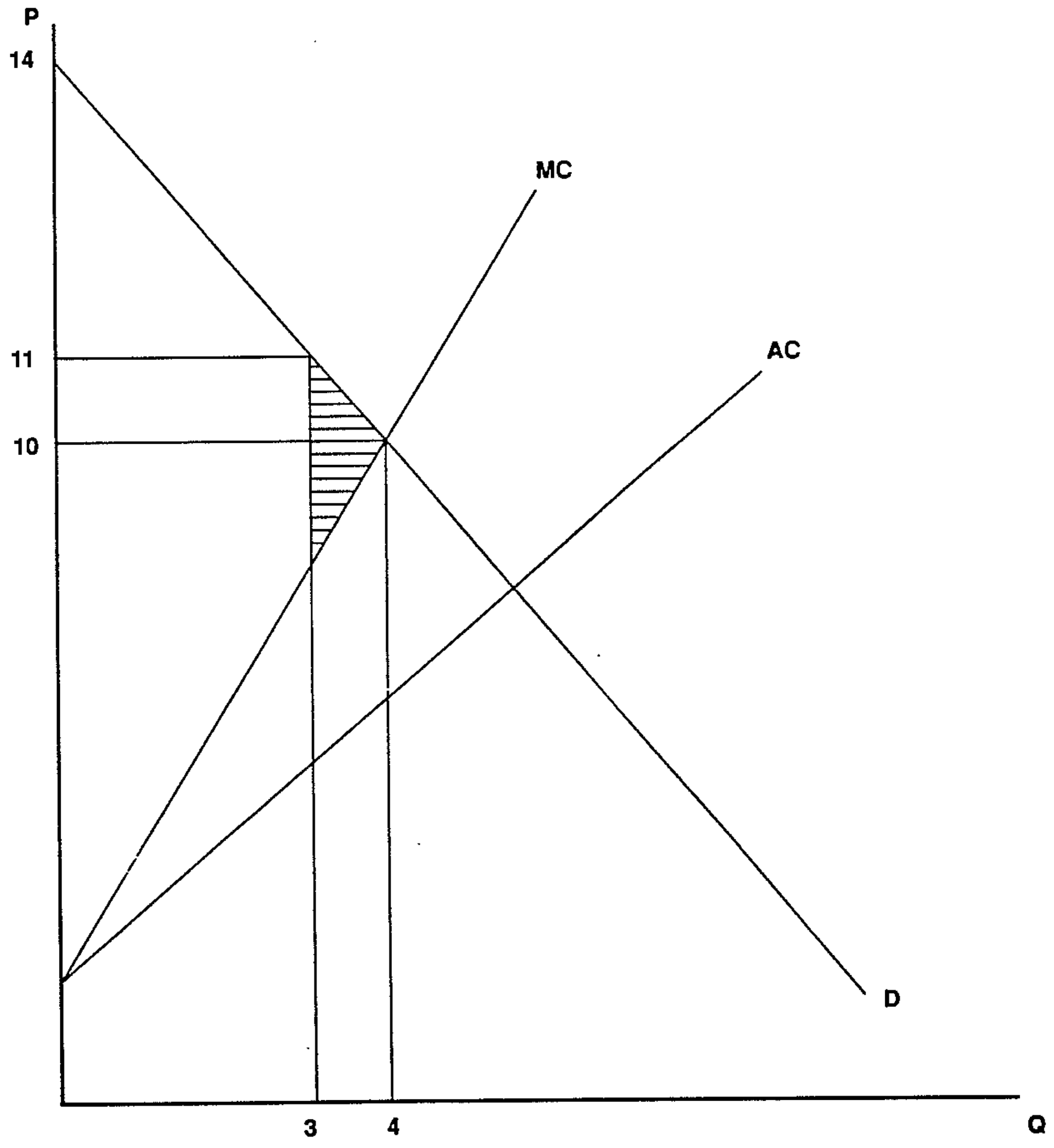


**Figure 2.1** **Loss of welfare caused by inefficient pricing.**

### 2.2.2 Effect of Competition

The **perfect competition** model provides a number of conditions which, if met, will ensure that the market will lead to an optimal allocation of resources. That optimal state is characterised by:

- All firms being in equilibrium, producing their output at the minimum feasible cost;

- Each price equalling the marginal cost of the product, i.e. the incremental cost of producing the next unit;

- Plant being used at full capacity so there is no waste of resources; and

- Firms earning only "normal" profits.

From this, P = MC is the key condition. This is the definition of **First-best**, which means that all other sectors of the economy are in long-term equilibrium with price (P) equal to marginal cost (MC).

However a number of definitions of marginal cost depend on the time horizon, and this is of particular importance for transport infrastructure. For example, in the short run, capital is often assumed to be fixed. In the long run, all factors are variable in that Short Run Marginal Cost (SRMC)[1] = Short Run Average Cost (SRAC) = Long Run Marginal Cost (LRMC) = Long Run Average Cost (LRAC), and the question of which marginal cost to use does not apply. The question of which to use in the real world is discussed in Section 2.4.

### 2.2.3 Pricing a Single Product

The economically efficient price of a single product in isolation is equal to the marginal cost, since, if any other price is charged, it is possible to make both producers and consumers better off by switching to marginal cost pricing and redistributing the surpluses.

A single example will illustrate this:

Suppose the demand for a good $Q = 14-P$ (P is price);
and total cost of production $TC = 2Q+Q^2$,
then marginal cost $MC = 2+2Q$, and
setting $P = MC$

gives an equilibrium price of 10 and quantity 4.

---

[1]
| | |
|---|---|
| LRAC | Long run average cost |
| SRMC | Short run marginal cost |
| SRAC | Short run average cost |
| LRMC | Long run marginal cost |

At this level, producer surplus (PS)(profit = revenue minus costs) is 16.
Consumer surplus (CS) is 8 and so overall welfare = PS+CS = 24.

Suppose now that P = 11 (above MC):
then PS = 18 and CS = 4.5,
giving PS+CS = 22.5.

This loss of welfare caused by inefficient pricing is represented by the shaded area in Figure 2.1.

### 2.2.4 Exceptions

In practice, setting price equal to Marginal Private Cost (MPC) may sometimes fail to produce optimality. This could happen in the presence of:

- Market dominance in either supply or demand (e.g. monopoly);
- Unexploited economies of scale in production or consumption;
- Externalities;
- Imperfect or costly information; or
- Public goods.

### 2.2.5 Examples for Setting Price

Two cases which give first-best grounds for setting price **not** equal to marginal private cost are presented now.

#### 2.2.5.1 Case 1

Assume the production of bus trips exhibits no operator economies or diseconomies of scale. If the number of passengers increases, then at existing fare levels the operator can increase his service level by the same proportion and still break even. In so doing, he reduces the mean headway and the mean passenger waiting time. Thus, the average passenger waiting time (APWT) is a decreasing function of passenger numbers. That being so, the marginal passenger waiting time function (MPWT) lies below APWT. Setting passengers' "time plus money" cost equal to the marginal "operating plus passenger time" cost inevitably involves setting the price (passengers' money cost) below the marginal operating cost. As a result, the operator incurs a deficit equal to the value of the difference between APWT and MPWT at the prevailing demand level times the demand.

This is a first-best economic efficiency argument for subsidising bus operations and encouraging divergence of price and marginal private cost.

#### 2.2.5.2 Case 2

Consider a road which, in the short run, requires no maintenance so that the cost of using it is simply the time it takes to travel on it plus the resources used in travelling. Up to a certain traffic level, an extra user on the road will have no impact on journey times of other travellers. So the marginal cost will be equal to the average cost which will be horizontal. Beyond this level of use, congestion causes the journey to take longer, and so the average social cost curve (ASC) rises. In this case, the marginal social cost curve (MSC) lies above ASC (Figure 2.2).

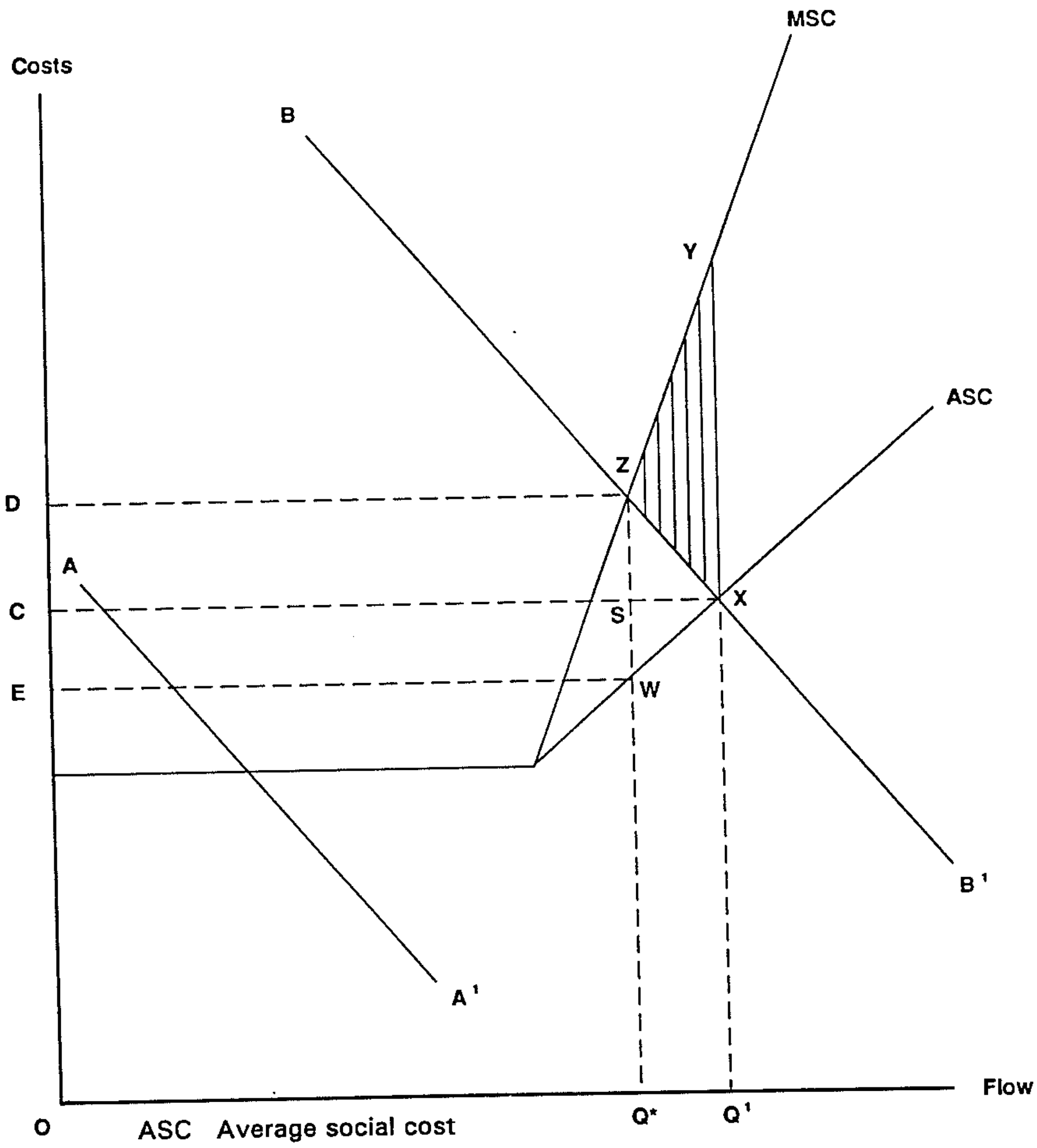


**Figure 2.2** **Benefits of setting price equal to marginal social cost (MSC), in a congested situation.**

If demand is as depicted by $AA^1$ on Figure 2.2, the road is uncongested and exhibits the public good characteristic of non-rivalry, that is one person's consumption does not affect another's. The optimal toll in a first-best world is zero, since the travellers' "time and money" cost is equal to the marginal social cost.

Consider now the demand represented by $BB^1$. An individual traveller will face costs of OC if he makes the journey. At this level, demand is $OQ^1$. However, although the traveller has considered the congestion he will face, he has not considered the costs of extra congestion that he is imposing on other users. In a first-best world, and using the reasoning outlined earlier, optimal flow is OQ*, where marginal social benefits equal marginal social costs. To achieve Q*, the user must be faced with costs OD. At this level of use, time costs are OE; so money costs must be set at ED to equate "time and money" costs with MSC. Doing this gives a loss of consumer surplus DZXC, a gain in producer surplus (the toll revenues) of DZWE and a net benefit of CSWE-ZXS which can be shown to be equal to XYZ. Although the marginal cost of supplying the road space is zero in the short-run, the congestion externality means there are first-best economic efficiency reasons for not setting $P = MPC$; instead P should be set equal to MSC.

### 2.2.6 Marginal Costs

The marginal cost pricing rule outlined here inevitably begs the question, "What constitute marginal costs?" Private costs are essentially the monetary costs of production. In transport, private cost would include also the time cost of making a trip. These costs would be taken into account by the market.

Other "social" costs which might not be included in a free market, but which should be reckoned in the private costs are used to arrive at overall costs. Examples include the costs of providing and maintaining public goods, for example building and repairing roads. The external effects in the production and consumption of trips: such as congestion imposed by one road user on others; pollution, which covers fumes and emissions (which may affect those who live near a road or railway, or may damage the environment for everyone), noise, vibration and visual intrusion; accident risk imposed on others; and loss of amenity, for example a road through a site of special scientific interest. Much of the road pricing debate has centred solely on the congestion externality, but all these factors need to be taken into account to arrive at the "full" marginal cost of a trip.

Specification of marginal costs includes the issue of how to treat the dynamics of road network operation. A car which enters a network approaching capacity may, because of the nature of the queueing system, impose costs on cars which enter the network after the first car has left the system. Cars which enter at the height of the peak - where the static marginal cost is greatest - may not impose such a high cost since the network may soon return to an uncongested state. Correct specification of marginal costs must take account of this.

## 2.3 Second-best Pricing Principles

The first-best rules given in Section 2.2 for setting P = MSC, apply only when all other sectors satisfy Pareto optimality conditions. If these conditions do not hold, or if the first-best rules cannot be applied (say political considerations rule out the possibility of financing a deficit in public transport operations, or road pricing is unacceptable to correct for the congestion externality), then a second-best state exists in which the application of first-best rules does not guarantee a welfare improvement.

**Case 1** - Consider a bus operator who runs a network of services and has a remit to break even. Baumol and Bradford (1970, reviving the ideas of Ramsey) have shown that the optimal pricing rule for a product "i" depends on the marginal cost of "i", the cross-elasticities of demand for "i" with respect to the prices of the other products, the own-price elasticity of demand for "i", and the tightness of the budget constraint (the marginal opportunity cost of using public funds which could be spent elsewhere, to subsidise the bus operator). In general terms, the rule is:

$$P_i = \frac{MC_i - \frac{\lambda}{1+\lambda}\left(\sum_j \frac{\partial P_j}{\partial x_i} * x_j\right)}{1 + \frac{\lambda}{(1+\lambda)\ \varepsilon_i}}$$

Where $\varepsilon_i$ is the own price demand elasticity of i,
$x_j$ is the amount of j, and
$\lambda$ is the net gain which would occur if the budget constraint were relaxed by one unit.

In the case where all the cross-elasticities of demand are zero, this rule requires that price be set so that "its percentage deviation from marginal cost is inversely proportional to the item's price elasticity of demand" (Baumol and Bradford 1970, p.267). Thus prices will be nearer to marginal costs for items which are relatively price-elastic, and further from MC where demand is relatively price-inelastic. Thus, insofar as markets are separable, operators should price up in inelastic markets.

When the cross-elasticities are not zero, the rule is more difficult to apply, but the principle is that price exceeds marginal cost by a greater amount:

- the tighter the budget constraint;
- the lower the own-price elasticity; or
- the higher the cross-elasticities (the greater the substitutability between i and the firm's other products).

Equivalently, the rule is that "all outputs be reduced by the same proportion from the quantities which would be demanded at prices equal to the corresponding marginal costs" (Baumol and Bradford 1970, p.267). These results are for a multi-product operator, but apply equally to social welfare maximisation across the products of different suppliers (e.g. car/bus/train).

**Case 2** - Consider a case where a road is congested but there is no road-pricing scheme or other congestion tax. The traveller's "money and time" costs are therefore less than MSC. What pricing policy should be followed for a (competing) railway service? If there is some substitution between the two modes, a case exists for departing from marginal-cost pricing rules to help correct the congestion externality. The general rule is:

$$P_i = MC_i - \sum_{j \neq i} \frac{\partial x_j}{\partial p_i} \frac{\partial p_i}{\partial x_i} * (P_j - MC_j)$$

The implications are:

(a) if there is no substitution, set $P_{rail} = MC_{rail}$;

(b) if car and rail are substitutes and $P_{car} < MC_{car}$,
set $P_{rail} < MC_{rail}$
if ($P_{car} > MC_{car}$, set $P_{rail} > MC_{rail}$)n

(c) if car and rail are complements and $P_{car} < MC_{car}$,
set $P_{rail} > MC_{rail}$
if ($P_{car} > MC_{car}$, set $P_{rail} < MC_{rail}$)

Note: in a world of more than two interacting goods, the information requirements are likely to be very high and costly.

Thus, in the congested road case, the price of the competing rail trip should equal the marginal cost for the rail trip less a discount on:

- the MSC of car use;
- the responsiveness of car use to a change in rail fare;
- the level of car use relative to rail use; and
- the own-price demand elasticity of rail.

## 2.4 What is the Appropriate Cost Measure?

Subject to the exceptions given above, price must equal marginal cost in order to allocate resources in an optimal way.

Other than noting the definition of a marginal cost as the incremental cost of producing the next unit of output, which is too simplistic an approach to use in the transport sector, how to obtain a marginal cost has not yet been considered. For example, assume an existing train service with a capacity of n passengers. What is the marginal cost of serving the n+1th customer? The cost of putting an additional coach on the train? The cost of running an extra train? The cost of buying an extra train (discounted?) and running it? Looking at the more general case, the problem was summarised by Lewis (1949):

(a) A whole range of marginal costs exists, depending on how far ahead one looks (all factors are variable in the long-run);

(b) Marginal cost may fluctuate from one moment to the next (an extra driver on a congested road at time T increases the marginal (social) cost of an extra driver at time T+ );

(c) Indivisible escapable cost should be allocated between users (in the short-run, policing of a road is an indivisible escapable cost - if there were less traffic, one less patrol car might be needed; in the long-run, engineering a road to the standard required for heavy lorries is an indivisible escapable cost); and

(d) The accounting and economic costs are different (once a road has been constructed, economists would argue that bygones are bygones and previous expenditure should not influence current pricing policy; accountants would disagree!).

We can identify a number of costs associated with the provision and use of road space:

(a) Fixed costs of constructing the track. These include land purchase and the costs of the actual building process. Walters (1968), in the seminal work on this issue, argues that all methods which seek to allocate these costs among motorists are arbitrary, and are irrelevant to the problem of defining the cost of a vehicle journey, and we have no reason to disagree;

(b) Maintenance costs which vary with the amount of traffic, including policing, and repairing wear and tear caused by vehicles;

(c) Maintenance costs which do not vary with the amount of traffic, for example repairing the wear caused by weather and time. Walters (1968) too argues that these too are not relevant to defining trip costs;

(d) User costs, both the resources used in making a journey and the time involved; and

(e) Social costs, including both the congestion externality and others such as pollution, accidents, noise and visual intrusion.

So what is the appropriate policy? In the congested case (Case 2), the quasi-rent extracted by moving to the intersection of demand and MSC provides a windfall gain for the highway authority. This could then be used to finance costs (a) and (c) above. There is no reason to suggest that the revenues will exactly cover the costs, or any economic efficiency reason to suggest that they should.

If there are no discontinuities in investment, and pricing and investment are optimal, then the shape of LRAC determines whether there will be a deficit or a surplus. In congested urban areas it is likely that LRAC is increasing, and so efficient pricing = SRMC and investment will generate surpluses. LRAC is likely to be increasing because of the scarcity of land for road building in urban areas. Walters argues that discontinuities in investment will also cause this increase.

For congested inter-urban/rural roads, the shape of LRAC is less clear. It is less costly to expand road capacity by widening or building new roads in these areas, where typically there are lower land values, or alternative schemes can be drawn up to take lower value land. So in some cases, the current LRAC may be declining notwithstanding a rising SRAC. For uncongested inter-urban/rural roads, current over-capacity means LRAC is declining, giving first-best grounds for a deficit and zero congestion pricing.

The short-run/long-run dilemma can be summarised as follows: within a given (short-run) time period, price must be set at the marginal social cost, given current capacity. At the same time, future demand has to be forecast and capacity planned so that investment can be determined and begun. If extra capacity is created, then current prices must be re-evaluated and the future re-forecast. In all cases, SRMC pricing is the efficient first-best policy. This is likely to lead to a surplus on urban roads, and a deficit on inter-urban/rural roads. It is not clear whether overall there will be a surplus or deficit as that will depend on specific traffic conditions at the time. Overall, there is no first-best economic case for balancing the roads budget. If it is desired for other reasons, then the Ramsey pricing rule referred to in Section 2.3 applies.

That pricing for economic efficiency within the transport sector does not necessarily bring financial viability has implications for the involvement of the private sector in providing transport services in line with defined financial criteria. Private sector toll roads, for example, are not trying to maximise economic efficiency and so should charge what the market will bear, up to any upper limits which might be set by a regulatory aurthority.

For rail, which has to generate a given return (and any other in the same position), then Ramsey pricing should be used, i.e. charge what the market will bear up to achieving this return.

Depending on the regulatory terms of a privatised rail monopoly operator, that operator will say what subsidy he needs to run a particular service. Amount of service is intrinsically linked to fare levels since private operators are unlikely to operate empty trains no matter how high the fare level. Once the costs are agreed, the government can make its choice of fare/subsidy combination, bearing in mind the benefits and other relevant fares. If the subsidy is too great relative to the benefits at any sensible price levels, then no subsidy should be provided. The essence is how badly the government wants services which the operator will not provide commercially, and how much the operator charges to provide them.

At a theoretical optimum, LRMC = SRMC and so the issue does not arise. Because of the existence of indivisibilities, a long-run optimum may not be attainable given current technology. If conditions are such that we are on the upward-sloping part of LRAC, then charging only SRMC (which is less than LRMC) may give the wrong price-signals to users and cause over-optimal use of roads. This may give the wrong investment signals, suggesting that more road capacity is needed, when in fact the willingness to pay for such increases in capacity is less than the long-run cost of providing it.

So, although in theory SRMC pricing is first-best optimal, in practice the question of whether to use SRMC or LRMC is an empirical issue and depends on how the investment procedure responds to the information available. If price is set at SRMC and future demand is forecast and capacity planned in an optimal way, then SRMC pricing should be followed. If SRMC pricing leads to building roads which should not be built, LRMC pricing is more likely to give the right price signals.

## 2.5 Optimal Investment

The question of optimal investment is inextricably linked with optimal pricing. The basic rule is that the marginal cost of providing capacity (annuitised over an appropriate period) should equal the value of the marginal savings in congestion costs of users in that period (Morrison 1986). This, though, depends on optimal pricing.

Consider an uncongested rural road where there is no congestion price and the optimal strategy is to disinvest. If users are charged and the price may be quite high because of inelastic demand caused by lack of alternative routes, the quasi-rent obtained on the capital invested may be high enough to obscure the optimal disinvestment strategy.

Conversely in congested urban areas, pricing below marginal cost would over-estimate the benefits to be gained from expanding capacity and cause over-investment for a given flow if first-best investment rules were followed.

Overall, the difficulties in specifying costs correctly and the likelihood that first-best optimality conditions are not met, suggest that the appropriate criterion for policy analysis is maximising benefits minus costs within a cost-benefit analysis framework.

This in itself raises questions about correct benefit measurements in a sub-optimal world and appropriate discount rates, the resolution of which is outside the brief of this report. Clearly, in the real world with all its complications of indivisibilities, externalities and non-constant returns to scale, there is no simple relationship between the profitability of a stretch of road and the case for investment in more capacity.

## 2.6 Pricing Structures

A theoretically optimal pricing structure would ensure that all vehicles would be charged a levy which raised the marginal private cost to the marginal social cost, and would therefore reflect the network congestion effect, which would vary at any point in time according to current traffic flows and the mix of traffic.

In a dynamic system, this would have the effect that the driver would not know, beforehand, the price he would be charged for using the roads. He may therefore make inappropriate decisions, since he would base his choices on expectations which may or may not be realised.

To simplify matters, the prices are assumed to be based on some "average" marginal cost appropriate to the time period the journey is made. The pricing problem would then be to determine a schedule of prices to cover the number of time periods. The smaller the time periods, the closer the correspondence between price and average marginal cost within each time period.

However, the smaller the time periods, the more costly the determination and implementation of the prices. So the problem is to subdivide time into an optimal set of periods such that, within each period, a single price prevails whatever the marginal costs at different times within that period.

The optimal uniform price within a period is found by weighting the marginal costs at different times within that period by the inverse of the absolute value of the slope of the demand function at each of those times (Turvey 1971, p.33).

Consider the time band 0700 to 0900hr in an urban area.
Marginal social cost $M_1$ can be identified between 0700 and 0800hr, and MSC $= M_2$ from 0800 to 0900hr.
The choice lies between setting $P_1 = M_1$ and $P_2 = M_2$, and

$$P^* = \frac{M_1\frac{dq_1}{dP_1} + M_2\frac{dq_2}{dP_2}}{\frac{dq_1}{dP_1} + \frac{dq_2}{dP_2}}$$

Thus, if the demand curve is steeper between 0800 and 0900 than it is between 0700 and 0800, then the absolute difference between the uniform price and marginal cost will be greater between 0800 and 0900 than it is between 0700 and 0800. The decision whether to charge a uniform price between 0700 and 0900 depends on the additional costs involved in setting and levying two prices instead of one. The uniform price will cause more consumption in the hour which has more traffic and less consumption in the hour which has less traffic compared with charging separate prices, and may be regarded as discriminating in favour of peak consumers at the expense of off-peak consumers.

Suppose that, under a differential pricing regime, more traffic occurs between 0800 and 0900 than between 0700 and 0800. This implies that $P_2 = M_2 > P^* > P_1 = M_1$.

If:

$$(P_1-P^*)\,\frac{dq_1}{dP_1}\left(\frac{P^*+P_1}{2}-M_1\right)+(P_2-P^*)\,\frac{dq_2}{dP_2}\left(\frac{P^*+P_2}{2}-M_2\right)$$

(-) (-) (+) (+) (-) (-)

is greater than the additional costs of charging two prices, then two prices should be charged.

In theory, this procedure of determining whether to subdivide an existing charging period can be continued ad infinitum. In practice, however the information requirements would be great if the number of charging periods were too great, and a limited number of charging periods, for example pre am peak; am peak; inter-peak; pm peak; post pm peak (with the possibility of subdividing the peaks into height-of-peak and shoulders of peak, or uniform off-peak pricing) may be adequate.

## 2.7 Other Issues

Section 2 has concentrated on economic efficiency rules for pricing transport, with the criterion being to maximise net social benefits, using economic tools to correct market failures. By efficiency we imply that any associated transactions costs are properly taken into account. At times, we have indicated that some decisions must be taken elsewhere. The job of the economist is then to achieve the most efficient allocation of resources subject to the external constraints. For example, the question of whether the roads budget should be in deficit, surplus or break-even is a matter for government.

Different considerations apply in the case of private toll roads. These may either operate fully commercially or receive a government subsidy in respect of concessions to particular groups of users. If the operator required a subsidy to build and operate the facility, and this subsidy was deemed acceptable value for money, given other spending priorities and the cost to the government of building and operating the road itself, this should be done. Note, though that there is no a priori reason to suppose this is either economically efficient or inefficient.

Note that economically efficient solutions should only be implemented when the various implementation, transition and transactions costs are outweighed by the efficiency benefits.

Furthermore, no account has been taken of the distributional implications of following these pricing rules. It can be argued that road pricing favours the "rich" at the expense of the "poor", since the "poor" user gets priced off the toll roads. It is also often argued that re-distribution is best achieved through directly targeted taxes and benefits, so that the distributional impacts of a transport initiative only need to be quantified to allow offsetting measures to be introduced to maintain the status quo. However, it may be difficult to raise additional taxes on those that benefit and target exactly offsetting tax reductions to those who lose out. Of course, we should not assume that the initial distribution of wealth is optimal and it is for politicians to judge how desirable are any distributional impacts of transport initiatives, and what will be done to offset or contribute these.

## 2.8 Road Track Costs - Charging Vehicles for their Use of Road Infrastructure

Conventionally, the cost to the highway authority of providing and maintaining the road system is apportioned between the vehicles using the system, and charges are raised in the light of this apportionment. For many items of current costs the sums involved are relatively small so that the exact means of apportionment has little effect on the overall costs. The key item of current costs is the repair of damage related to the "weight" of traffic using the roads. For many years an acceptable approximation that has been used is to charge vehicles per km in proportion to the sum of the fourth power of their axle weights (while in use). From time to time, amendments to the fourth power rule have been proposed, and our current view is given below, together with a discussion of how to deal with "weathering" and whether or not there are constant returns in road maintenance.

### 2.8.1 Capital Charges

The current UK method is called "Pay-As-You-Go" (PAYGO), by which the current (average) rate of capital expenditure is taken as the amount to be apportioned. Of this 15% is set aside for large heavy vehicles, which cause the lanes to be wider, gradients shallower and pavements thicker than would otherwise be required. The remaining 85% of the capital charge is allocated in proportion to the amount of road space each vehicle takes up, proxied by a passenger car unit (PCU) measure.

Newbery (1987 and elsewhere) was one of many to point out that a normal commercial approach would require current traffic to pay interest and depreciation on the entire capital stock of roads, which would be equivalent to what the UK government requires of the commercial sectors of British Rail, which must generate an 8% return on new investment.

The major argument against charging road users a given rate of return on road investment is the placing of an asset value on the road stock, on which to give a base to raise that percentage return. The easy way out of this is to assume that all road capital costs are "sunk" and therefore not relevant to the Short Run Marginal Cost approach adopted in this report. However, this may cause problems since it would lead to road users being charged nothing for the extra capacity continually being provided in order to cope with increased traffic levels. The best way of dealing with this matter is to consider the incremental position. If road usage were constant, then no new capacity enhancement would be required to maintain road conditions as at present, and the costs of road use would be correctly reflected in the SRMC charges covering maintenance, delay and external costs.

Clearly, however, this is not the case with road usage. Additional capacity is provided in response to additional vehicle use. If this increased capacity is to be paid for by users, each vehicle kilometre should be charged annually the construction cost required to hold road conditions constant, having costs at the SRMC levels discussed above. Without this capital expenditure SRMC would rise with time as the road system became more congested. This system of cost allocation, though, bears no relation to whether a given motorist uses the new capacity, and it is a rather arbitrary way to recover costs.

In mathematical terms, let the required rate of return on capital be r% pa,
the rate of traffic growth be q%,
actual capital expenditure £ya, and
the capital expenditure required to hold road conditions constant, in response to traffic growth q%, be £y(q).
The "value" of an increase in capacity of q% is therefore £y(q).
Hence 100% increase in capacity is worth:

$$\frac{£y(q)}{q}$$

and this can be taken as the value of current capital stock.

The capital charge is then

$$\frac{£ry(q)}{q}$$

Although expressed as a percentage of the total capital stock it is not a charge for these "sunk" costs but merely a charge for ongoing capital stock expansion.

Current UK practice charges £ya, while most informed opinion would say that congestion conditions were worsening. This implies £ya < £y (q), so that actual capital expenditures understate that required by current traffic growth q. Even if £ya = £y (q), the capital charge would only be correct if q = r. In fact, in the UK in the 1980s, the rate of traffic growth has been averaging about 4% pa whereas r is set at 8%. Hence, for this use of capital funds to be economically efficient, the capital charge should be doubled.

### 2.8.2 The Fourth Power Rule

The debate regarding the appropriate experience to use for road damage related to axle weights falls into two categories:

(i) re-computations of data from the original AASHO (1962) tests which originally established the value 4, as an average, in 1962, and

(ii) results from later studies.

A recent report (Road Transport Research 1991) prepared for the New Zealand road transport industry attacks the fourth power rule on a broad front, citing many relevant sources. However, they state (on p.22) that the book by Small et al. (1989) provides "the best guide available". Indeed, the book has been very well received by the profession. It calibrates new equations on the AASHO data and, as RTR approvingly quote, conclude (on p.26) that the relationship between road damage and axle weights was "closer to a third-power law than the fourth-power law conventionally used to approximate the AASHO findings".

However, there are two reasons why this finding is not appropriate to New Zealand. First New Zealand pavements are predominantly flexible as opposed to rigid. The Small et al. estimate of the exponent for flexible pavements is 3.652 $\pm$ 0.288, i.e. in the range of 3.36 - 3.94. Second, RTR (p.28) argue for a lower exponent on the grounds that "thin surface pavements [are] typical of New Zealand roads". However, the evidence to suggest that the exponent for thin surfaces, i.e. low structural number, is higher not lower than thick surface roads is overwhelming. For the UK Department of Transport, Addis and Whitmarsh (1981) found that, for an 80 kN axle weight (the New Zealand limit), the exponent rose from about 4 for pavements with structural numbers above 5 to an exponent of 6.6 for a pavement with structural number of 2.38. For a 65 kN axle weight, the exponent was 3.5 for structural number 5.18, and 5.8 for structural number 2.38.

More recent tests have not (yet) shaken the findings from those AASHO (1982) tests. Small et al. (1989) were happy to rely solely on the AASHO tests, despite being aware of other work. RTR (1991) contented themselves (p.23) with saying that "there has been broad agreement that power relationships apply in some fashion but only weak consensus as to what and how, save for the fourth power as a rule of thumb". Clearly, not all maintenance arises from damage caused by axle weights (e.g. replacing a fallen signpost) but this is adequately allowed for by the present allocation methods. For those damage costs which are attributable to axle weights it is clear that we must use an exponent and that no better value exists at present for the exponent than four.

Considering the effects of this decision, RTR (1991, p.25) agree that any exponent greater than 2 will allocate virtually all the relevant costs to heavy trucks, as opposed to light vehicles. Small changes to the exponent will only affect the allocation between truck types. If the true exponent were felt to be only, say, 3.6, then too much cost would be allocated to large axle-weight trucks. However, some allowance in this direction is probably beneficial if we consider the effect of overloaded vehicles. Because of the power-rule, if all trucks have axles overloaded by 1 tonne, say, then the extra damage caused by heavy axle-weight trucks is much greater than average. Hence, with a system which ignores overloading and if overloading is equal across all vehicles, heavy trucks will be benefitting unfairly. Hence any slight overcharge due to approximating by the fourth power rule should not worry us unduly.

### 2.8.3 Weathering

Whether any maintenance costs should be attributable to the passage of time, and in particular to "weather", as opposed to that of vehicles using the road, is now reviewed. Small et al. (1989, p.19) comment as follows:

> *"Some analysts, especially members of the trucking industry, suggest that a substantial fraction of the total maintenance cost of a highway is attributable to age and weather. They then go on to claim that the extent of these costs invalidates the argument for user taxes that are steeply graduated by axle weight. In fact, the opposite is true. All evidence indicates that these effects are mainly interactive - it is weathering of the pavement in conjunction with heavy axles that causes the problem."*

In support of this they quote Gomez-Ibañez and O'Keeffe (1985) who, after reviewing conflicting claims in the literature, concluded that time and weather mainly aggravate the effects of traffic loadings, having little independent effect. The evidence from the AASHO tests (AASHO 1962, p.123), quoted by Small et al., is that "no significant serviceability loss was found in flexible pavements ... that were not subjected to traffic over the 2 year period of the Road Test". This contradicts the more extreme estimates made by Patterson (1987). Small et al. present an algebraic proof that the marginal maintenance cost of road wear is higher when ageing and weathering are present, and give their view of the best value of the ageing parameter to use.

### 2.8.4 Economies of Scale

The other issue to be discussed is that of economies of scale in road maintenance. The argument here is that, if there are approximately constant returns to scale, marginal costs could be approximated by average costs, as is the case with most cost-allocation systems in use today. If, on the other hand, there were increasing returns to scale, so that marginal costs were below average costs, then systems of allocating total maintenance costs would overstate marginal costs. The evidence here is rather unclear.

Regarding economies of scale for providing highway capacity, Small et al. (p.100) argue that "a single road of a particular type probably has increasing returns for two reasons: first, capacity goes up faster than number of lanes ...; second, cost rises more slowly than the number of lanes because certain features such as shoulders and median strip need not be expanded. On the other hand, a system of roads may have decreasing returns to scale because of the need for intersections, whose costs may well grow more than proportionally to the widths of the roads. Furthermore, in dense urban areas the road system occupies such a large fraction of available land that expanding the road may drive up the cost of land noticeably, which would tend to produce a rising average cost function - that is decreasing returns to scale".

They cite two sources of empirical evidence on returns to scale to road capacity provision. The first (Keeler and Small 1977) found constant returns to scale, while the second (Kraus 1981) found a ratio of average to marginal cost of about 1.2 (i.e. increasing returns to scale), although both probably overstate returns to scale as they neglected the effect of consequential land price inflation. Small et al. took the constant returns result as the most reliable for urban areas.

To what extent these results translate into similar effects for the cost of maintaining a fixed set of roads is not clear (though clearly, the argument about increasing number of intersections is solely a long-run argument). In the absence of any further evidence, we would suggest that constant returns to scale is a reasonable working hypothesis but one that needs further testing.

### 2.8.5 Other Issues

Some costs caused by traffic are not explicitly charged for, either because they do not fall on the public purse, or are for items customarily met from central funds. The key example of the latter are those accident costs which fall on the public purse, e.g. ambulance costs, hospital costs, etc. The Armitage inquiry (Armitage 1980) in the UK recommended that these costs be included in the track costs allocation.

However, the government decided to reject this recommendation on the grounds that other sources of accidents were not similarly charged (e.g. sports injuries). Other costs of accidents were taken to fall on the users themselves or to be "external costs" to non-road-users. In the first case it was argued that the users themselves were paying, and in the second case that such externalities were not charged for in other sectors. The case for including these costs in order to gain an efficient volume of traffic is convincing, but has only been very loosely accepted by the UK government in the form of a 30% margin of charges above allocated costs. There are, of course, considerable difficulties in producing reasonably precise and generally acceptable estimates of the costs involved.

Current UK methodology now disaggregates by type of road (Motorway, Trunk, Principal and Other) with vehicle classes being allocated costs relating to each road type in proportion to their use of that road type. For example, the categories of costs largely subject to the fourth power rule (reconstruction, resurfacing, patching and minor repairs) represent 71% of motorway costs, but only 27% of the costs of other (i.e. minor) roads. However, because there are so many fewer heavy trucks on the minor roads, their total of standard axles is much lower, so their charge per standard axle is nine times that for the motorway. Consequently (usually articulated) truck types which handle long distance general merchandise traffic over the motorway system pay much less per km than (usually rigid) truck types which carry short distance bulk commodities over local roads.

A further question relates to the interaction between road expenditure, traffic, and public utilities (water, gas, etc.) that are placed under the road. Economic efficiency requires that each party pay the costs that they inflict on the other. Thus on the one hand traffic should be charged for any damage it causes to the utility, for instance through pipe fractures. On the other hand, utilities should pay for any costs they impose through roadworks, including not just the cost of reinstating the road but also the cost of delays to traffic. Whether they should pay any more than this, for instance a rental for the use of the road, depends on whether this is seen as a fair and efficient way of meeting budgetary targets. Certainly this in no way affects the appropriate charge to cover marginal social costs of road use, although it might affect the margin needed above this for budgetary purposes from road users.

## 2.9 Summary

In an ideal world, an optimal state would be reached by having all prices equal to marginal social costs. These social costs would consider not only the monetary cost of production but also factors such as damage to the environment caused by the production process, or costs imposed on other people such as congestion in the case of road traffic. Because the market is unlikely to internalise these social costs and take account of them appropriately, intervention may be needed to correct market failure. This raises problems of its own:

(a) Difficulties in measuring and valuing marginal social costs. How exactly is the extra congestion caused by one car entering a network determined?

(b) Optimal MSC pricing would cause price to vary continuously across time and space. In practice, it will vary discretely, and the greater the variations, the greater the administrative costs. It may be that the administration costs will outweigh the extra benefits of optimal pricing.

(c) Efficient pricing may also require producers to operate at a loss. For various reasons, budget constraints may prevent this, which will alter the optimal prices.

(d) If some prices do not equal MSC, we are in a second-best world which means that applying first-best principles does not guarantee an improvement.

Notwithstanding the above problems, P = MSC is the basic rule, and forms the obvious starting point for any analysis of transport pricing. The question which needs to be answered, for the specific circumstances in each case, is whether the benefits from moving to P = MSC exceed the costs of doing so, given the practical problems of varying charges for the use of roads by time and place.

This critical issue is addressed in Section 3. Certainly, the constraints on implementing and administrating a charging system are valid pragmatic considerations, while the costs involved are a genuine component of social cost. In short, it may not be either economically or financially cost-effective to recover all the direct costs imposed by road users.

# 3. PRICING METHODS

## 3.1 Criteria for the Design of Road Pricing Systems

The Smeed Report (Ministry of Transport 1964) produced a list of criteria for the design of road pricing systems:

(1) Charges should be closely related to the amount of use made of roads;

(2) It should be possible to vary prices for different areas, times of day, week or year and classes of vehicle;

(3) Prices should be stable and readily ascertainable by road users before they embark upon a journey;

(4) Payment in advance should be possible although credit facilities may also be permissible;

(5) The incidence of the system upon individual road users should be accepted as fair;

(6) The method should be simple for road users to understand;

(7) Any equipment should possess a high degree of reliability;

(8) It should be reasonably free from the possibility of fraud and evasion, both deliberate and unintentional;

(9) It should be capable of being applied, if necessary to the whole country and to a vehicle population expected to rise over 30 million.

May (1992) has stressed the validity of these criteria for assessing proposed pricing systems 30 years on, suggesting that criterion (9) may need to be revised to apply to potential international systems and even greater numbers of vehicles. Three additional criteria are also suggested by Thompson (1990) and Hau (1992):

(10) The system should allow occasional users and visitors to be equipped rapidly at low cost;

(11) The charge recording system should be designed both to protect individual users' privacy and to enable them to check the balance in their account and the validity of the charges levied;

(12) The system should facilitate integration with other technologies, particularly driver information systems.

The value of criterion (1) is that charges closely related to the use made of roads will provide clear signals at the time that consumers incur the charge and are consequently more likely to affect consumer behaviour.

## 3.2 Alternative Charging Structures

Bearing in mind criteria (3), (6), (9) and (11) above and general economic and technological constraints, a road pricing system which closely reflects the economic theory described in Section 2, and requiring the calculation of separate charges for every link in the road network, is unlikely to be either feasible or desirable. In practice the systems which have been proposed, and even more those which have been implemented, are conspicuous by their simplicity. Four principal categories of systems can be identified, and are discussed in order of complexity: extension of existing charging and taxation arrangements, supplementary licensing, cordon tolls, time-, distance- and congestion-based charging. If a stricter definition for road pricing were applied, may be only the fourth category would be included, as only time- and distance-based charges attempt to approximate the economic concept of pricing for individual users.

### 3.2.1 Extension of Existing Charging and Taxation Arrangements

Road pricing charges are presented through three conventional taxation systems:

- Vehicle purchase tax;
- Vehicle licensing; and
- Fuel tax.

The first two systems attempt to reduce vehicle use by constraining ownership, and have been used in Hong Kong and Singapore. In 1982, purchase tax for new cars was doubled and the annual licence fee trebled in Hong Kong, resulting in a 25% reduction in car ownership during the following twelve months (Dawson and Brown 1985). In Singapore new car sales have been regulated by a monthly quota, with purchase tax determined by bids. Also, some cars have been licensed at a reduced rate for use only at weekends (LPAC 1991).

The problems with these methods are that they have a low flexibility for discriminating by time and location and are completely unrelated to the amount of road space used (thus failing criteria (1) and (2) specified by Smeed). Evidence from Hong Kong shows that the impact on car use was negligible in the most congested areas but produced a 19% reduction in the lower income, less congested areas. This implies that the other car owners were using their vehicles more, that the wrong geographical areas were being targeted, and that there may have been serious equity disbenefits to lower income car users.

Relating vehicle licence costs to the amount of road use has been attempted in New Zealand for vehicles exceeding 3.5 tonnes by adopting a distance- and weight-based licensing system. Fourteen categories of vehicles are used to define the charging rate. Vehicle operators are then required to purchase licences relating to the maximum gross laden weight which they wish to carry and the distance they intend to travel. The distance actually covered is recorded by a hubodometer attached to the vehicle so that the validity of licences can be checked (Starkie 1988).

This approach satisfies criterion (1) but cannot distinguish by location and time of day (criterion (2)). Its application to heavy vehicles, which would be expected to travel the majority of their distances on inter-urban roads, illustrates that this method may be suitable for representing environmental and maintenance costs in an uncongested situation but it is unlikely that it would be considered appropriate in congested urban areas.

The experience from New Zealand also suggests that there may be enforcement problems, although it should be noted that in 1984-85 the resources used for enforcement were less than 2% of revenue.

Administering road pricing charges through fuel tax would be closely related to the amount of vehicle use, and there is evidence of an elasticity demand with respect to fuel prices in the range -0.1 to -0.5 (Goodwin 1988). However, it is not possible to discriminate at all by time and location (criterion (2)) and there is evidence that the wrong trips are targeted, with off-peak and leisure journeys being hit first (Atkinson and Lewis 1975).

In addition, in recent international discussions, a carbon tax has been greeted with resistance by politicians. The potential of fuel taxation to tackle the regional and global environmental impacts of transport remains, but it seems to be rather less effective at the local level and would have economic and political implications beyond those expected from other road pricing methods.

### 3.2.2 Supplementary Licensing

Supplementary licensing may be considered as an extension of administering road pricing charges through conventional vehicle licences, but attempting to add flexibility for targeting specific times and locations. The system involves the purchase of an additional licence to travel within a particular area defined by a specified cordon. Charge levels can be varied by time of day, direction of movement across the cordon, and type of vehicle. The cordon may be a single perimeter boundary or a series of cells. Such a system was proposed for London (GLC 1974) and has operated in Singapore since 1975.

The Singapore system has required licences to be purchased on a daily or monthly basis, to be displayed in the vehicle windscreen to allow access to the centre during the morning peak period. Enforcement has been manual, requiring comprehensive staffing on the cordon, but an electronic alternative would be possible and is being considered to allow a more complex system to be introduced covering the national road network (Holland and Watson 1978, LPAC 1991).

The main criticism of supplementary licensing is that it may not sufficiently satisfy criterion (1), relating charges to amount of road use, although a more complex series of cordons or cells may help to address this.

### 3.2.3 Cordon Tolls

Cordon tolls are similar in principle to supplementary licensing, with a charge being levied to permit travel within a specified area defined by a single boundary or series of boundaries. The main distinction is that the charge incurred is directly related to the number of boundary crossings, which may help to address criterion (1). As for supplementary licensing, charges may be varied by time of day, direction of travel and vehicle type. Tolls may provide greater flexibility for applying the charge structure to one-off or unpredictable journeys, with the purchase of access being instant rather than pre-planned (see criterion (10)), although a sophisticated electronic system may enable instant purchase of a licence. Cordon toll systems operate in three Norwegian cities and a pilot project has been conducted in Hong Kong.

In Norway, a single toll cordon was installed around the city centre of Bergen in 1986 and similar systems have since been added in Oslo (1990) and Trondheim (1991). As their main objective has been revenue collection to fund other transport projects, no attempts have been made to apply a more complex cordon arrangement and tolls have been charged throughout the day at a uniform rate. A limited examination of the effects upon traffic in Oslo has revealed only a very small reduction in volumes, principally outside peak hours (Waersted 1992, Hoven 1992). A wide range of technology levels have been used for toll collection, from manual booths to electronic tags, with cordon crossing points controlled by individual toll stations on local roads and major plazas on the heavily trafficked arteries.

In Hong Kong, a much more complex system was envisaged. It was proposed that all vehicles would be fitted with electronic number plates which would be identified by loops buried in the carriageway. All vehicles would possess an account to be billed on a monthly basis. A series of charging regimes were considered, of which the most complex involved the adoption of 13 different cells, requiring 185 charging points, with eight separate charge levels per day (Catling and Harbord 1985, Harrison et al. 1986).

Despite the technical success achieved in the pilot project, the Hong Kong system was rejected, partly because of the invasion of privacy implied by vehicle identification (criterion (11)) though political factors cannot be overlooked. Although car ownership is only around 10%, these owners represent the most influential sectors in the population.

Even cordon tolls have been criticised for failing to meet criterion (1) on the grounds that they do not discriminate by the level of congestion on the network (Oldridge 1990), levying the same charge whatever the prevailing conditions and additional delays resulting from a trip. Also, there are implications related to levying the whole charge for travelling within an area at a single cordon point rather than on a continuous basis. Trips which terminate just inside a charge point will pay the same as those travelling extensively within the cordon, while trips with origins and/or destinations just outside a charge area will experience a disproportionate incentive to change their travel decisions. These "boundary effects" raise concerns regarding the ability of cordon tolls to satisfy criterion (1) and may lead to perceptions of unfairness (criterion (5)).

Norwegian experience has identified the need to retain manual toll booths in a population where some vehicles would be unequipped to cater for one-off and occasional users (criterion (10)). The physical space required to accommodate toll booths would constrain the level of complexity of toll cordons that would be feasible in many urban situations. By contrast, a fully electronic system requires no additional space, but may need special provisions to satisfy criterion (10).

### 3.2.4 Time-, Distance- and Congestion-Based Charging

Other systems where charges are directly related to the time spent travelling and/or the distance covered tend to be favoured by critics of the first three road pricing systems. Such systems can be regarded as immediately addressing criterion (1) and reflecting levels of congestion. Two are currently being considered in the UK:

- TIMEZONE system in Richmond, London; and
- Congestion metering in Cambridge.

TIMEZONE levies a charge based on the time spent travelling in a specified area. Charge rates can be varied by time of day, user class and across a series of different zones (EASAMS 1991).

Congestion metering involves recording the time taken and distance covered for each vehicle on a rolling basis, with a charge only being levied when a specified threshold is exceeded (Oldridge 1990).

Both these systems require the technology of an in-vehicle unit to calculate charges and conduct transactions. Although there are no operational time- and distance-based charging systems, plans exist to test the technology of TIMEZONE in the field during 1992 and to progress to more extensive trials.

A major concern relating to time- and congestion-based charging structures is the possibility of adverse effects on driver behaviour and the consequent safety implications. The fear is that a direct variable charge levied in relation to time or any other variable parameter may lead to an increase in erratic and illegal driver behaviour in order to minimise payments. A number of possible effects have been suggested:

- Increased red-running at traffic signals;
- Increased frustration at congestion bottlenecks;
- Increased rat running into residential areas;
- Increased violation of speed limits; and
- Decreased consideration for the needs of vulnerable road users, in particular inexperienced and elderly drivers, cyclists and pedestrians.

The criteria for charging within the proposed Cambridge congestion metering system have to be modified in response to criticisms about potential effects on driver behaviour. The concept of defining a congestion threshold in relation to the numbers of vehicle stops per unit distance has been discarded, following suggestions that drivers would attempt to evade charges by failing to stop at junctions and pedestrian crossings. It may be that the effects upon driver behaviour and safety should be an additional criterion for designing the road pricing systems set out above.

It would also be feasible to design a charging structure based purely on the distance travelled within a specified area. This would be directly related to the use made of roads by the individual driver. It would have the attraction that charges would be extremely predictable, based on route choice. This may, in turn, improve perceptions of fairness because drivers would have no grounds to consider that they were being charged for congestion caused by incidents on the network, such as road works, failure of signals or accidents (i.e. criteria (3) and (5)). The principal drawback of this approach is that, without a time element, the charging structure is unresponsive to levels of congestion, which could only be represented through pre-set charge levels for different times of day. It is probably for this reason that no firm proposals exist for solely distance-based charging structures.

### 3.2.5 Other Approaches to Charging

Another approach to charging has been proposed to relate charges directly to the costs imposed upon other users, including those travelling later during the congested period (Smith and Ghali 1991). This would involve either a charge levied retrospectively or a reliable method for predicting future short-term traffic patterns. It seems unlikely that such a system could ever satisfy the needs for simplicity of understanding and predictability of charge level (criteria (3) and (6)), especially bearing in mind the complex effects on driver behaviour and travel decisions. These could occur as the result of incurring the costs which would be higher earlier in the peak and unrelated to prevailing traffic conditions. In the absence of operational evidence for the effects of time- and distance-based charging systems, current research using modelling techniques may provide the best insight (May et al. 1991).

### 3.2.6 Fairness of Charging Structures

Although the Smeed criteria have been used throughout this review of alternative charging structures, little reference has been made to criterion (5) regarding perceived fairness. This is very closely related to the equity objective of road pricing. In general, all charging structures will have winners and losers, but the more complex the system the more able it is to address equity issues. Particular equity concerns relating to the above systems are as follows:

- Extension of existing taxation will particularly affect lower income groups, those with the greatest need to use a car, and those with no satisfactory alternative.

- Supplementary licensing and cordon tolls have been criticised as well for resulting in inequities relating to the locations of cordon points, requiring some users to cross cordons more than others (Waersted 1992), and to the effects of transferring congestion-related problems to new areas just beyond the cordon (Thorpe and Hills 1991). It is generally accepted as unfair that short trips terminating just within a charge area pay the same as drivers travelling extensively within the cordon.

- Any system which levies a charge when roads are uncongested is inherently unfair, as suggested by supporters of congestion metering (Oldridge 1990). This viewpoint makes the implicit assumption that all transport costs in uncongested conditions are catered for sufficiently through existing taxation and licensing arrangements. Inequities are also related to time- and congestion-based charging structures, where the charges for particular journeys may be difficult to predict.

Difficulties with the treatment of occasional users and visitors (criterion (10)), tend to correspond to the higher levels of technology beneficial to some charging structures, but precise effects depend upon the design of individual schemes.

## 3.3 Technology

The technology required to operate road pricing successfully depends upon the choice and complexity of the charging structure. Although supplementary licensing in Singapore has shown that totally manual operation is possible, benefits are to be gained from automation in terms of operating costs, speed of passage for users and, potentially, limitation of errors. The technology for electronic road pricing (ERP) systems comprises three elements:

- A procedure for levying charges;
- A communications system between the roadside and passing vehicles; and
- Provisions for enforcement.

All three elements should be designed to meet Smeed's criteria (4), (7), (8), (9), (10), (11) and (12).

### 3.3.1 Systems of Payment

Systems of payment are of two types (Thompson 1990): off-vehicle recording and on-vehicle recording.

#### 3.3.1.2 Off-vehicle recording

Off-vehicle recording uses an electronic tag which identifies a vehicle as it passes charge points, with charges being calculated by a central computer. It is not able to handle time- and distance-based charging but, as the roadside recorder is able to incorporate time of day along with the vehicle identifier, a complex cordon toll system could be accommodated. The principal drawback relates to objections regarding invasion of privacy, which caused this system to be rejected in Hong Kong. However, in Norway, off-vehicle recording has been introduced successfully using more recently developed tag technology, involving encryption and electronic transactions, which enable charges to be deducted on line. This would allow complete privacy if all records were immediately destroyed, but would introduce potential problems regarding the accountability of the system because the user would be unable to check his transactions.

A more favoured approach is the retention of transaction details in a register without any link between the tag number and the user or vehicle. This is intended to provide an acceptable level of privacy while keeping records for checking and audit purposes. Introduced on an optional basis as an alternative to manual toll collection in Norway, this system has allowed drivers to choose between time savings and any perceived privacy limitations. In addition, the adoption of a tag in the form of a portable card, similar to a smart card, allows vehicles to be equipped much more quickly and cheaply than was the case in Hong Kong, where tags were permanently fixed to the underside of the vehicle.

#### 3.3.1.2 On-vehicle recording

On-vehicle recording requires an in-vehicle unit (IVU) which accepts payment from a smart card. The IVU is potentially able to handle any charging regime about which information can be provided by the vehicle or from the roadside. Cordon-based charging would require the IVU to be triggered to deduct a specified charge at each cordon point. Time- and distance-based charging would require the IVU to be switched into and out of charging mode on passing cordon points, with additional information regarding the charging level and criteria to be used also being transmitted on entering a charge area. Thus on entering a TIMEZONE area the IVU would be switched on and provided with the relevant information regarding the cost per unit time to be deducted. For congestion metering the IVU would require information about the charge level and that of the charging threshold.

#### 3.3.1.3 Comparison of the two systems

The on-vehicle IVU has three principal advantages over off-vehicle recording:

- Lack of central records ensures privacy;
- IVU can provide immediate information regarding charges incurred; and
- IVU technology could be extended to cover other transport costs, such as parking and public transport fares, and has potential for use as part of driver information systems (Van Vuren and Smart 1990).

It has also three disadvantages:

- Smart cards could be stolen and would not be identifiable as easily as vehicle tags: although various measures adopted from the consumer credit and debit card industry, such as personal identification numbers (PINs), could be employed;

- Problems of policy regarding the allowance of a credit margin on used smart cards if there is no central record and new cards can simply be purchased, while an old card with a negative balance is discarded; and

- Smart cards may allow fraud and tampering.

### 3.3.2 Communication Systems

Three potential means of communication are possible between the vehicle and the roadside:

- Low frequency radio transmission from loops in the road: was proposed for Hong Kong, but can only be used for very limited information transfer and is only feasible over short distances;

- Infra-red technology: has so far only been used for route guidance (Jeffrey et al. 1987);
- Microwave technology: the focus of most road pricing work.

Both the TIMEZONE and Cambridge road pricing proposals are based around microwave beacons, and the development of the technology has been the centre of the EC DRIVE PAMELA project (Blythe and Hills 1991). The results of recent experiments have suggested that a very high level of reliability in data transfer is achievable even in heavily trafficked, high speed, multi-lane conditions (Hills 1992).

### 3.3.3 Enforcement

Generally enforcement of the above technology presents the greatest challenge of all. Any electronic road pricing system requires the ability to identify and classify all vehicles passing through a cordon point to ensure that any unequipped vehicle is not allowed to pass. This process can be carried out automatically, but in Singapore manual enforcement was required to allow operation of a policy of free entry for high occupancy cars (Holland and Watson 1978). Once an offending vehicle has been identified as possessing no charging facility, a wrong permit for that class of vehicle, or an insufficient credit balance, it must then be identified. An IVU is capable of providing this information electronically, but the most favoured approach is the use of video recording equipment.

Experience from Norway has found some problems with identification of vehicle licence plates from video recordings because of light or weather conditions, and dirty number plates. In addition a hardcore of persistent offenders have been identified who resort to some lengths to avoid detection (Waersted 1992). Their measures include the removal and amendment of number plates, obstruction of plates with dirt and even the use of specially designed mechanical devices to turn or cover plates from the view of the camera.

Also, potentially very high administration costs are involved in processing large numbers of photographs. These costs are particularly high if systems also attempt to deal with visitors and casual users using a simple non-electronic daily permit, as has been proposed with TIMEZONE (EASAMS 1991). In this system visitors would initially be identified as potential offenders from the video, but exonerated once the number plate has been checked against permit purchases. This approach also fails to protect privacy.

Identifying the correct authority to take responsibility for enforcement issues is another problem. To bring about prosecutions of offenders the authority would need to be able to empower and justify penalties based upon information provided by the system technology, and would need to be able to withstand the reliability of such information being questioned. If such motoring offences, perceived by the public to be very minor, were to be dealt with by the conventional policing and legal systems, an intolerable burden would then be placed on existing services, and public support may be lost. It is also likely that local government agencies would wish to avoid both the extra administration burden and endangering their public popularity. Therefore, enforcement may be the greatest stumbling block for establishment, especially of the more complex technology-based charging systems.

### 3.4 Summary

Section 3 has taken the broad definition for road pricing set out in Section 1 and examined the full range of charging mechanisms which can be applied to private transport. The criteria for system design proposed by the Smeed Report have been set out and used to assess the range of possible road pricing systems. Four categories of charging structure have been identified:

- Extension of existing charging and taxation arrangements;
- Supplementary licensing;
- Cordon tolls; and
- Time-, distance- and congestion-based charging.

In general the more complex charging structures allow greater flexibility and come closest to relating charges incurred to actual road use, but maintain a charging structure which can be easily understood by the user and can also cater for visitors and occasional users.

The review of road pricing technology shows that on-vehicle recording of charges is required for time- and distance-based pricing and that there are potential problems for invasion of privacy with off-vehicle recording. Microwave technology has been identified as the most suitable communications system for road pricing between the vehicle and the roadside, given the current state of technology. Enforcement has been the principal challenge to all road pricing methods, particularly to complex systems dependent upon the performance of technology.

# 4. PUBLIC ATTITUDES TO ROAD PRICING

## 4.1 Introduction

While many academics and practitioners may regard the case for road user charging as well made (either to cover only infrastructure-related costs or externalities as well), there are many places around the world where schemes which sought to apply such principles to car traffic were not implemented because of adverse public attitudes and political pressures, even though they had considerable technical merit. Instances include proposals for supplementary licensing in London and Kuala Lumpur, for electronic road pricing in Hong Kong and the Netherlands, and various attempts to raise petrol tax in the United States.

It is likely, therefore, that considerable efforts in devising appropriate charging structures could be wasted unless due account is taken of public perceptions and attitudes. This does not mean that nothing can be done, as most people do recognise the reality of having to pay for transport provision and the impacts it causes in some way or other, but that the way in which it is done should take into account public concerns and sensitivities.

### 4.1.1 Attitudes to Charging Structures

The range of charging structures discussed in previous chapters include:

- Annual car registration tax;
- Tax on petrol and other fuels;
- Tolls for using new road links (e.g. tunnels or bridges); and
- Area road use charges.

The first three are well established in most countries, and have generally become accepted by the public. Area road charges are discussed in an urban context, with first a few observations about public attitudes regarding the others.

In countries such as the UK, the annual car registration tax was originally hypothecated for roads, and is still referred to as the "annual road fund licence". (Hypothecation here is defined as the designation for a specific, defined purpose of the revenues raised from a tax.) Although the link was broken more than fifty years ago, many motorists are very aware of the origins of the charge, and cite it as reason for suspicion that any new form of charge would end up becoming "just another tax" within a few years. Past political actions can act as a severe constraint on what can be achieved in the future.

Many drivers would accept that the annual car registration tax is "unfair", in that it does not take any account of how much the roads are used, and in that sense a tax on petrol is fairer. However, there are concerns that petrol taxes put rural dwellers at a disadvantage, since they have to travel further to reach essential services and contribute less to most externalities such as congestion, noise, air pollution. Certainly it is doubtful in the UK whether the former is true: rural dwellers do not travel substantially further than urban dwellers and, given better driving conditions, will be consuming less petrol per kilometre. Similarly, the arguments about the varying incidence of externalities carry less weight as the $CO_2$ issue gains in importance.

The application of tolls to fund specific road links seems to be well established in most countries, although there is some public resentment at "paying twice" through tolls and annual taxes on vehicles and fuel. However, given current government spending constraints in most countries, the argument that tolling is the only way of ensuring implementation does seem to be accepted, albeit grudgingly.

Some of the evidence regarding public attitudes to traffic-related problems, what people feel should be done, and how pricing solutions are perceived are discussed in the rest of this section. The available evidence either deals with national attitudes or with surveys in specific urban areas. No evidence is available on public attitudes in rural areas. Most of the information quoted here comes from structured surveys, with a smaller amount from qualitative work (e.g. from group discussions).

### 4.1.2 Limitations of the Review

It is important to note the strength and limitations of the information reviewed in the rest of this section. First, none of the data relate specifically to New Zealand, and so does not obviate the need for local surveys, though it should assist in deciding where to focus questioning and how to present issues. Second, qualitative research is rich in insight but has to be corroborated by structured surveys in which attempts are made to gauge the strength of opinion on national issues. Third, public opinion surveys themselves have come in for some criticism in the UK since their failure to correctly predict the results of the 1992 UK general election. Care is thus needed in interpreting attitudes towards contentious issues such as road pricing.

Qualitative evidence suggests that initial reactions to road pricing as a "solution" to urban transport problems may be positive. However, when respondents start thinking about what would be involved (e.g. implications for them personally, concerns about "big brother", etc.), views can swing sharply the other way, before settling back to a more central position once more considered opinions have been formed. It is very difficult to know the point on this cycle that individual surveys are tapping.

Nevertheless, by piecing together evidence from a variety of surveys in different countries, it is generally possible to give useful guidance about the attitudes of the public towards road pricing.

## 4.2 Awareness of Traffic-related Problems

Various opinion surveys carried out in the UK in the last few years have confirmed that traffic congestion, and the road safety and environmental implications of traffic, are at the forefront of most people's minds. Nationally, around 80% of adults regard current traffic levels in general as posing a "Very Serious" or "Fairly Serious" problem. Concern about traffic-related problems rises to an overwhelming 95% when people are asked about congestion and pollution in larger towns and cities (Jones 1991a). In a recent survey in

London (NEDO 1991), traffic congestion was more often cited as a serious problem than house prices or crime.

While one of the main trigger points for discussions about traffic-related problems is congestion and the unpredictability of journey times, it is not necessarily perceived to be the most serious problem. Quimby and Downing (1991) asked how concerned people felt about a wide range of social issues, including some traffic-related problems. Overall, 56% reported being "Very Concerned" about pollution of the environment (the highest score), 41% about road safety, and 35% said they were "Very Concerned" about traffic congestion.

This order of ranking seems to reflect the relative concern found for these issues in several other national UK surveys. Although traffic congestion may have a higher profile in everyday discussion, deeper concerns are generally felt about environmental deterioration and injury or loss of life. This is supported by qualitative surveys in the UK too (Jones 1992), where drivers seem more willing to contemplate measures that may in some way restrict or penalise them if the measures result in clear safety or environmental benefits. This also seems to be borne out politically, in that cities that have taken action against the car (e.g. in Athens or Milan) have done so primarily because of concerns about deteriorating air quality rather than about traffic levels per se.

In Europe, the International Union of Public Transport (UITP) and the European Commission (EC) sponsored a study of European attitudes towards "Access to City Centres", comprising a public attitude survey (1000 adults per country), and a smaller study of decision-maker attitudes. Respondents were asked about the consequences of car traffic in the urban area in which they lived/worked/shopped. Across Europe as a whole, 59% described these as "Hardly bearable" or "Unbearable", with this proportion ranging from a low 27% in Denmark to a high 84% in Italy. For political decision-makers across Europe, 73% rated the consequences of urban car traffic as being "Hardly bearable" or "Unbearable", and all mentioned some traffic-related problem in their city.

When asked more specifically about what contribution they thought that car traffic in the city centre made to a deterioration in the quality of the air, 78% of adults across Europe as a whole saw this as the main cause or an important cause of the deterioration, with percentages ranging from a low of 57% in Ireland up to 95% in Italy. Among decision-makers the mean percentage across Europe was higher, at 92%.

Surveys in Japan have raised similar concerns. A study of around 1000 adults in Osaka, reported by Nitta (1991), found that 67% of respondents rated traffic accidents as a "Very Serious" problem, 57% gave this rating to traffic congestion, 47% to air pollution and 35% to noise. When asked whether it was more important to reduce traffic congestion or air pollution, 50% said both equally, 30% favoured air pollution reduction and 20% traffic congestion reduction. This is in line with the UK experience. Around 90% of respondents regarded road traffic as the main source of air pollution in the city.

Baldassare (1991) reports on local public attitude surveys of residents in the affluent Orange County area of California. In a series of annual surveys, respondents rated traffic and transportation as being the most serious policy problem in each year, rising from being first ranked by 33% in 1985 up to 48% in 1988. This is more than twice the score achieved by any other issue. In addition, 89% cited air pollution as a problem, with 48% describing it as a big problem. Figures for the Southern California region were even higher than Orange County, being 93% and 72% respectively. Cars are viewed as a major contributor to this problem.

## 4.3 Support for Pricing and Other Externality-Reduction Measures

### 4.3.1 UK Surveys

A number of UK national opinion surveys have asked about public support for different policies for dealing with urban traffic problems. Overall, these surveys show strongest support for policies that provide alternatives or supplements to car use, without directly constraining the person's ability to continue travelling by car. Such policies include Park and Ride schemes, general public transport improvements, encouraging walking and cycling. Traffic regulations, comprising both better enforcement of existing regulations (e.g. better parking enforcement), and the introduction of new regulations (e.g. new restrictions on cars entering central areas) come next in level of support, and generally have majority endorsement. Support for more urban road building is expressed by about half the population, but there is also a sizeable proportion against as well as for the measure.

The introduction of some form of road user charging in inner and central city areas is generally supported by only a minority (typically a quarter to a third). A general increase in petrol tax is regarded with the least enthusiasm, though this does not prevent government raising it periodically in line with inflation.

Comparable surveys in London have come to similar conclusions, although support for road pricing is somewhat higher at around 30-50%, depending on the type of system proposed. Here the evidence suggests that support is higher:

- for an Area or Cordon-based charge, than for some trip length-based measure such as travel distance or travel time; and
- where exemptions are available for certain groups of travellers.

One general factor affecting reported attitudes is the context in which respondents are asked to express a view. Table 4.1 illustrates what happened when respondents in one national UK survey were asked about the best balance of expenditure on road and rail, taking account of first the national interest and then their personal interest. This resulted in clear differences. For example, only 27% thought that more expenditure on railways and less on roads would be in their own best interest, but 39% thought that it would be in the country's best interest. The newspaper sponsoring the survey chose to interpret this pessimistically, i.e. people would "vote" for what is best for them.

However indications from group discussions (Jones 1992) are that, in cases where conditions are felt to be very bad (as in some city areas), many people feel that their own personal benefit should come second to that of the community interest. A similar response might be found, for example, where people are very concerned about the maintenance of rural communities and lifestyles.

**Table 4.1 Effect of context on attitudinal response.**

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**Respondents were asked:**

"Assuming the government has a fixed amount of money to spend on transport, which of these policies do you think would be best ....

- for the country?
- for you and your family?

| | COUNTRY | SELF |
|---|---|---|
| More on railways, less on roads | 39% | 27% |
| Less on railways, more on roads | 20% | 39% |
| Same balance as now | 37% | 27% |

Source: Newspaper opinion poll carried out for The Independent newspaper, reported in an article: "Transport poll shows double standards"

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### 4.3.2 European Surveys

The UITP/EC Survey (Section 4.2) asked which measures people would support to improve city centre traffic-related problems, and where they felt the balance of priority between competing road users should lie. Some findings are summarised in Tables 4.2 and 4.3.

When asked how effective they thought car restrictions, pedestrianisation and tighter parking controls would be in improving environmental and movement conditions, much higher support was given for the first two than the latter across Europe as a whole (Table 4.2).

The views of local political decision-makers were also sought. These reproduced the same preference rank ordering as the public responses, but they were more supportive of the measure in each case. At the same time, however, they perceived the public to be less supportive of the measures than was in fact the case. For example, 80% of policy makers thought that strictly limiting car traffic in city centres would be effective, but at the same time judged that less than half the population would hold that view. In fact it was found that 71% of the public were supportive of such measures.

**Table 4.2 Views of Europeans concerning the effectiveness of different measures for improving traffic movement and the environment in city centres.**

| MEASURE | AV.SUPPORT | MAXIMUM | MINIMUM | UK |
|---|---|---|---|---|
| Limiting traffic in city centres | 71% | 81% Denmark | 62% Belgium | 76% |
| Creating more pedestrian areas | 75% | 82% East Germany | 57% Denmark | 80% |
| Tighter parking controls | 53% | 78% Ireland | 38% Italy | 65% |

Source: Eurobarometer and Socialdata surveys carried out for International Union of Public Transport (UITP) and the European Commission (EC), in 1991

**Table 4.3 Views of Europeans concerning priorities of user groups in traffic planning conflicts.**

| TRADE-OFF | AV.SUPPORT | MAXIMUM | MINIMUM | UK |
|---|---|---|---|---|
| Pedestrians over cars | 85% | 90% Italy | 75% Ireland | 87% |
| Public transport over cars | 84% | 91% East Germany | 67% Ireland | 82% |
| Cyclists over cars | 73% | 87% Netherlands | 55% Portugal | 75% |

Source: Eurobarometer and Socialdata surveys carried out for UITP and EC, in 1991

The survey also asked questions about which mode should be given priority when conflicts arise in making traffic planning decisions, and results are shown in Table 4.3. In all cases the "environmentally friendly" mode is favoured over the car. On average, around 85% of respondents said that they favoured giving priority to walking and public transport over the car in city centres, and 73% would give preference to cyclists.

As with attitudes towards specific measures, the views of policy makers and the public agree quite closely, but the perception of the former is that the public are much more "pro-car" than is the case. While around 85% of adults would give priority to public transport over the car, the estimate of public preference by the decision-makers is half this level (43%). The contrast is even more marked for cyclists versus cars: instead of the public's 73% support, the decision-makers' estimate is only 30% support. The survey also confirms that the public believe that the decision-makers are out of touch with their views.

At a local level, Brog (1991) notes how public attitudes to traffic measures can change over a period of time. An opinion survey in the Austrian town of Graz in 1973 found that 53% of residents supported restrictions on motor traffic in favour of other modes; this proportion gradually rose in subsequent years, and by 1989 reached 85% in favour of such measures. Although there are no comparable surveys in the UK, the impression is that similar shifts in attitudes may have occurred because of the worsening in conditions.

### 4.3.3 Surveys in Japan and USA

In a survey in Osaka, 77% of the adults questioned supported a reduction of traffic levels in the city to reduce congestion and air pollution. Table 4.4 shows the degree of support for various measures to achieve these objectives. Vehicle emission controls received strongest support, followed by stricter controls on illegal parking, and reliance on self restraint on use of a car. Road pricing received some support from 47% of those questioned, and a licence plate control was least popular at 31%.

**Table 4.4 Support for different congestion and pollution control measures in Osaka, Japan.**

Proportions of adults who strongly or partially support or oppose each measure:

| MEASURE | SUPPORT | OPPOSE |
|---|---|---|
| Vehicle emission controls | 89% | 1% |
| Stricter controls on illegal parking | 86% | 6% |
| Self restraint | 71% | 9% |
| Road pricing | 47% | 22% |
| Licence plate control | 31% | 32% |

Note: Both for Road Pricing and the Licence Plate Control, around a third of respondents were undecided

Not surprisingly, national surveys in the United States tend to be more supportive of increasing road capacity than those in Europe, although other kinds of measures to combat congestion are also endorsed. The TRIP National Transportation Survey (Apogee Research Inc. 1990) found that the proportions of respondents who supported each of a range of government actions to combat congestion were as follows:

- 69% for expanding mass transit (75% among urban residents);
- 67% for adding lanes to increase highway capacity;
- 62% want businesses to introduce flexible working hour schemes;
- 60% for building additional circumferential motorways around cities;
- 55% for use of separate lanes for car pools; and
- 28% for introduction of increased tolls during rush hours.

While congestion-related tolls only achieved minority support, around 65% said they would be willing to pay some additional toll if it actually led to a reduction in congestion (75% in urban areas).

Findings from the Orange County study among high income suburbanites, reported in Baldassare (1991), are less encouraging however. The author concludes that:

> *".. there is little evidence that residents are willing to change their driving habits in response to a perceived worsening suburban traffic situation. Nor do they appear willing to support policies which require financial and lifestyle sacrifices to reduce traffic congestion."*

## 4.4 Attitudes Towards Road Pricing

While road pricing is not in general a very popular measure, the level of support can vary appreciably according to the type of scheme that is proposed, and how specific concerns are addressed. A number of factors have been shown to affect the willingness of the public to support road pricing. For example, support appears to be greater in larger cities than smaller ones, especially when it is being advocated as a congestion-relief measure. There seem to be two reasons for this:

- Traffic-related problems are generally much worse in larger urban areas, and so the need for effective action is perceived to be greater; and

- Alternatives are perceived to be less effective in larger cities (e.g. improving public transport alone may not be enough).

In particular, there is some evidence in the UK, Japan and The Netherlands that city centre car bans are preferred in smaller cities and road pricing in the larger ones.

Several of these factors affecting public willingness to support road pricing can be grouped into three broad clusters, relating to:

- Scheme conception: the objectives of the scheme, allocation of revenues, and the provision of complementary measures.
- Charging basis of the scheme (who, how, when, where) and the policy concerning exemptions.
- Practical feasibility.

### 4.4.1 Scheme Conception

The stated reason why a measure is proposed can affect public attitudes towards it, independently of the impact of the measure on behaviour. A study in Adelaide found that households were more willing to accept changes in work and school hours to reduce accidents than to reduce congestion (Jones et al. 1985). Motive seems to be particularly important for road pricing, where the issue of hypothecation seems to a key issue, and is linked with provision of adequate alternatives to car use.

Evidence from public surveys is that hypothecating revenues does increase support considerably if, as a consequence, improvements in transport systems can be achieved. In the TRIPS study in the US, for example (Apogee Research Inc. 1990), only 33% said they would support increases in petrol tax to finance roads and bridges in general. But this rose to 78% if the money was to be used for transportation purposes only, and would result in the road network being safer and less congested.

An in-depth study of public attitudes towards urban traffic regulations in the UK, carried out for Traffic Policy Division (Jones 1989), found that some form of traffic restraint in cities was seen by most people as inevitable, even if unpopular, and that a pre-condition of acceptance was likely to be a broader approach to transport policy . The study concluded that:

> *"In order to be acceptable to the public, any restrictive measures would need to be part of a package:*
>
> - *a simple but fair method of vehicle restriction, coupled with*
> - *improvements in public transport, and*
> - *some re-allocation of road space (e.g. new cycle or bus facilities, extra space for pedestrians or for residents' parking)."*

Two surveys set out to test this proposition, one nationally and the other among Londoners.

**Survey 1 - National support for a road pricing-based package**
The UK national survey was commissioned by the Transport Studies Unit, Oxford University, to specifically compare attitudes to road user charging as a stand-alone measure, and as part of a comprehensive, internally funded package (Jones 1991b).

The stand-alone road user charging option was described to respondents as: "Charge motorists a fee for driving in heavily congested/polluted areas of cities", and this only received support from 30% of adults nationally - with a net support (i.e. supporters minus opponents) of -27%.

Then the **same** respondents were asked whether they would support a **package** of measures that included road user charging, with revenues generated from the scheme being used to pay for the other elements. This produced a significantly different pattern of response.

Support for road pricing **virtually doubled** when it was presented as the cornerstone of a package of measures that improves alternative modes and provides a safer and more pleasant environment. A net rejection of 27% was transformed into a net support of 23%, leaving around a third of the population opposed. Only about half of the respondents who supported the package had also supported road pricing as a stand-alone measure.

Variations in support among various groups of the population nationally are as follows:

- Similar levels of support across social groups, among car owning and non-car owning households, and among men and women. There is slightly greater support among younger people, and those living in urban areas.

- Support is highest for the package in the congested South East (62% for, and +31% net support) and the West Midlands (63% for, and +34% net support); least in Scotland (49% for, and + 7% net support) and the North region (42% for and 42% against), where congestion is generally less of a problem and incomes are lower.

- Support is lowest among the 13% of respondents who travelled by car daily (51% for, and +6% net support), but it is correspondingly more strongly supported by less frequent car users and non-car users.

In virtually every grouping of the data, more people are in favour of such a package than are opposed to it.

**Survey 2 - Support among Londoners for a road pricing-based package**
As in the national survey, respondents were first asked in the NEDO study how acceptable they would find the introduction of a road user charge in London at the present time. The response for 43% said that they would find it either "Totally" or "Fairly" acceptable.

Second, they were asked how they thought the money raised from road user charging should be spent by showing them a list of possible items and asking them allocate 100 points among them. Overall, 38% of the revenue was allocated to improvements to public transport (26% in London, 74% nationally). Road improvements came next (25% overall), followed by

**Table 4.5 Most and least acceptable methods of road user charging in London.**

| Base: ALL | Most Acceptable | Least Acceptable | Difference |
|---|---|---|---|
| By adding the charge for road use onto petrol prices in London area | 30% | 32% | -2% |
| By adding the charge for road use onto parking charges in London area (car parks and parking meters) | 19% | 10% | +9% |
| Daily, weekly, monthly or annual area licences which allow you unlimited travel in London area after buying the licence | 24% | 9% | +15% |
| Meter in your car which monitors your journeys in London area. An itemised bill then sent to you (cf. telephone bill) | 15% | 26% | -11% |
| Meter in your car which accepts tokens or plastic cards (cf. phone card), bought in advance | 8% | 20% | -12% |
| Other | 2% | <1% | +2% |
| Don't know | 3% | 2% | +1% |

Source: NEDO (1991), Table 6

**Table 4.6 Support (% Very Much or Somewhat in Favour) by drivers and non-drivers for different restraint/control measures in Central London.**

| Restraint/Control Measures | Survey No. (A) | | Survey No. (B) | |
|---|---|---|---|---|
| | Whole Sample | Regular Central London Car Drivers | General Residents | Regular Central London Car Drivers |
| 1. Reduce the road space available to cars by providing more bus lanes and giving more space to pedestrians and cyclists | 65% | 47% | 69% | 53% |
| 2. Make everyone pay a fixed charge every time they drive a car into or through Central London | 47% | 48% | - | - |
| 3. AS FOR 2 - Except for certain priority groups | 55% | 57% | 46% | 46% |
| 4. Make everyone pay by the mile for driving a car in Central London, assuming that a suitable charging mechanism can be found | 30% | 29% | - | - |
| 5. AS FOR 4 - Except for certain priority groups | 37% | 35% | 34% | 29% |
| 6. Ban cars from Central London except for certain priority users, such as people who live in Central London | 39% | 23% | 53% | 41% |
| Very much or Somewhat in favour of at least one of the measures | - | - | 87% | 79% |

Source: Metropolitan Transport Research Unit (MTRU) Reports non-transport central government services (14%) and reducing the community charge (12%); 7% opted for reductions in the road fund licence.

Third, they were asked to assume that if the money raised from a road user charge would be spent in the way they proposed, how acceptable would they then find a road user charge? The percentage who found such a charge totally or fairly acceptable rose from 43% to 63%. It is interesting to note, however, that the percentage remaining opposed was very close to that found in the national survey (at 32% and 34%, respectively).

Some differences in the balance of views were found among various subgroups of the population. In particular, respondents in the professional/managerial social groups were more strongly in favour and skilled manual workers more strongly opposed to road pricing than average. Such a variation might be related to differences in education and awareness of the issues, or it might be an income effect. The skilled manual workers would be more likely to feel they could not afford the charges. In addition, some of the latter are self-employed (e.g. builders or electricians) and need a car or light van to transport tools, samples, etc.

#### 4.4.2 Charging Basis of the Scheme

The three related issues involved are:

- the principle behind charging;
- the area subject to charging; and
- the times of day subject to charging.

Linked to this are questions of exemptions for certain groups.

##### 4.4.2.1 Principle behind charging

In a study of Londoners' attitudes by NEDO (1991), respondents were shown a list of possible methods of road user charging, and asked which they would find most and least acceptable. Results are shown in Table 4.5.

Adding the charge onto petrol prices evoked strongest reactions, both for and against, but with a net negative effect.

Adding the charge onto car parking charges (+9% support), or Area Licences allowing unlimited travel during the designated period (+15%) were the most popular.

Two versions of electronic road pricing (one using pre-payment cards, the other itemised bills) in which charging was according to journey length were both rejected with equal strength. However, it is unclear whether this was a reaction against the technology, or against the more precise targeting of the charge that the technology would make possible.

A study of five West London boroughs (MTRU 1989) found between 30 and 55% support for road user charging, depending on the charging principles. Another study (MTRU 1990), covering two other London boroughs, resulted in between 34 and 46% support. Unfortunately, an Area Licence was not included in the options. These two surveys looked separately at the views of Central London drivers and others regarding a range of restraint measures. Results are summarised in Table 4.6, together with views on some non-pricing options for comparative purposes. Note that in survey [A] the first column includes **all** respondents, whereas in Survey [B] the General Residents represent a separate sample.

Table 4.6 shows that the option of re-allocating road space to "green" modes received the greatest support among the population as a whole, though much less so for Central London drivers. In other cases (apart from the Central London car ban), there was very close agreement between Central London drivers and the total population. Of the road pricing options a simple cordon toll scheme (whereby car drivers pay a fixed charge for each entry to the area), with exemptions "for certain priority users", was supported by 46% and 55% of those questioned. But support for a mileage-based charge for non-priority users dropped to 34% and 37%. Of the non-Central London driver sample, 40 to 50% were also in favour of a ban on cars in central London, except for those with special permits such as doctors and local residents.

Thus, for most options there was a surprisingly close agreement between the views of Central London drivers and the population as a whole, particularly for all the road pricing options.

#### 4.4.2.2 Views concerning possible exemptions or priorities

Support increases if the scheme includes exemptions for certain priority groups (see Table 4.6), but these groups have not usually been defined. An exception was a Consumers' Association study (1990), which asked respondents:

> *"Assuming there was a permit system to drive into or through central areas of larger towns and cities during busy times, which, if any, of the following groups should be given a permit?"*

The national response broadly clusters as follows: disabled drivers (89% in favour of giving them exemption); buses and local residents (84%); important goods vehicles and people running businesses inside the area (79%); taxis (68%); and a lower level of support for commuters (though still around half respondents were in favour of giving them permits). Although "through traffic" was not included as a category, implicitly it seems as though most respondents would have ruled out permits for this group.

Responses from those living in the London area were broadly in line with national views, with two exceptions:

- reduced support for entry by important goods vehicles and businesses (about 10% less, at 69% and 70%, respectively); and
- much reduced support for exemptions for car commuters, with only 36% in favour.

#### 4.4.2.3 Area subject to charging

In the London study, respondents were asked whether some form of road user charging should be introduced: now; only if journey times double or only if journey times treble; and whether it should be introduced in Central London, the Inner Suburbs, or the Outer Suburbs. The key findings were as follows:

- Road user charging should be introduced in Central London now, according to over half the respondents (56%).

- Support for the use of road pricing - now or later - declines with distance from Central London: even with a trebling of travel times, only 21% favour its introduction in Outer Suburbs, compared with 36% in Inner Suburbs, and 58% in Central London.

- Road pricing should not be introduced at all according to 31%, even if journeys took three times as long as at present.

#### 4.4.2.4 Times of day subject to charging

Little attitudinal research into the appropriate time periods for charging has been published, but it is worth noting that:

- Most schemes include uncharged periods (usually evenings and weekends), even though there may be traffic problems at these times. The exception has been Oslo, where the scheme operates 24 hours, seven days a week (which might contribute to its lack of popularity compared with other Norwegian toll schemes).

- There is a common perception in cities that the centre is busy all day, and that radials and suburbs have only peak hour problems, suggesting the possibility of differentiating charged time periods by area of the city.

### 4.4.3 Practical Feasibility

Once attention switches from issues of principle to those of practice, a number of concerns are expressed by the public about the practical feasibility of introducing road pricing. In a study in one London Borough by the MVA Consultancy (1988), those who objected to road pricing were asked why. The most common response was that it would be unworkable or impossible to enforce (expressed by 21% of respondents), well above issues of civil liberties (14%) and equity (13%).

The main concerns about practical feasibility in various discussion groups, and discussed further in Section 4.5, include:

- Drivers will not be deterred by higher prices and there will still be congestion;
- Technology will not be reliable;
- Technology will be unenforceable;
- Serious local problems will occur at the boundary of the area (caused by diverted traffic and parking); and

- The existing public transport services may not be able to cope with a perceived influx of car drivers.

#### 4.4.4 Views of Businesses

Business organisations such as the Confederation of British Industry have come out in favour of road pricing in London. There appears to have been much less attention paid in general to the views of industry and commerce than to the views of the public, possibly because the former groups are generally effective at lobbying and presenting their viewpoint to government. Consequently there is very little evidence of attitude surveys of industry and commerce groups.

Research carried out in London by the Metropolitan Transport Research Unit found that people who came into Central London by car were either daily commuters (usually with a company-provided car parking space), or those who came in less frequently by car, on average, but needed to carry bulky supplies, materials, samples, etc. In addition, there are light vans and heavier goods vehicles used for deliveries, and the clients and customers who arrive by car (ranging from ordinary shoppers, to buyers, etc.). The impression gained was that most of the groups actively involved in business activities would be willing to pay to drive into Central London. Some would actively welcome the opportunity to pay for a faster or more predictable journey.

When questioned about the form of charge, there was much less support for a mileage-based rather than a flat charge in Central London, both among business people and the public in general. This was because the vehicles that are used all day, and would pay much more under a mileage charge, are the ones that are perceived to be "essential traffic" (e.g. goods, deliveries and service engineers). On the other hand, the "optional" commuter cars would accumulate less mileage in Central London, would thus pay much less and so be less likely to be deterred. However, the recent CIT Supplementary Report on Road Pricing (Chartered Institute of Transport 1992) suggests that even under a mileage-based charge, certain groups such as light vans would on average be better off with than without a road pricing scheme.

A Dutch study into employers' reactions to road pricing and congestion (reported in Vrolijk and Kleijn 1990), looked at how businesses would be affected by a charge on business journeys by car made on the inter-urban network during peak periods. It covered all business travel, including business meetings, maintenance and service activities, customer visits and various administrative activities. Company executives were asked whether they would support the introduction of regional road pricing, and a bare majority were favourable towards the idea: 52% were Very or Moderately Positive, and 38% were either Moderately or Very Negative. However, faced with a choice between road pricing or increasing congestion on the inter-urban road network, two-thirds opted for the road pricing scenario.

In an unpublished survey in Osaka, Nitta (1991) carried out a mailback survey among businesses in the central city area. Asked if they would support the introduction of a Road Pricing scheme, 48% said they would (with 30% opposed), which is about the same proportion as the residents questioned in a related survey in Osaka (see Section 4.3).

Overall, therefore, the limited indications are that businesses appear to be at least as supportive of road pricing as - and in some cases more so than - the public at large. There is also some evidence from the Oslo toll ring that employers are prepared to assist employees with the costs of the tolls. In one attitudinal survey, one in three households had a season ticket for the toll ring, and over half of these subscriptions were paid by employers.

## 4.5 How Can Road Pricing Be Made More Acceptable?

Although there is a strong and increasing recognition of the need to take action to deal with the growing traffic-related problems, particularly in urban areas, it is also evident that road pricing is not a very popular measure. It has 50-60% support at best in the UK, and quite strong opposition among a sizeable minority.

Even in Norway, where revenues were both hypothecated and matched with Central Government funding, the toll rings were not very popular. Larsen (1988) reports that in Bergen a poll taken on behalf of the local newspaper just before the toll ring was implemented found that 54% of those questioned were opposed to the toll ring, and only 13% were unreservedly in favour. The remaining 33% were either undecided or for or against with reservations. A second poll taken a year after its introduction found quite a large swing in opinion, however, with 50% in favour and only 37% opposed. A similar pattern has been found in Trondheim, though in the latest opinion surveys in Oslo (April 1991), 57% were still opposed to the scheme.

A number of issues need to be addressed if road pricing is to receive maximum public support, though in attempting to meet some of these points, the benefits of road pricing might become rather diluted.

**1. Make sure the objectives of the scheme meet the main public concerns**

As noted in Section 2.1, transport pricing may have a wide variety of objectives. A road pricing scheme is most likely to succeed if it addresses the traffic-related issues of most concern to the public, **and** is seen to be the best way of tackling them. In different circumstances, these issues might relate primarily to congestion, environmental factors, or the need for better mobility per se.

This will have implications for the type of charging scheme that is introduced. For example, congestion reduction (other things being equal) can be equated with a reduction in vehicle miles travelled at peak periods. In terms of $CO_2$ emissions however, reductions in travel-mileage at all times of day may be desired. In cities such as Los Angeles that are very concerned about air quality, limiting the number of trips is important too, because of the high proportion of pollutants that are contributed by cold starts in car stock that are equipped with catalytic convertors.

**2. Revenues should be hypothecated and alternatives provided**
The three points are:

- In many situations, transport alternatives do need to be improved (e.g. better bus services, safer routes for walkers and cyclists), before people perceive a viable alternative to car use. Hypothecated revenues make this finacially possible, and imply a commitment to doing so.

- There is much more resistance to paying "another tax" than paying a direct charge for road use where the charge is seen to buy something.

- As in the Norwegian situation, if road user charging is the **only** way of raising revenue for the transport improvements that are seen as important to the local community, then it may be possible to start charging for road use, even without majority public support.

Although the Singapore government is formally opposed to hypothecation, nevertheless large sums have been invested in better public transport and road systems, so that alternatives to car use to the CBD are readily available.

**3. The scheme should be kept as simple as possible**
Although this has its disadvantages, simplicity seems to be important in the public mind in two respects:

- it will be easier for drivers to understand the system and calculate the costs of making journeys more easily; and

- it implies simpler technology, with less scope for errors (although this in fact may not be true).

However, simplicity is also likely to mean a less efficient or equitable solution, and would probably have severe boundary problems.

**4. Technological issues should be carefully considered**
Aside from the concern that the technology might not work, there are worries about invasion of privacy arising from:

- the regular monitoring of vehicles, either to calculate charges or for purposes of enforcement; and

- the notion of having a meter in the car may be seen as analogous to the "spy in the cab" reactions when tachographs were first introduced.

It is possible that these might diminish following successful demonstration of the equipment, especially if they were viewed as a more convenient way of paying, rather than as an imposition from government.

**5. Issues of equity need to be addressed**

These will probably involve a mixture of debate (e.g. pointing out the potential benefits that low income travellers would gain from public transport improvements paid for from hypothecated revenues), plus efforts to address the issues of concern, without diluting the effectiveness of the scheme too much. Dilution can arise in two respects:

- Dilution of revenues, if many vehicles are exempt or pay reduced charges; and

- Dilution of the congestion-reduction benefits if many vehicles are exempt, leading to the need to restrain other traffic to a greater extent to compensate.

An equivalent dilution issue arises in relation to parking, where the existence of substantial Private Non-Residential means that restraint is focused more sharply on those parking in public spaces.

The most obvious case for straight exemption in the private motorist group is that of disabled drivers, but there are likely to be pressures for some concessions from local residents and possibly businesses. General issues of equity could be addressed in several ways. For example:

- Charges might be related to engine size, so providing cheaper travel for those willing to have small vehicles.

- Every driver could be given a certain number of free units per month; if these were tradeable, there could be direct redistribution of income if poorer drivers were prepared to sell their units.

Another aspect of equity is in relation to commercial vehicles. Some members of the public favour an Area Licence charge because it would affect to a lesser extent goods deliveries and other essential traffic. If it was relatively high it would discourage peak period car commuters and through traffic, which are generally viewed as the lowest priority users of congested urban road space.

It may seem perverse that high mileage vehicles should be "protected" from high charges but, in very congested conditions, high mileage is associated with essential movements in most people's minds.

## 4.6 Summary

Issues relating to the externalities caused by traffic, and to the funding of road improvements and maintenance, are generally of considerable concern to people. Governments are likely to gain more from encouraging than discouraging public debate on these issues.

Proposals for new sources of funding are generally greeted with suspicion. However where problems are perceived to require urgent attention, and public funds are acknowledged to be in short supply, there is scope for introducing new forms of road user charging by ring-fencing funds for transport and environmental improvements.

Issues over which people may feel sufficiently strongly to accept some restrictions on behaviour or increases in charges, often include road safety and the environment. Although there are many complaints about urban congestion, drivers are very resistant to the idea of being charged for it, although use of the funds to improve public transport services may reduce such resistance. Direct charging for new road construction is, however, being increasingly accepted by drivers.

In addition to hypothecation, it is clear that the successful introduction of new forms of road user charging requires that the issue of complementary measures be thought through, and that government explains carefully why existing alternative charging mechanisms are either inefficient, insufficient or inequitable.

# 5. RESPONSES TO ROAD PRICING

## 5.1 Introduction

A number of different possible effects can be identified at different times after the introduction of a road pricing scheme. It is not possible, though, at this stage to specify the precise effects which would occur for two reasons. First the effects are bound up with the nature of the charging schemes, other transport strategies are pursued and the redistribution of the revenues raised. Second, the longer term effects on the relationship between transport and land use are uncertain. Even the short-term effects can largely only be derived from first principles, since there is little practical experience of road-pricing schemes which cover a network. Nonetheless, the possible effects of road pricing in the short-, medium- and long-term are examined, and the macroeconomic effects and distributional impacts are considered here.

The differential impacts of different road pricing schemes are first considered briefly. Specifically, any scheme which did not relate the price to the use of particular road space at particular times might introduce further distortions. For example, an area licensing scheme (ALS) which gives unlimited travel in the area once the fee has been paid will not give the same result as a congestion pricing scheme. ALS will necessarily lead to sub-optimal consumption patterns, since those who pay will be encouraged to travel too much, and those who would only make a short journey but choose no longer to enter the area lose out. Quantification of the effects is therefore inextricably linked with the charging basis of the scheme.

Use of the revenues will also affect the outcome of a road pricing scheme. Benefits may well be contingent on an improvement in public transport to cope with the flows of people priced off the roads. This may require subsidy. Additionally, it may be necessary to improve roads outside the pricing area. For example, ring roads round the area may be improved to carry the increased through-traffic which now travels round the boundary.

## 5.2 Short-term Effects

If the introduction of a road pricing scheme causes the generalised cost of travel to a city centre to rise, a number of effects can be identified which may appear over time. In the short term, some individuals would pay the toll and continue to drive; some others would switch modes to make the same journey; and others would do something else, for example change the time of travel to avoid the charge, change the route, change journey frequency or change destination. If road pricing has increased overall travel expenditure of travellers, then discretionary trips may be re-scheduled to fit in with trips to work to avoid road pricing costs. For example, people may sequence their activities so that a shopping trip, previously made separately, can be incorporated within the journey from work to home.

Some evidence on the effects of an area licensing scheme is available from the Singapore experience, reported in the Annex to May and Mackie (1989). In Singapore, there was a decrease of 73% in the number of cars entering the charging area in the morning peak over the first six months of the scheme in 1975. By the early 1980s, traffic levels were 64% of the pre-scheme flows.

Some of this decrease came about because drivers who previously drove through the restricted zone diverted around it. Similarly, a portion of it was brought about by drivers travelling earlier; there was a 23% rise in the volume of cars travelling before 0730 hours although the volume before ALS was introduced was small relative to the peak hour flows. Other drivers changed mode. Before the ALS, about 56% of work trips were made by car; but by 1983 this had fallen to 23%. The main gainers were the buses, whose share of work trips rose from 33% before ALS to 69% in 1983. The absolute number of car pools also grew during the restricted hours, as did their number as a proportion of all cars, from less than 7% to 37% by the end of 1975.

## 5.3 Medium-term Effects

In the medium term, employees may seek to change jobs to one nearer home. This may further alter the use of various modes. In response to this, firms may increase pay or relocate to areas outside the road pricing zone in order to retain scarce skills. Presumably whichever course of action is more profitable will be followed. Relocation will change industrial land values, which will tend to dampen the scale of the effects. In the longer term, households may relocate.

## 5.4 Changes in Land Use and Activity Patterns

The relationships between transport and land use are rather indirect when compared with, for example, the effect on demand for a mode of the change in the price of that mode. The relationship is also two-way: changes in transport provision lead to changes in travel patterns and, eventually, changes in activity and land use; and changes in activities and land use cause changes in travel patterns which eventually impact on transport provision.

Modelling this relationship has severe problems. Planners have typically concentrated on the allocation of the use of land rather than changes in land price. Sufficiently detailed evidence about land values tends therefore not to be available, and the actions of economic agents which would have occurred in a market system have been constrained by the planning process. Even if these difficulties were superable, it would remain difficult to separate out the transport change effects from those which would have happened anyway. At a methodological level, the problem is essentially one of using comparative statics to understand a dynamic situation where understanding the transition path may be more important than characterising equilibrium which is, anyway, transient.

### 5.5 Differential Impacts

The introduction of road pricing will have different effects on different types of user and different classes of vehicle. Commercial vehicles in particular would benefit from shorter journey times, more predictable traffic conditions and more kerbside space for loading and unloading. Offset against these benefits are, of course, the user charges. An example of the potential effects of road pricing in London (CIT 1992) suggests that light goods vehicles in particular would benefit, while costs and benefits for heavy goods vehicles would be of a similar magnitude.

By and large, businesses which generate a large amount of traffic for relatively low unit turnover (for example DIY stores or mass retailing) would be encouraged to relocate to a low or no pricing area, whereas high value-added activities (quality/specialist shops, hotels, some office-based firms) would be encouraged to move into the CBD. However, the charges are likely to be small relative to turnover (CIT 1992) and there would therefore only be gentle pressure for change. Although these changes are difficult to predict, not allowing for them will overstate the changes in mode split that would result from road pricing.

### 5.6 Macroeconomic Effects

The consensus view appears to be that changes in transport have little effect on the urban economy overall, but lead to shifts of activity within the region concerned (Webster and Bly 1980). So road pricing will not necessarily inhibit economic growth. However there may be an impact on the rate of price inflation. This impact depends on what happens to the revenues collected. If all revenues were rebated to users through reductions in vehicle excise duty or fuel tax or used to reduce other indirect taxes, then the inflationary effect should be zero. If, though, the revenues were retained by the government to finance an increase in spending or to reduce direct taxation, there would be a once and for all increase in the general price level. It was estimated that a road pricing scheme in London would raise prices by 0.1% (May and Mackie 1989).

### 5.7 Distributional Impacts

If road pricing is introduced, there will be gainers and losers. Car users with high values of time may gain because they value the reduction in congestion more than the price they have to pay. People who switch from car to public transport are likely to be worse off; if they are utility (benefit) maximising when using the car, another mode must be less preferred, although the losses may be offset to some extent by any improvements which may be possible in public transport. Public transport users will gain, because shorter journey times and greater reliability will result from road pricing. If the switch of people from car to public transport is sufficiently great, operators will be able to provide higher service levels and/or lower fares, thus providing even more benefit. The general pattern is for higher and lower income groups to gain and the middle group to lose.

Again, though, this depends on what happens to the revenues. If general taxation is reduced across the board in a distributionally neutral way, the above pattern will persist. However, general taxation could be reduced in a manner to minimise the impact on middle income groups. Indeed it might be possible to compensate specifically those losing by the introduction of road pricing, for instance by reducing or abolishing annual licence duty for those who have a road pricing meter fitted to their cars. Alternatively, using the revenues to subsidise public transport or reduce local taxation will tend to be progressive. The precise distribution effects will also depend on the nature of the scheme introduced. If free transferable permits are issued (a few to all users, or even many to low income users), the ability of poor car users to sell their permits will reduce their losses.

## 5.8 Elasticities

The simplest way of predicting the effects of road pricing would be through knowledge of "own price" and "own journey time" elasticities for all modes of transport likely to be affected. It should be stressed however that these elasticities will simply reflect the amalgam of the effects considered above for whatever time scale is appropriate to the study in question, and they will still miss some forms of reaction such as the re-timing of trips.

Nevertheless we have undertaken a brief study of the evidence on elasticities currently available from the number of very good recent surveys of the available evidence on demand elasticities for transport (Goodwin 1992; Oum et al. 1990, 1992; Fowkes et al. 1992). Only the most important and relevant published evidence is discussed here, while attempting to obtain a consensus from the disparate values reported.

The elasticities reported have been obtained from many different methods: time-series, cross-sectional, before-and-after, discrete choice models. Some estimates refer primarily to commuting trips (especially in the case of London). The question of transferability must also be taken on board since, for example, own-price elasticities of car use in London have been found to be lower than elsewhere. There are also some difficulties concerning the output variable as it is not always clear whether authors have used trips or passenger kilometres. This need not matter too much if average trip length can be accepted as broadly constant over time, but some forms of road pricing will clearly reduce trip lengths. For car travel the "price" is the petrol cost plus any tolls or parking charges, whereas for public transport modes the price is the fare.

The evidence available for urban, inter-urban and freight transport is presented using elasticities with respect to price. Generalised cost elasticities are generally not available, but could be determined by making one or two assumptions. For example, a reasonable assumption might be to take the price elasticity of demand for urban buses to be of the order of -0.4. For some users bus fares may constitute half the generalised cost (the remainder being mainly time related). For these users the elasticity of bus travel with respect to its generalised cost is -0.8. This is because an x% increase in generalised cost is equal in absolute terms to a 2x% increase in fare. Another example to consider would be car usage, where elasticities with respect to petrol costs have generally been estimated at about -0.2. For drivers whose petrol costs constitute only a fifth of the total time and money (generalised) costs, then the generalised cost elasticity is -1.0. In general, the procedure is merely to adjust up elasticities by their proportion of generalised cost.

## 5.9 Urban Transport (Table 5.1)

Fowkes et al. (1992) found most studies of "traffic levels" (either vehicle kilometres or number of trips) reported elasticity of demand for car, with respect to petrol price, of the order of 0.1 to 0.3. These are clearly short-run values. Similar elasticities were found from studies which looked at other car costs (such as tolls or parking charges). It is not possible from these results to distinguish between urban and inter-urban trips. Note that petrol cost elasticities understate the total money cost elasticity, which would include also parking etc. The suggestion is that price has some effect on road traffic but that its effect is rather limited, at any rate in the short term.

The cross-elasticities are much less secure, since they have been derived from fewer sources. Nash (1982) cites Lewis' work in London, which gives car-use elasticity with respect to public transport prices of 0.06 in the peak; the figure of 0.14 comes from Kemp's work in Boston. Dodgson (1990) reports that Glaister and Lewis assumed very low cross-elasticities of car usage with respect to public tranpsort fares in their METS model. To two decimal places the elasticity with respect to train fares was taken to be zero, while that with respect to bus fares was taken to be 0.01. In other words, changes in relative prices cause some diversion between modes, but the effect is small. A warning should be given, however, that cross-elasticities tend to vary more sharply with existing situations and market shares than do own elasticities, so that these values should not be regarded as readily transferable.

**Table 5.1 Urban short-run own-price and cross-price elasticities of demand.**

<table>
<tr><th rowspan="2">Price of</th><th colspan="3">Demand for</th></tr>
<tr><th>CAR</th><th>BUS</th><th>TRAIN</th></tr>
<tr><td>CAR</td><td>-0.1 to -0.3[1]</td><td>+0.62[2]</td><td>-</td></tr>
<tr><td></td><td></td><td colspan="2">+0.34[4]</td></tr>
<tr><td>BUS</td><td>+0.01[2]</td><td>-0.4[4]</td><td>+0.2[2]</td></tr>
<tr><td></td><td>0.14[3]<br>0.06[3]</td><td></td><td></td></tr>
<tr><td>TRAIN</td><td>0[2]</td><td>+0.1[2]</td><td>-0.5[4]<br>-0.8[4]</td></tr>
</table>

Source: [1] Fowkes et al. (1992) [2] Dodgson (1990)
[3] Nash (1982) [4] Goodwin (1992)

There is a vast literature on the elasticity of demand for bus transport with respect to bus fares in urban areas. The rule of thumb used has traditionally been an elasticity of 0.3. Goodwin (1992), however, updates this to 0.4 on the basis of over 40 different studies. Again the cross-elasticities are less common. Dodgson (1990) reports an elasticity of bus use with respect to underground fare of +0.1, but much lower elasticity with respect to British Rail fare. He cites a much higher elasticity of bus use with respect to car costs of +0.62, based on work in six American cities. This seemingly large figure is probably because of the minor role played by bus; relatively few car drivers switch to bus use, but they are large relative to the number of existing bus users. Goodwin obtains an average public transport use elasticity with respect to car cost of +0.34.

The own-price rail elasticities are 0.5 for London Underground and about 0.8 for a number of other suburban rail services, as reported in Goodwin (1992). Elasticity of demand for underground with respect to bus fares was reported as +0.2 in Dodgson. Note, though, that other studies reported in Webster and Bly's study (1980) suggest that the rail own-price elasticity in urban areas is rather lower than those given here. Note that, in general, the nature of the models used will affect the elasticities. Own-price elasticities derived from mode-split models will be smaller than "ordinary elasticities" conversely, cross-price elasticities from mode-split models will be larger than ordinary cross-elasticities.

## 5.10 Inter-Urban Transport (Table 5.2)

Data on inter-urban services are much less common than for urban transport. Reliable own-price elasticities are available, but most cross-price evidence is from rather old data (1961-76) in Canada analysed by Oum and Gillan (1983). Many of these elasticities seem to be of the wrong sign, a problem which is also apparent in Lave's work cited in Nash (1982).

**Table 5.2 Inter-urban own-price and cross-price elasticities of demand.**

| Price of | Demand for | | | |
|---|---|---|---|---|
| | CAR | BUS | TRAIN | AIR |
| CAR | -0.1 to -0.3[1] | | | |
| BUS | +0.05[2] | -1.45[3]<br>-1.1[4] | -0.7[3]<br>-0.8[2] | -0.01[3]<br>+0.8[2] |
| TRAIN | | -0.35[3] | -1.1[5] | +0.03[3] |
| AIR | | -0.08[3] | +0.3[3] | -1.6[2] |

Source: [1] Fowkes et al. (1992); [2] Nash (1982); [3] Oum and Gillan (1983); [4] Douglas (1987); [5] Owen and Phillips (1987)

The car own-price elasticity is discussed in Section 5.9. Long-distance buses have been found to have elastic demand in Canada (Oum and Gillan, 1983) and in Britain (Douglas, 1987), and rail elasticities are thought to be about -1.1 (Owen and Phillips, 1987). Clearly, these results are sensitive to the balance of traffic (with much lower elasticities for business trips) and the availability of alternative modes.

A study to discover the magnitudes of cross-elasticities in the inter-urban market is due to commence at the University of Leeds, Institute for Transport Studies in 1993. It is hoped that this study will fill the gaps in existing knowledge.

## 5.11 Freight Transport (Table 5.3)

A number of studies have examined the price elasticity of demand for freight of various types. In Table 5.3 the aggregate results summarised by Oum et al. (1990) are reported with the warning that the characteristics of individual commodities/ shipments/ flows/ customers will influence the figures in different elasticities. In the UK, many flows are below the 300km threshold at which rail becomes competitive, and so, although sensitive to price, many firms find that the market dictates the price of transport, and all they can do is shop around for the best deal. Indeed, work by Fowkes et al. (1989) shows that service quality attributes, such as speed of delivery and reliability of delivery at the required time, are as important as price. For many firms, transport costs are a sufficiently small element of total costs that they can let service quality requirements dictate their choice of mode. Therefore, the higher values in the elasticity ranges quoted by Oum et al. will only apply when there is effective competition between modes. In the urban market in particular, where traffic is captive to road, the elasticities are likely to be much lower.

**Table 5.3 Own-price elasticities of demand for freight transport (all commodities) in situations where shippers face a choice.**

| TRANSPORT MODE | PRICE ELASTICITY |
|---|---|
| RAIL | -0.3 to -1.2 |
| TRUCK | -0.5 to -1.3 |
| INLAND WATER | -0.3 to 1.5 |
| AIR | -0.8 to -1.6 |

Source: Oum et al. (1990), taking their reported quartiles of elasticities

## 5.12 Summary

The evidence considered suggests that urban transport prices and journey times do have some impact on both the volume and mode of traffic, although the effects of a moderate price change are not dramatic. For example, for urban road pricing to have any appreciable effect in reducing traffic levels the charge would have to greatly exceed current petrol costs. For particular situations it would be difficult to say even roughly what the multiple should be, and it will in any event vary from situation to situation.

In the inter-urban market, the literature suggests that the sensitivity of both passenger and freight traffic to price and journey time is a great deal higher. This may not be so in New Zealand where there are fewer modal alternatives and fewer untolled routes.

CIT (1992) lists the impacts of road pricing in the context of a stand-alone scheme in London. They are reproduced verbatim:

(a) Overall reductions in vehicle miles travelled would be small, with effects concentrated in the peak periods and in particularly busy areas;

(b) In London, rail use would go up by only 2% or 3%;

(c) Higher income households would tend to be affected most as they own more cars and therefore use cars more;

(d) Professional and managerial workers would tend to be affected most as they drive more during peak periods;

(e) Low income groups, children, women and the elderly would benefit most from higher bus speeds as they use buses most. Bus operations would also be better off;

(f) While residents in the pricing area would tend to have to pay more in road pricing charges, they would benefit most from reduced congestion, better bus services and less environmental intrusion;

(g) Commercial traffic should gain particularly from road pricing as they will save on costs from reduced congestion; and

(h) Retail outlets in the pricing area should also benefit from a better environment and easier deliveries.

# 6. PRICING AND OTHER POLICY MEASURES

## 6.1 Pricing and the Objectives of Transport Policy

This report is essentially concerned with the pricing of land transport and has dealt so far with various aspects of this subject:

- Principles that should be followed;
- Mechanisms for putting these principles into practice;
- Public attitudes toward transport pricing, specifically towards charging for the use of private vehicles;
- Likely responses that may be engendered by the application of defined pricing principles; and
- Magnitudes of responses in the form of elasticity values.

However, it is important that pricing policies are not seen as a panacea, that in isolation they are seen as providing the solution to whatever transport problems are currently of greatest interest, and that other decisions related to transport can be ignored. Pricing policies are a means to an end, not an end in themselves.

Pricing policies for transport therefore need to be part of a co-ordinated policy package which also embraces land use planning policies, policies towards investment in, and management of, the transport system. A series of objectives towards which this policy package might be directed has recently been suggested (Buchan 1992). These quality-of-life objectives (given in Table 6.1), translated into operational objectives, set a policy framework for policy making and scheme design, influencing conclusions on, for example, the mix of investment, regulation, pricing or operational control.

**Table 6.1 Quality-of-Life objectives for transport.**

*Accessibility*

- To encourage and provide a transport system which will give people access to work places, to shops and public buildings, to industry and commerce, to facilities like doctors' surgeries, to centres for recreation and entertainment, to other goods and services, and to one another;
- To co-ordinate transport planning with land use and economic development planning with the aim of minimising the overall need to travel.

*Environment*

- To protect and enhance the quality of the environment as an objective in its own right and not merely to minimise the damage resulting from transport developments;

- To set quality standards which should apply throughout the country, not just in certain areas;

- To ensure that transport policies contribute towards reducing environmental damage nationally and worldwide;

- To set clear constraints which prevent the destruction of irreplaceable environmental assets.

*Economic Developments*

- To create patterns of transport infrastructure which support sustainable economic development at local and national levels;

- To encourage research, innovation and technological progress both in manufacturing for, and in the operation of, the transport industries;

- To regulate the transport industry itself to provide reasonable pay and conditions and fulfilment at work.

*Fairness and Choice*

- To improve freedom of choice of destination and mode for everyone, tackling the inequalities that currently exist;

- To ensure that a major part of benefits from the design and operation of the transport system are distributed to those who are most in need of them.

*Safety and Security*

- To reduce the risks and fear of personal injury, assault and harassment on all modes of transport (including walking);

- To reduce the number, risk and level of severity of road traffic accidents for drivers, passengers, pedestrians and cyclists.

*Energy and Efficiency*

- To meet the accessibility requirements of residents, visitors, industry and commerce at the lowest resource cost;
- To minimise consumption of non-renewable sources of energy;
- To reduce congestion, and encourage transport efficiency.

*Accountability*

- To give people an unequivocal right to participate in the transport planning process;
- To establish mechanisms for people to exert influence through local democratic means over the decision-making process for transport schemes;
- To set up mechanisms by which users can directly influence the quality of service offered by the transport providers.

*Flexibility*

- To make the system responsive to changes in the external constraints operating on the transport system, and to new understanding about its impacts.

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While the components of a package of complementary measures will vary from place to place, a growing consensus (CIT 1992) suggests they should include the following:

- Improvement in the quality and capacity of the public transport system, particularly modern light rail or other high capacity fixed track systems. There may also be more extensive bus priorities or improved park and ride facilities. These measures are required to provide an acceptable alternative for displaced private vehicle users.
- Environmental management schemes, including traffic calming to reduce traffic flows and speeds in sensitive areas, generally tilting the balance back towards residents, pedestrians and cyclists and away from vehicles.
- Pedestrianisation of shopping streets to enhance the environmental quality of central city areas.
- Advanced traffic management systems, including automatic driver guidance and integrated traffic signal control, to get the most effective use out of the existing road network. This no longer means simply maximising vehicle-throughput but giving

priority to the more important elements of the traffic stream such as buses and delivery vehicles and also improving safety standards.

- A road pricing regime, that provides a real test of willingness to pay and therefore gives an accurate indication of the values placed by different road users on different types of road space at different times, will clearly indicate where there is an economic case for additional road (or other transport) capacity. This is likely to result in the selective improvement of the road network to eliminate costly bottlenecks and increase capacity for demands that cannot be met by public transport.

Other policy measures which may complement pricing policies in tackling urban transport problems and achieving these objectives are briefly commented on under two headings:

- Planning policies: recognising that the demand for movement is a derived demand having value in enabling activities to take place at physically separate locations. There will be advantages to society if, for a given level of economic or other social activity, the amount of travel can be reduced.

- Regulation: there is some support for the notion that some environmental impacts of traffic are so damaging that it is inappropriate to value them in money terms and to price for them. Regulation may be more appropriate in these cases.

The range of traffic management measures, other than pricing, which may be used to bring network demand and supply better into balance is discussed more fully in Section 7 of this report.

## 6.2 Planning Policies

Planning policies consistent with the quality-of-life objectives put forward in Table 6.1 can be summarised as:

- Providing access to the facilities necessary and desirable for our daily activities, and

- Co-ordinating transport with land use and development planning to minimise the overall need for travel.

The value of planning policies which minimise the amount of travel required to fulfil activities was pointed out by Thomson (1977) and has recently been repeated by James and Pharoah (1992):

> *"A short walk trip is the highest achievement of urban transport planning. Obviously it is not possible for all activities to lie within walking distance, but it is possible by bad planning for the great majority to lie beyond walking distance."* (Thomson 1977)

> *"The fundamental objective of the spatial aspects of planning should therefore be to create settlement patterns which allow people to have better lives with less traffic."* (James and Pharoah 1992)

Adams (1992) has forcefully expressed the need to reduce the demand for travel, using land use planning and other policies:

> *"The main objective of any transport policy that purports to be intellectually, morally and environmentally sustainable should be to reduce the* ***demand*** *for motorised transport; merely stopping growth will not suffice, ........... The challenge now is to reverse the process by which we have become dependent on an unsustainable level of mobility. The skills of transport planners should be turned to the task of "trip degeneration" - reducing the length and number of motorised trips".* (Adams 1992)

### 6.2.1 Access Planning

The need is to provide for accessibility - to facilities, by private car and by other modes including public transport, cycling and walking, for all sections of society - rather than for mobility which encourages increased volumes of travel (numbers of trips, trip lengths) principally by private cars. Germany has been described (by Roberts 1992) as the arch-mobilisers making substantial investment in autobahn construction in pursuit of a long-standing objective that no house should be more than 5km from an autobahn. This concentration on mobility may now have been overturned in pursuit of a commitment to reduce $CO_2$ emissions by 30% from 1987 levels by the year 2005.

The "Netherlands Travelling Clean" study found that to achieve environmental targets, 90% of all non-work trips (including commuting trips) made by car would need to transfer to other modes. To achieve this required investment in public transport and reduction of travel distances. To reduce travel distances "mobility" was redefined as "many destinations in close reach".

Added weight has been given to the importance of reducing travel distances by May (1990) who has shown that, in the UK over the last twenty years, growth in average trip lengths has contributed more to growth in total travel demand than growth in the number of trips.

Journey lengths over the last 20 years have been increasing. This is associated with a tendency to move away from those modes of transport which are ideally suited for short travel (i.e. cycling and walking), towards motorised modes (May 1990). It is also the consequence of land use changes which have promoted lower density suburban and "out of town" development. And there is an increasingly wealthy society where leisure, linked to travel, is a growing part of most people's lifestyles. While such changes are clearly important in generating additional travel demands they have not been researched in order to establish whether the perceived lifestyle benefits could be obtained with a smaller overall travel requirement.

### 6.2.2 Land Use Planning

The relationship between land use and travel demand is currently being studied in the UK, independently by TEST and, separately, on behalf of the Departments of Transport and the Environment.

Densities of development are being questioned, with low-density, car-dependent, urban sprawl being criticised on sustainability grounds. Traditional development patterns, with single land use developments separated from other land uses, often by some distance, are more likely to generate car trips than mixed use developments.

Cervero (1988) cites a study carried out by the US Institute of Transportation Engineers which found that mixed land use developments in Denver reduced trip generation rates by as much as 25%.

The new town of Almere near Amsterdam in the Netherlands provides an example of new urban development based on a hierarchy of transport modes and economic functions. In this concept daily needs should be met within walking distance, while employment and more specialised services should be located within reasonable cycling distance, or at a location where bus or train routes are focused. Neighbourhoods are arranged around infant schools, local shopping and health facilities, and provided with pedestrian routes to allow access. Larger shopping centres, schools and employment areas are within reach of a dense network of cycle tracks, and of a segregated system of bus routes which stop no more than 400m from any home. Bus and cycle routes give access to railway stations, and thus to Amsterdam. Cars are restricted to a small number of roads, often accessing houses from the rear with the normal "street" being for cyclists and pedestrians only (James and Pharoah 1992).

Recent developments in out-of-town shopping centres and larger, centralised health and education facilities are being questioned as they encourage mobility at the expense of accessibility.

Out-of-town shopping centres are normally accessible only by car and, insofar as they weaken traditional urban shopping centres, will encourage further transfer to longer trips and to trips by car. They will substantially reduce accessibility for those without access to a car. Such centres are now being legislated against in France and Germany,

An alternative to legislating against such developments is to charge developers for the full costs they impose on the community in increased infrastructure capacity. In the UK, for example, the Department of Transport is currently consulting on proposals to amend and augment its policies on developers' contributions to those highway works which are required as a result of proposed developments. The three elements to the proposals are as follows:

- where the relevant section of road is already at or above a defined capacity and there is no scheme in the roads programme to remedy this, a developer would be required to pay the full costs of the improvement made necessary by his development;

- where the relevant section of road is not yet at capacity but might become so within the life of the plan, taking account of the combination of general traffic growth and the traffic generated by potential developments, and there is no scheme in the roads programme to remedy this, each developer would be required to pay a share of the cost of the improvement equivalent to the share of the critical traffic growth for which his development would be responsible; and

- where there is a scheme in the roads programme the need for which would be brought forward if the potential developments went ahead, the developer would pay a contribution which would make neutral the effect on the roads programme of the advancement.

## 6.3 The Sustainability Argument for Regulation

In their report Pearce et al. (1989) argued convincingly for progress to be made in valuing the environmental impacts of transport infrastructure and traffic, and explained the concept of "sustainability" as a framework for setting values. The approach to sustainable development adopted in their report is called the "constant natural capital" approach. Its basic principle is that the next generation should be bequeathed an amount and quality of wealth at least equal to that inherited by the current generation. The broad concept of "wealth bequest" needs refinement. It comprises man-made and natural capital. Two rules built into the concept of sustainable development in respect of natural capital are:

- Irreversible losses of environmental assets are to be avoided; and

- The stock of environmental assets as a whole should not decrease.

These rules can be justified on the grounds of:

- Inter-generational equity;
- Intra-generational equity, particularly in respect of poorer countries;
- Resistance to stress and shock; and
- Risk aversion.

If this concept of sustainable development is accepted, the case can be made for regarding some environmental limits as binding constraints. The recent SACTRA report (1992), for example, identified the following as classes of environmental effects which cannot sensibly be valued in money terms:

- Potentially catastrophic changes in global conditions, from damage to the ozone layer or the greenhouse effect;

- Unique or sacrosanct environmental assets, where political judgement is required in assessing their loss; and

- Irreversible cumulative impacts which are felt by future generations; and where it seems wrong that the values of the current generation should be imposed on those future generations who may not share them.

To these can be added a variation on the first category, again concerned with potentially catastrophic change to the global environment. Given our current lack of understanding and our inability to predict fully the environmental consequences of policies, caution is needed in respect of actions which may have unknown environmental impacts.

In these cases there will be an argument for regulation to prevent the degradation of the environment by:

- Setting a target for vehicle emissions and limiting the traffic flow as necessary (by pricing policies perhaps or by investment and management policies) to ensure the target is not exceeded;

- Preventing designated sites - of outstanding natural beauty or special scientific interest, of archaeological significance or religious significance, etc. - from damage by transport infrastructure schemes or traffic; or

- Controlling the transport-related consumption of environmental assets to ensure stocks are maintained and irreversible losses are avoided.

# 7. OTHER DEMAND MANAGEMENT MEASURES

## 7.1 Introduction

Where the demand for use of a road network is close to, or in excess of, network capacity, there is often a desire to bring network demand and supply into better balance. The measures available in these circumstances, in addition to pricing policies, can broadly be categorised as follows.

### 7.1.1 Measures Affecting Supply

1. Increasing the capacity of the road network by investing in new roads.

2. Increasing the capacity of the existing road network by investing in traffic management measures, such as one-way systems, area traffic control systems or Intelligent Vehicle-Highway Systems (IVHS), to increase the overall traffic flow that can be accommodated.

3. Allocating the existing road capacity in favour of activities and vehicles which enhance network throughput, effectively by banning some activities: e.g. loading/unloading and parking on urban clearways, low occupancy private vehicles from using bus lanes or high occupancy vehicle (HOV) lanes.

### 7.1.2 Measures Affecting Demand

4. Investment Measures - investment in enhanced public transport services to attract demand from private vehicles. Such measures are more likely to be effective as part of a package which would also include measures to control the use of private vehicles.

5. Measures with a Strong Voluntary Component - measures to promote the re-scheduling of activities so that travel demand is spread more evenly throughout the day.

6. Measures to promote higher vehicle occupancies.

7. Physical Control Measures - physical controls on the use of vehicles.

8. Regulatory Measures - regulatory methods to restrain the use of particular vehicles in particular circumstances.

9. Measures to restrict the ownership of cars.

10. Parking Control Measures - which may embrace pricing or regulatory measures to restrain car use through parking controls.

Measures affecting land use and planning policy, in terms of the disposition of land uses or patterns and densities of development for example, which allow the value of activities to be gained while reducing total demand for travel could also play a part, at least in the longer term.

Investment measures (items 1, 2 and 4), and pricing policies are not discussed further as these are fully reviewed elsewhere. The demand management measures - those with a strong voluntary component, physical controls, regulatory measures and parking controls - are discussed in Sections 7.2 - 7.6 as measures which, in some circumstances, may be alternatives to pricing policies. The principles of the various demand management measures are emphasised, with some examples of their application.

### 7.1.3 Criteria for Assessing Demand Management Measures

The measures are assessed against the following criteria:

- **Effectiveness** - can road traffic demands be reduced to desired or target levels?
- **Efficiency** -
  - can only selected traffic be affected without adversely affecting other traffic?
  - can the mechanism discriminate explicitly in favour of high-occupancy vehicles?
  - does the mechanism bear directly upon the cost of each journey, and would it be perceived by the road user as doing so?
  - is the mechanism flexible in both the times and severity of application?
  - is the mechanism likely to be good value-for-money in economic terms. That means are the benefits in terms of users' time savings and resource cost savings likely to be maximised and high in relation to the costs of implementation and operation?
- **Practicality**
  - is the mechanism easy for the public to understand?
  - is it simple and cheap to introduce?
  - is it simple and cheap to administer and operate?
  - is it simple and cheap to enforce?
  - can the mechanism provide for casual as well as regular users?

- **Fairness** - does the mechanism avoid discriminating against the poorer sections of the community?

  - does it regulate traffic on the basis of need, as opposed to willingness or ability to pay or other criteria?

  - does it allow users to determine their own response or do they have no choice?

  - does it minimise the diversion of traffic to unsuitable roads, principally outside the controlled area?

Material has beeen drawn particularly from the following documents:

- Halcrow Fox and Associates (HFA). 1988. Introduction to road traffic demand management in London. Department of Transport (unpublished).

- Goodwin, P.B., Jones, P.M. 1989. Road pricing: the political and strategic possibilities. In *Systems of road infrastructure cost coverage. Round Table 80.* European Conference of Ministers of Transport.

## 7.2 Demand Management Measures as Alternatives to Pricing Policies

The relevant demand management measures are described and assessed against the defined criteria as alternatives to pricing policies. For this purpose the measures are categorised, as shown in Figure 7.1, under the following headings:

- **Voluntary Methods including car sharing/pooling.**

- **Voluntary Methods including rescheduling of activities** using staggered hours or flexible hours schemes, for example.

  While participation in such schemes may be voluntary, it can be encouraged by such measures as exemption from charging, as in Singapore, or access to high occupancy vehicle (HOV) lanes.

- **Physical Controls**, regulating the flow of traffic at a series of points on a cordon or along a corridor by such measures as capacity restrictions, access metering and restrictions on access.

- **Regulatory Methods**, to some degree either arbitrary or random, which ban some vehicles from specified areas or streets.

- **Parking Controls**, which until recently have been the only system in widespread use in the UK and have incorporated physical (rationing the number of spaces) and pricing elements.

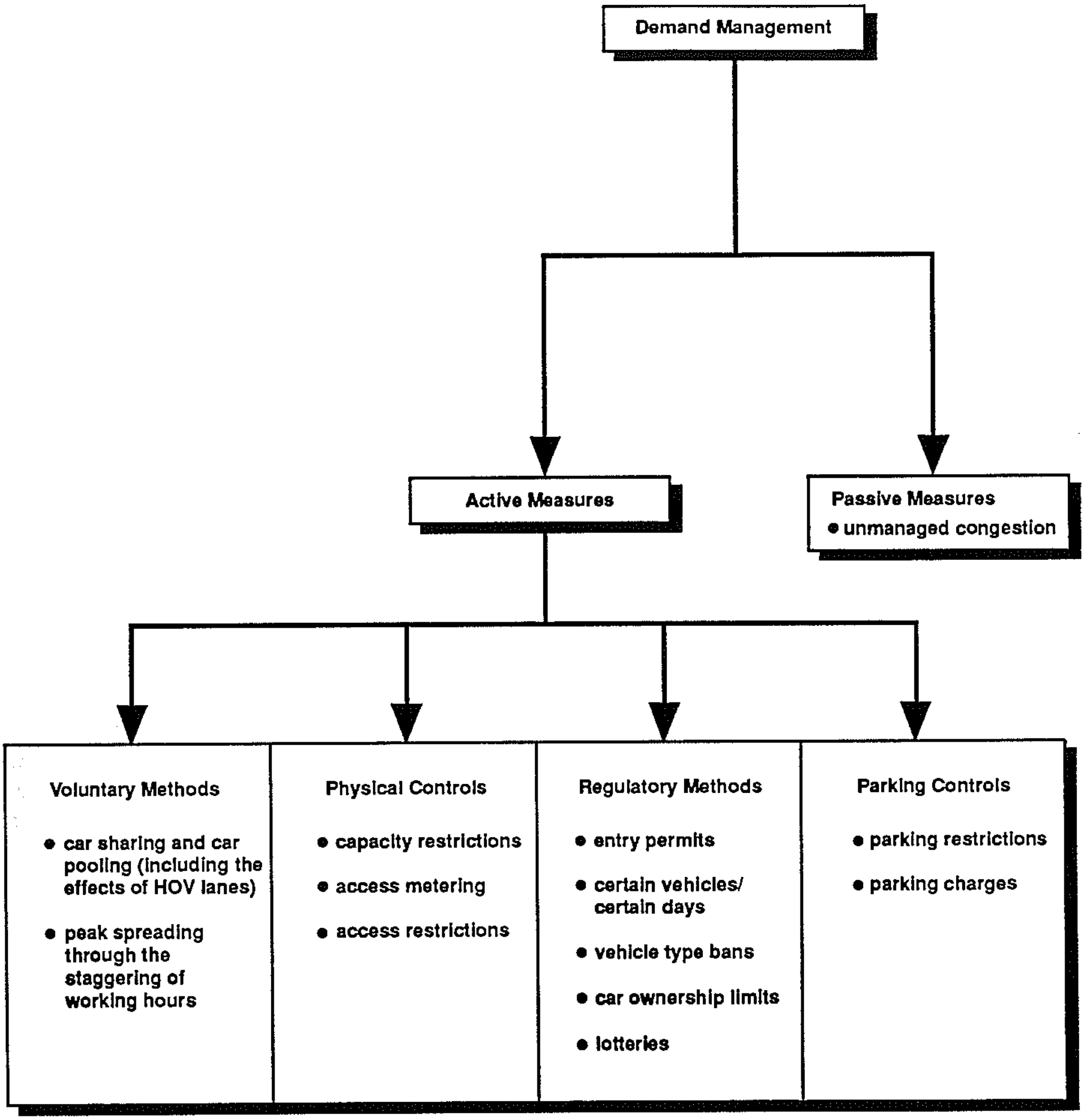


**Figure 7.1** **Categories of demand management measures.**

## 7.3 Voluntary Measures: Car Sharing and Car Pooling

**Car sharing** is where one driver uses only his car to give regular lifts to a group of people. **Car pooling** is an arrangement whereby a group of car owners and drivers take turns using their own cars on a regular basis to provide lifts to other members of the group.

Both car sharing and car pooling are feasible where people have trip origins and destinations in the same areas and make regular journeys between the two. Although car sharing can be organised among people who do not necessarily live in the same area but live along the same route for a journey, such potential sharers may be more difficult to identify. Computerised brokerage systems can assist in overcoming such difficulties.

The type of peak journey which offers the most opportunity for the formation of car sharing/pooling groups is the journey to work, which generally takes place to and from the same destination at the same times on each day during a week for identifiable groups of people.

Car sharing/pooling groups are best organised at the employment end of a trip where large employment centres exist. People at the same centre can be organised, or encouraged to organise themselves into groups, the members of which have similar home locations and start-finish times for work. It is also easier to offer incentives through the employer to encourage the formation of groups. The groups could be formed at the home end of the trip from neighbours who have similar work locations.

### 7.3.1 Effectiveness

Experience of car sharing/pooling programmes is limited in the UK and most of the schemes implemented have been in the United States. Based on an analysis of the 1977-79 Nationwide Personal Transportation Survey (NPTS), Teal (1987) found carpooling to be the commuting mode of 18-20% of American workers, with this percentage being remarkably stable across different sizes of urban areas.

In south-east Amsterdam the Vervoer Coordinatie Centrum (VCC), effectively a transport co-ordination centre with central government, local government and local business representation, has implemented a car pooling programme, which covers five local businesses including ABN-AMRO bank, NMB Postbank, Fokker and IBM. There are some 7000 current participants.

The effectiveness of such ride-sharing schemes can be enhanced through the provision of incentives, either physical or financial. The physical incentives are facilities such as HOV lanes or preferential parking, and the financial incentives are reductions in parking fees or exemption from tolls or other charges.

HOV facilities have been most effectively pursued in the US, where many examples exist of large expenditure on the provision of lanes and where some advantage in higher vehicle occupancies have been gained. An example is the Katy Freeway Transitway in Houston (Christiansen and Ranft 1988), where the operation of a special median lane for buses, van pools and 2+ person car pools has increased overall car occupancy on the whole freeway facility from about 1.3 to 1.5 (i.e. by around 15%).

The experience from the US suggests the following requirements for an effective HOV lane:

- the non-HOV lanes should be operating in a congested mode;
- the HOV facility should expedite the flow of HOVs without adversely affecting the flow of mixed traffic;
- the HOV lane should appear fully used, i.e. at least 800 vph, but should not be over-subscribed so that it offers a poor level of service;
- time savings should exceed 40 seconds per kilometre with a minimum of 5 minutes time saving per trip;
- the HOV lane should be separated from other lanes by a barrier;
- enforcement should be integrated into the design of the project; and
- the HOV lane should be supported by other strategies to increase vehicle occupancy such as park and ride lots, carpool transfer centres, special ramp treatments, ride sharing matching services, van pool programs and new bus services designed to take advantage of the higher speed.

Preferential parking for HOVs in the US has often taken the form of parking spaces closer to the work place (e.g. on the premises, rather than at a more remote lot). It could also be introduced in central city conditions by making some conveniently located car parks available for use either by HOVs only or by HOVs at a reduced charge.

### 7.3.2 Efficiency

Ride-sharing schemes can very satisfactorily meet many of the proposed efficiency criteria. They can be targeted closely at selected traffic, being most effective when applied to peak period home-work trips and when targeted at those travelling as the single occupants of vehicles. Ride-sharing schemes make natural complements to positive discrimination in favour of HOVs.

As it is largely a voluntary mechanism, the severity of application of ride-sharing as a demand management mechanism is not under the control of the authorities. Nevertheless, there are indications from the schemes which are in place that worthwhile reductions in traffic flow can be achieved at relatively low cost, i.e. that such schemes can be cost-effective. It may be, however, that ride-sharing schemes attract users whose alternative mode might be public transport, and this would not add to overall efficiency gains.

### 7.3.3 Practicality

The key to obtaining maximum response to a car sharing/pooling scheme has been found to be a good promotional campaign. This campaign must stress that each individual in his own car is contributing to congestion and parking problems that will steadily worsen if the traffic growth is left unchecked. Car sharing/pooling can then be introduced as a means of alleviating these problems, although further incentives (financial or convenience) are likely to be necessary.

The role of the various sections of the community must be emphasised in the campaign, and a system organised by the relevant public authority, as overall sponsor, to co-ordinate the efforts of employers and organisations who are arranging the car sharing/pooling programmes.

It has also been found important to give some attention to the maintenance of the organisation if car pools are not to break down because members drop out and are not replaced. Thought must be given to possible back-up arrangements, as lack of assistance for anyone missing the car is the most common cause of abandoning car sharing/pooling.

Membership of a car sharing/pooling arrangement imposes a certain rigidity on the members' working hours. The denial of the freedom to leave work when one wants in the evening is a common criticism of car sharing/pooling. Membership of an arrangement can complicate working overtime, as employees may no longer be able to alter their work hours at short notice without affecting their group.

Car sharing/car pooling programmes may also be limited by the need of some people to use their own car during the day. They could still have this flexibility as the driver in a car-sharing arrangement, or on the days when they used their car in a car pooling scheme, but otherwise they would be restricted in this respect.

### 7.3.4 Fairness

Car sharing/pooling is voluntary and therefore essentially fair. Users are, by definition, allowed a choice of response. The users' own perception of need will influence their decisions whether or not to join a ride sharing programme. The mechanism neither discriminates against the poor nor encourages traffic to divert to unsuitable roads.

## 7.4 Voluntary Measures: Rescheduling Activities

Staggered hours can take one of three forms in practice: formal staggered hours with start and finish times rearranged; flexible working hours whereby, within set limits, employees may start and finish work at times of their own choice; and the compressed working week where more hours per day are worked for fewer days per week.

### 7.4.1 Effectiveness

Staggered hours of both work and attendance at school **can** lead to reduced demands for travel in the peak periods. The trend over recent years has been to shorter working hours, and more part-time workers, as well as to the introduction of flexible working hours. There can be significant local benefits.

The introduction of flexible work hours at government offices in Ottawa had a dramatic impact on the distribution of arrival and departure times. There was a reduction of peak loads in excess of 50% and a tendency to arrive earlier and depart earlier than before.

Studies in the United Kingdom have found similar results. Following the introduction of flexitime at a large government office in north-east England (employing some 10,000 people), peak (fifteen-minute) period vehicle movements declined by about 35%, which was sufficient to eliminate local congestion. The scheme also enabled the bus company to reduce peak vehicle requirements in the area by 20%.

### 7.4.2 Efficiency

The effects of such schemes could be quite limited in parts of some urban areas of very high demand, such as Inner and Central London, where the peaks have spread to the extent that demands are more or less constant throughout an extended working day.

If non-work activities are staggered, the effects could be less productive in reducing peak hour travel demands. Later shopping hours, for example, might significantly affect morning peak demands but have less impact on evening peak demands, while later school hours might add to evening peak demands.

### 7.4.3 Practicality

Staggered hours schemes are not wholly consistent with car sharing/pooling programmes. Formal staggering of hours would spread the peaks, making it more difficult to match people in appropriate groups, although small adjustments in working hours could facilitate the formation of some car sharing/pooling arrangements.

### 7.4.4 Fairness

Staggered hours schemes might be viewed more favourably, however, by employers in a controlled area than other demand management mechanisms and, like car sharing/pooling, can produce worthwhile, but marginal, benefits at low cost.

## 7.5 Physical Control Measures

The basic principle of physical controls is to regulate the flow of traffic at a series of points on a cordon or along a corridor by traffic management measures. Traffic is metered into the area or onto the main route in the corridor at a rate which avoids congestion within the area or on the main route.

Physical controls, which are intended as deliberate means of managing demand rather than results of a lack of road capacity, can take a variety of forms including:

- Restrictions on the capacity of major roads (usually radials near centres) with special provision for public transport and possibly other HOVs to bypass the resulting queues of other traffic;
- Restrictions on the rate of access to a major route, to give priority of access to buses, or to encourage stable conditions on the route thereby enhancing the route's capacity, or to reduce traffic flows, with special provision being made for traffic crossing or travelling in the non-peak direction along the controlled route;
- Delays throughout an area, or restrictions of the kinds described above, produced by means of a computer-controlled set of linked traffic signals, with special provision being made for public transport and possibly other HOVs; and
- Diversion of traffic away from an area by traffic management measures while still enabling access traffic to penetrate the area concerned.

### 7.5.1 Effectiveness

The key requirement of many physical controls is the ability to accommodate large queues of traffic without affecting other traffic that does not need to be managed. The large queues arise from traffic being metered into areas and onto routes, or they can be deliberately generated in an attempt to persuade drivers to change mode or their time of travel. In practice, in typical towns and cities in the UK, it has often been found that insufficient queuing space is available for very large flow reductions to be achieved before the queues interfere with upstream junctions and cross-traffic. The effectiveness of physical controls is therefore often very limited.

In Nottingham, for example, during the zone and collar experiment conducted in the mid-1970s, the maximum delay which could be imposed at a collar control was 3 to 4 minutes without the queue unacceptably blocking back across the ring road. This, together with the use of fixed time signals, meant that the maximum delay was constrained and could only be imposed at the peak of the peak. There was thus very little incentive for car users to transfer to bus (Vincent and Layfield 1977, Singleton 1976).

A cordon restraint scheme was also tested in London in the mid 1970s (Cracknell et al. 1975), with the aim of reducing the volume of traffic entering Central London by one third. Three sectors of London were studied. The highest feasible level of delay varied from 5 minutes in one corridor to 15 minutes in the other two. Taking all three corridors together, a reduction of between 5% and 7% of traffic crossing the Central Area cordon was predicted. If a complete collar were implemented, flow reductions of between 8% and 11% were expected.

The traffic flow reductions likely to result from the scheme were limited to these modest values because of the configuration of the network. Queue lengths were limited by the storage space available, and by the need to keep queues from blocking upstream junctions. Such modest delays were insufficient to bring about any significant modal shift to public transport.

### 7.5.2 Efficiency

Physical controls can sometimes be selective in the traffic movements they affect, but sometimes they have unavoidable impacts on traffic which it is not desired to manage (for example, traffic wishing to gain access to a controlled route in the non-peak direction). They can be devised so that HOVs are able to bypass any large queues. They do bear directly on the perceived cost of each journey, although delays caused by physical controls may need to be very high to bring about a significant change in choice of mode.

Flexible times of operation are possible with physical controls, and the severity of application can also be varied, within limits, if so designed (for example, if incorporated in a computer-controlled signal system).

Physical measures rely on controlled congestion for their effectiveness (as opposed to price or regulation as the principal means of rationing). This is one of the strongest arguments often raised against physical controls, as time is wasted by them, and time, unlike a monetary charge, is a resource. Because they deliberately waste resources, they are likely to be economically inferior to some other forms of demand management. If the objective is to improve the efficiency with which the transport system operates, such schemes are almost self-defeating given their reliance on building in inefficiency (in the form of delay) in order to effect any substantial modal transfer.

### 7.5.3 Practicality

People are able to react, as intended, to physical controls to the extent that traffic regulation orders can be comprehended and obeyed, and that the drivers can negotiate the physical road layout satisfactorily. They may not, however, readily appreciate why queues are deliberately formed at specific locations, and situations where the traffic regulations can be broken with impunity need to be avoided in the design of the controls.

The ease of introduction of physical controls depends upon the availability of a road system which enables the selected traffic to be controlled while not affecting other traffic. Most physical controls would be implemented within existing highway limits and are likely to be relatively cheap to introduce. Operating costs are likely to be no greater than normal road system maintenance costs.

Traffic regulation enforcement could be required at queues that are created where they would not occur otherwise, and where it is not easy for the public to understand the reasons for the presence of the queues. Otherwise, they will be as easy or as difficult to enforce as traffic regulation orders in general.

Casual users would be affected by physical controls in the same way as regular users.

### 7.5.4 Fairness

Physical controls do not discriminate against the poorer sections of the community, and that they are fair in this sense is a point often made in their favour. On the other hand, they do not take account of need, since those who continue to travel with physical controls in place will tend to be those who are prepared to spend most time, and therefore who tend to value time least. They do, however, allow travellers to exercise their choice of mode.

Physical controls can result in traffic diverting onto unsuitable roads to avoid the measures and their queues, but careful design can minimise these effects.

## 7.6 Regulatory Measures

Regulatory methods of managing demand, excluding parking controls (discussed in Section 7.7), include:

- Permits issued by the controlling authority, either free or on payment of an administration fee, which allow entry by vehicle to the controlled area;
- Allowing certain vehicles to enter an area on certain days only (e.g. allowing those vehicles with odd registration numbers to enter on odd dates, and those with even numbers to enter on even dates);
- Bans by vehicle class from specified areas or streets;
- Limits on car ownership; and
- Lotteries, where permission to enter the controlled area is given by a random draw process.

All these methods are arbitrary or random to some degree in their effect. Permit systems can, in theory, be designed to achieve specific aims and are the most realistic of the regulatory methods (except for parking space allocation controls).

Perhaps the best example of a permit scheme is that introduced in Milan in 1985 when permits were required to enter the Central Area first between 0700 and 1000 hours, and then between 0700 and 1130. Permits were issued to:

- Public transport vehicles,
- Emergency vehicles,
- Cars owned by residents of the Central Area,
- Commercial vehicles, and
- Certain employers.

From surveys conducted soon after the introduction of the scheme, it appears that the volume of traffic entering the Central Area in the morning peak period fell by almost 50%. Of trips prevented from entering the Central Area during the peak, some 25% are thought to have made the same journey by car later in the day, 35% are thought to have parked outside the permit zone and walked to their destination, while 40% are thought to have transferred to public transport. Difficulties with the operation of the scheme reflected a lack of parking provision and traffic management measures outside the permit zone and the reliance on police and wardens to check vehicles at the entry to the controlled zone.

### 7.6.1 Effectiveness

With the exception of limits on car ownership, all the regulatory methods can, in theory, reduce traffic to the desired levels. If car ownership were to be limited in a draconian way, then it too would be very effective. A more practical limit such as one car per household, however, is unlikely to be very effective.

It is possible to devise systems for allocating permits so that a reasonable approximation to allocation on the basis of need is established, if sufficient administration resources are devoted to the task. There is, however, the possibility for fraud with permit systems and any cars given permission to travel may well make more journeys than they otherwise would have.

### 7.6.2 Efficiency

Permit systems can be designed to be very selective in terms of which kinds of road users are allowed to travel and which are prevented. This is one of the strongest arguments in favour of such a system. Permit systems are not able, however, to select those users imposing most costs on others. The other regulatory methods are all blunt instruments as far as selectivity is concerned.

All the regulatory methods, except limits on car ownership, could allow high-occupancy vehicles to be exempt from the controls on the use of the road system. However, none bear directly on the perceived cost of travel.

All could operate at certain times of the day, again excepting limits on car ownership. All could allow some flexibility in the severity of their application. However, none is aimed to maximise economic benefits because their effects on those users imposing most costs on other road users are random.

### 7.6.3 Practicality

In principle, all the regulatory methods could be easy to understand, but this would depend upon the design of the mechanism.

The introduction of all the methods would require special legislation. Given the essentially arbitrary nature of all the methods except permits, they could arouse considerable controversy and are unlikely to find favour with those seeking some rational way of managing demand. Limits on car ownership would represent a new kind of restriction on people's freedom, and it might be particularly difficult to get the necessary legislation through Parliament.

Administration costs of a permit system, and a lottery system to perhaps a lesser extent, could be very complex and costly. Other methods could cost less to administer. Considerable enforcement effort would be required with all the regulatory systems.

Only a permit system could cater satisfactorily for the casual user. With the other systems, people wishing to make regular or infrequent journeys are affected alike.

### 7.6.4 Fairness

All the regulatory methods could be designed not to discriminate against poorer people. Indeed, all the methods except permits are essentially random in selecting who they affect, and in this sense they may be said to be fair.

Only a permit system could regulate traffic on the basis of need, although defining which people need a permit and which do not is fraught with difficulty. None of the other regulatory methods takes account of need, and none enables self-choice on the part of the traveller.

All the methods except car ownership limits could quite easily lead to higher levels of traffic outside the area of control. Measures could be needed to protect unsuitable roads from the traffic diverting around the controlled area. (Even car ownership limits, if related to a specific area, could mean that those wishing to own a vehicle would relocate to outside the controlled area, and lead to increased traffic levels there. This sort of effect is however a possible consequence of almost any demand management scheme applied to a specific area.)

## 7.7 Parking Control Measures

Management of demand by means of parking controls has, until relatively recently, been almost the only system in widespread use in the UK (although a few physical controls have been tried). Control has been effected both by rationing the number of spaces, and by price. The objective of this form of management has generally been to relate the number of parking spaces in an area to the amount of traffic which the road system can accommodate.

Various approaches to controlling parking supply and use are practised, including:

- Restricting the numbers of publicly available spaces used for long-stay parking (these being used primarily, it is argued, by those travelling in the periods of peak road traffic demand), by implementing on-street parking restrictions and charging high prices for off-street car parks;

- Restricting the number of parking spaces which can be provided in new developments;

- Charging for spaces in the heart of a city centre geared to accommodate short-stay parkers and to deter long-stay parkers;

- Locating long-stay car parks away from the heart of the central area;

- Closing certain car parks at peak times;

- Issuing permits for parking, e.g. residents parking permits; and

- Imposing restrictions on parking duration in the form, e.g. of maximum times permitted to be spent at meters.

Attempts have also been made, notably in London, to reduce the numbers of private non-residential spaces now existing in developments built when the planning controls were more lax, and required high levels of parking space to be provided.

Provision of spaces reserved for residents can also reduce the parking available, for short or long stays, to people coming from outside the controlled area.

### 7.7.1 Effectiveness

The essential point about parking controls is that they only affect trips terminating in the controlled area. The reduction in terminating trips will leave more road space for through trips. Often, as has been the case in London, overall traffic levels in the area of controlled parking have not decreased with the implementation of parking controls. Rather, the controls have simply led to increases in through-traffic which has no business in the controlled area, in contrast to the terminating traffic which will often make at least some contribution to the life and economy of the controlled area. In theory, the diversion of through-traffic to make use of the capacity released by the deterred terminating traffic should relieve areas around the controlled area. In practice, in cities such as London where demand is substantially suppressed, this relief may not materialise. These same comments apply equally to parking charging policies.

Studies in Norwich and Ipswich, towns in the UK with populations of around 125,000, have established that central area parking controls could reduce demands to the central area by around 18%, but over the whole urban area, traffic flows would only be reduced by 3 to 5%.

The other factor severely limiting the effectiveness of parking controls and parking pricing policies, at least in the UK, is the predominance of private non-residential parking which typically accounts for 40%-60% of the existing parking stock in UK cities. Control over the use of this parking capacity can be exercised only with great difficulty. For practical purposes this part of parking capacity lies beyond the scope of policies introduced by highway authorities.

### 7.7.2 Efficiency

Parking controls are not very selective. In general, they can only bear on those making use or wishing to use publicly available spaces. Those using privately available spaces generally escape control, although standards which reduce the numbers of parking spaces which can be provided in new developments will tend to provide more scope for efficiency in controlling demand.

Parking controls normally operate in a manner that affects all long-stay parkers wishing to use the controlled parking, irrespective of whether or not they arrive in the peak and whether or not they use a congested route. Discrimination in favour of high-occupancy vehicles is not normally made, but could be in some circumstances.

In practice, parking controls are frequently inflexible in terms of time and severity of application. Parking controls would bear only obliquely, for example, in imposing inconvenience on the perceived cost of a journey. Rationing the use of parking spaces is likely to lead to additional search time which of course imposes delay on other road users.

Brown (1990) used the results of a town centre parking survey in Brighton, along with local data on the location of car parks to produce estimates of the times and operating costs of parking movements. The results revealed an average estimated search and walk time that cost 40.5p (pence) per parking action, operating costs of 3.5p per action and parking fee of 50p per action. Thus, the total average generalised cost of an off-street parking action was 94p.

Parking charging policies are likely to be more efficient than controls in the following respects:

- it may be easier to vary prices by time of day;
- insofar as charges could be shared between vehicle occupants, discrimination would be in favour of high occupancy vehicles; and
- with the important exceptions of those parking in private spaces and those with season tickets, parking charges do normally bear directly on the perceived cost of each journey.

Thus, parking price controls may perform better in economic terms than some other restraint mechanisms as they are likely to deter the marginal users who would suffer least disbenefit by not travelling by private vehicle to the controlled area. Parking provision, itself a resource, could also be saved.

### 7.7.3 Practicality

Control of publicly owned and publicly available off-street spaces is simple for the public to understand, simple and cheap to introduce, administer and enforce. These car parks can provide for the casual as well as the regular user, providing the number of spaces is not severely limited.

Control of privately owned but publicly available off-street car parks is also easy for the public to understand, and is simple and cheap to enforce. Again, parking controls can provide for casual users. Legislation is needed for local authorities to be able to exert control over tariffs and opening times. The Greater London Council had the necessary powers under the Transport (London) Act 1969, although no other local authority in the UK is thus empowered. The introduction of controls over these spaces could be complicated, and their subsequent administration would not necessarily be a simple matter.

There are very great practical difficulties in controlling existing private non-residential parking, especially where these spaces form a large proportion of the total supply. Feasible but complex methods have been devised in principle. New legislation would be needed. Enforcement would require considerable effort as would the administration of the procedures. Control over the number of spaces provided in new buildings is a relatively simple matter under current planning procedures.

On-street parking controls are, in some cases, easy for the public to understand but, in many cases, the traffic regulation orders are more complex. While they may be regarded as a relatively simple matter to introduce, the administration of parking meters can be costly, both to collect the revenue and to maintain and repair the meters.

The main difficulty with on-street parking controls is their enforcement. The widespread disregard for the regulations in London has led to enforcement by wheel clamping and towing vehicles away. The wheel clamping activities have been privatised, to good effect, and the towing operation is also handled partly by private contractors. In theory, the fines imposed during enforcement could go a long way to covering the costs involved, but this will depend upon compliance levels and the level of enforcement activity.

On-street parking controls can cater for, and apply to, the casual user just as much as to the regular user.

Parking controls involve the rationing and pricing of publicly available off-street spaces, and on-street spaces. While the provision of new private non-residential (PNR) off-street spaces can be controlled, it is not possible to control existing PNR spaces, in the UK at least.

The mechanism as a whole can only be as effective as its weakest part. Two very significant weaknesses of the parking mechanism are this very limited control that can be executed over off-street parking, particularly private non-residential spaces, and the difficulties of enforcing on-street controls. These comments apply in principle both to controls by rationing and by pricing.

| CRITERIA | | PHYSICAL CONTROLS | REGULATORY METHODS | |
|---|---|---|---|---|
| | | | PERMITS | CERTAIN VEHICLES/ CERTAIN DAYS |
| **Effectiveness** | can road traffic demands be reduced substantially? | NO - effects often very limited | YES | YES |
| **Efficiency** | can only selected traffic be affected? | YES - but only to some extent | YES - very selective in terms of kinds of road user | NO |
| | can discrimination in favour of high-occupancy vehicles be given? | YES | YES | YES |
| | does the mechanism bear directly on the perceived cost of each journey? | YES - but delay costs exceed private perceived costs | NO | NO |
| | is the mechanism flexible in the times and severity of application? | YES - although severity can only be varied within modest limits | YES | YES |
| | is it likely to be good value-for-money in economic terms? | NO - time (a resource) is wasted by the controls | NO attempt to maximise economic benefits | NO attempt to maximise economic benefits |
| **Practicality** | is the mechanism easy for the public to understand? | YES - but could be difficult in some circumstances | YES | YES |
| | is it simple and cheap to introduce? | YES - can be implemented with existing legislation but measures can be expensive | NO | NO |
| | is it simple and cheap to administer and operate? | YES | NO | YES |
| | is it simple and cheap to enforce? | YES - but some special enforcement might be needed | NO | NO |
| | can the mechanism provide for casual as well as regular users? | YES | YES | NO |
| **Fairness** | does the mechanism avoid discrimination against the poor? | YES | YES | YES |
| | does it regulate traffic on the basis of need? | NO - willingness to spend time | YES - but could be expensive to do so | NO |
| | does it allow users a choice of response? | YES | NO | NO |
| | does it minimise diversion of traffic to unsuitable roads? | NO - traffic could divert unless other measures were implemented to prevent it | NO - not necessarily | NO - not necessarily |

**Figure 7.2** **Summary and comparison of the principles of demand management measures.**

*continued:*

| CRITERIA | | REGULATORY METHODS (Continued) | | |
|---|---|---|---|---|
| | | BANS BY VEHICLE CLASS | LIMITS ON CAR OWNERSHIP | LOTTERIES |
| **Effectiveness** | can road traffic demands be reduced substantially? | YES | NO - effects would probably be limited | YES |
| **Efficiency** | can only selected traffic be affected? | NO - although it could prohibit those that cause most environmental nuisance (lorries) | NO | NO |
| | can discrimination in favour of high-occupancy vehicles be given? | YES | NO | YES |
| | does the mechanism bear directly on the perceived cost of each journey? | NO | NO | NO |
| | is the mechanism flexible in the times and severity of application? | YES | NO | YES |
| | is it likely to be good value-for-money in economic terms? | NO attempt to maximise economic benefits | NO attempt to maximise economic benefits | NO attempt to maximise economic benefits |
| **Practicality** | is the mechanism easy for the public to understand? | YES | YES | YES |
| | is it simple and cheap to introduce? | NO | NO | NO |
| | is it simple and cheap to administer and operate? | YES | YES - possibly | NO |
| | is it simple and cheap to enforce? | NO | NO | NO |
| | can the mechanism provide for casual as well as regular users? | NO | NO | NO |
| **Fairness** | does the mechanism avoid discrimination against the poor? | YES | YES | YES |
| | does it regulate traffic on the basis of need? | NO | NO | NO |
| | does it allow users a choice of response? | NO | NO | NO |
| | does it minimise diversion of traffic to unsuitable roads? | NO - not necessarily | YES | NO - not necessarily |

**Figure 7.2 Summary and comparison of the principles of demand management measures.** *continued:*

| CRITERIA | | PARKING CONTROLS | PARKING PRICING |
|---|---|---|---|
| Effectiveness | can road traffic demands be reduced substantially? | NO - only affects terminating traffic, and through traffic is encouraged | NO - only affects terminating traffic, and through traffic is encouraged |
| Efficiency | can only selected traffic be affected? | NO | NO |
| | can discrimination in favour of high-occupancy vehicles be given? | NO - except in the case of HOV car parks | NO - except in some circumstances |
| | does the mechanism bear directly on the perceived cost of each journey? | YES - to some extent except those parking in private spaces and season ticket holders | YES - except those parking in private spaces and season ticket holders |
| | is the mechanism flexible in the times and severity of application? | YES | YES |
| | is it likely to be good value-for-money in economic terms? | YES - to some extent | YES - to some extent |
| Practicality | is the mechanism easy for the public to understand? | YES - although some on-street regulations are not easy to understand | YES |
| | is it simple and cheap to introduce? | YES - on-street<br>NO - off-street control will often require new legislation | YES - on-street<br>NO - off-street control will often require new legislation |
| | is it simple and cheap to administer and operate? | YES - on-street<br>NO - off-street, especially private non-residential spaces | YES - on-street<br>NO - off-street, especially private non-residential spaces |
| | is it simple and cheap to enforce? | NO | NO |
| | can the mechanism provide for casual as well as regular users? | YES | YES |
| Fairness | does the mechanism avoid discrimination against the poor? | YES - if rationing is the basis | NO |
| | does it regulate traffic on the basis of need? | NO - unless permits are issued to the more needy | NO - ability/willingness to pay |
| | does it allow users a choice of response? | YES | YES |
| | does it minimise diversion of traffic to unsuitable roads? | YES - in that it tends to attract more through traffic but encourages parking in fringe areas | YES - in that it tends to attract more through traffic but encourages parking in fringe areas |

**Figure 7.2 Summary and comparison of the principles of demand management measures.** *continued:*

| CRITERIA | | ROAD PRICING |
|---|---|---|
| **Effectiveness** | can road traffic demands be reduced substantially? | YES |
| **Efficiency** | can only selected traffic be affected? | YES - very selective in terms of those users imposing most costs on others |
| | can discrimination in favour of high-occupancy vehicles be given? | YES - except private cars with high occupancies |
| | does the mechanism bear directly on the perceived cost of each journey? | YES - but might not be easily perceived |
| | is the mechanism flexible in the times and severity of application? | YES |
| | is it likely to be good value-for-money in economic terms? | YES - in theory, the best mechanism in this respect |
| **Practicality** | is the mechanism easy for the public to understand? | YES - possibly |
| | is it simple and cheap to introduce? | NO - legislation required, as well as electronic number plates on each vehicle |
| | is it simple and cheap to administer and operate? | NO |
| | is it simple and cheap to enforce? | NO |
| | can the mechanism provide for casual as well as regular users? | NO - not easily |
| **Fairness** | does the mechanism avoid discrimination against the poor? | NO - but degree of unfairness depends upon how revenues are disbursed |
| | does it regulate traffic on the basis of need? | NO - ability/willingness to pay |
| | does it allow users a choice of response? | YES |
| | does it minimise diversion of traffic to unsuitable roads? | NO |

**Figure 7.2** **Summary and comparison of the principles of demand management measures.**

### 7.7.4 Fairness

Where rationing of spaces on a first-come-first-served basis is the basis for regulation, parking controls do not discriminate against the poorer sections of the community. They cause gainers and losers arbitrarily. Wherever price is used as the mechanism, poorer users are discriminated against, though, in theory, measures to compensate them could be funded from the revenues generated. For parking controls to be the sole means of managing demand, and for them to reduce traffic levels appreciably, charges may have to be very high, discriminating further against the poor.

The provision of private off-street spaces at their places of work for some employees, especially those not needing to use their car during the working day, is regarded by many as unfair.

Fines as a means of enforcement also discriminate against the poor. To some richer people, the payment of a fine for parking illegally may be regarded as no more than an appropriate charge for parking where they want. By contrast, enforcement by wheel clamping or towing away is fairer, although again fines are involved. A problem with wheel clamping is that the offending vehicle remains the wrong place, unless or until it is towed away.

Parking space rationing does not regulate traffic on the basis of need, while price controls regulate on the basis of ability or willingness to pay. But all parking controls do permit the user to choose how he or she will travel.

As parking controls do not usually force through-traffic out of an area, increased usage of unsuitable roads outside the controlled area is unlikely to result.

In summary, parking controls have the advantage over parking charging in terms of "fairness", simply because pricing policies may require charges and/or fines to be set at high levels placing a premium on ability to pay.

## 7.8 Summary of Demand Management Measures

The active (i.e. non-voluntary) demand management mechanisms described in this section are summarised in Figure 7.2 against the criteria defined in Section 7.1.3. Physical controls, various regulatory methods and parking controls and pricing policies are summarised alongside a generic road pricing system for comparative purposes. In Figure 7.2, YES is a good feature and NO is bad. The important aspects are underlined, and the following broad conclusions can be drawn.

Physical controls are likely to have only limited use, given their limited effectiveness and their waste of resources (travellers' time spent queueing). However, there may be specific circumstances where they can be applied, more particularly to achieve environmental benefits or improved facilities for pedestrians in relatively confined areas.

Regulatory methods are unlikely to find favour in view of their greater or lesser degree of arbitrariness, and given that not all would allow travellers freedom to choose how and when to travel. Permit systems can be effective in reducing traffic volumes and in allocating permits to those with greatest need, provided sufficient attention is given to defining the beneficiaries of permits then administering and enforcing the systems.

Parking controls are very limited in whom they affect. Very great difficulties are involved in making them more effective by attempting to control the use of private non-residential parking spaces. Control over the use of privately owned but publicly available spaces would also not be simple. Enforcement of on-street controls is likely to require a continued effort, with wheel clamping and towing away activities being important enforcement tools.

The voluntary measures, including car sharing/pooling and the staggering of working hours are unlikely to lead to large scale reductions in road traffic demand. Such schemes, however, can produce worthwhile but marginal benefits at low cost.

None of these demand management mechanisms can match the efficiency of the pricing mechanism in reducing numbers of trips. The pricing mechanism will act to deter marginal trips and ensure that the value of all trips that are made exceeds or at least equals their marginal costs. Non-pricing mechanisms, by contrast, all suffer from a greater or lesser degree of arbitrariness in the trips they deter with a resulting less efficient solution.

Work undertaken in Hong Kong (Hau 1992), for example, demonstrates that electronic road pricing (based on dynamic link charges) can generate very high benefits compared with less sophisticated pricing and demand management methods. For example, car ownership restraint produced only 24% of the estimated benefits of the optimum option (electronic road pricing) and area licensing produced 27%. Other pricing and demand management schemes generated 44% to 75% of the optimum scheme's benefits. Similarly, Hau reports findings from Oslo on the benefits of various cordon toll schemes:

- a 24-hour inbound flat toll of NOK10 would generate annual benefits of NOK21.9 million,
- an inbound peak toll of NOK25 would generate annual benefits of NOK95.2 million, and
- a link-based fully electronic pricing scheme (i.e.. marginal costs on a link by link basis) would generate benefits of NOK150.9 million.

The effectiveness of pricing as a mechanism is further demonstrated by Hau in the following data relating to the assessment of road pricing with automatic vehicle identification in Hong Kong and of road pricing with smart card technology in the Netherlands.

| | Hong Kong | Netherlands |
|---|---|---|
| Revenue:Cost ratio | 7.9:1 to 10.4:1 | 2.6:1 |
| Benefit:Cost ratio | 14.7:1 to 17.8:1 | 4.5:1 |
| Long-run cost (US cents in 1990) per transaction | 6.6 | 12.5 |

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# RESEARCH REQUIREMENTS 3.

# 1. INTRODUCTION

## 1.1 The Need for a Research Programme

An important requirement of this study is that suggestions are put forward for a programme of research into land transport pricing in New Zealand. In particular, suitable research projects should be identified which are necessary to:

- quantify particular costs and benefits, where existing data are not sufficiently precise; and

- select appropriate policy options where the best option is not obvious, following the literature review.

The study has consisted of three elements:

- a brief review of current approaches to land transport pricing and taxation;
- a theoretical review of the pricing principles and methods that would help to achieve a more efficient and equitable land transport system; and

- an assessment of the practical merits of various pricing and other demand management measures.

The principal issue to be addressed by the research is therefore how to facilitate a progression from the current system to one which achieves higher levels of economic efficiency and a more equitable distribution of costs and benefits. Subsequent work must thus focus on the **application** of the economic theory and the **implementation** of specific pricing methods.

## 1.2 Research Issues

The main research issues to emerge from this study that have major implications for the progression from theory to practice can be summarised as follows:

- **Policy Issues** - A policy framework is required for the introduction of any new transportation programme, in which goals, priorities and key performance measures are clearly identified.

- **Valuation Issues** - Practical methods are required for placing economic values on the various impacts of land transport.

- **Measurement and Prediction Issues** - The scale of impacts (costs and benefits) must be determined and must also be forecast so that an efficient pricing regime can be designed and evaluated.

- **Technical Issues** - Road pricing instruments must be appraised and selected.

- **Attitudinal Issues** - If a road pricing programme is to be successful, public and political acceptability must be considered.

- **Institutional Issues** - The design and introduction of a road pricing programme has major organisational implications for the operating authority.

- **Evaluation Issues** - New or amended methods for investment appraisal and project assessment are likely to be required where wide scale road pricing has been introduced.

- **Funding** - While funding issues are theoretically distinct from those of economic efficiency, in practice the operating authority of a road pricing system is bound to be concerned with how revenues can be used to finance transport schemes.

Particular areas of research can be identified under some of these headings and these are summarised in Sections 2.3.3 - 2.3.7. However, for good practical and methodological reasons it is sensible to think first of an appropriate research programme rather than to itemise all of the ultimate information requirements for the successful implementation of a changed pricing policy.

The high costs of undertaking new research and the very real prospects of New Zealand benefiting from research currently being undertaken elsewhere provide good practical reasons for developing an appropriate staged programme of research. Likewise the need for clarification of objectives and priorities before major expenditures are incurred provides a methodological motive for establishing a focus to any research programme.

## 2. RESEARCH REQUIREMENTS

### 2.1 Dimensions of a Research Programme

Land transport pricing in New Zealand is currently concerned with recovering the costs incurred by transport system operators in providing transport infrastructure and services. These can be defined as internal costs. Transport system operators could be Government (in respect of road and rail networks) or the private sector (toll roads, privatised bus or rail services). Issues about assessing how well current pricing policies and levels achieve their aims are referred to below.

Current pricing policies take no account of any of the external costs imposed by the transport system or system users on others. The more important external costs are congestion, environmental externalities and safety externalities. The incorporation of these external costs into pricing policies would enhance the efficiency of the transport system.

The external costs associated per trip kilometre are likely to be greater for trips in urban areas than for inter-urban trips, and similarly greater for inter-urban trips than for trips in rural areas. Any analysis of costs and pricing policies ought therefore to distinguish between trips made in urban, inter-urban and rural areas.

Insofar as there is interaction between the different land transport modes, the pricing policies for all modes should be determined jointly having regard to the interactions between modes.

Thus, the dimensions of the setting of land transport pricing policies, and of the research to inform such policies, should be:

- internal costs and external costs;
- urban, inter-urban and rural trips; and
- all relevant modes.

### 2.2 Objectives of a Research Programme

The objectives of a land transport pricing research programme in New Zealand may be defined along the following lines:

- to compare the current land transport pricing system and charges with an economically efficient system;

- to understand the consequences of moving towards an efficient system; and

- to understand the efficiency gains which would be forgone by pursuing objectives other than efficiency maximisation.

A research programme fulfilling these objectives would give decision-makers a firm basis for setting pricing policies. They would know:

- what levels of charges for different trips/vehicle types in different areas might be proposed;
- the consequences of these charges (in terms, for example, of demands, revenues, benefits, acceptability and public reaction); and
- the trade-offs involved in pursuing alternative objectives and policies.

## 2.3 Structure of the Proposed Research Programme

A structured, sequential research programme is proposed:

- **Stage One** would be a **preliminary review**, using current information and, where necessary, best estimates of different pricing scenarios to clarify objectives and priorities. Stage One would necessarily be stronger in dealing with internal costs than with external costs, in dealing with rural and inter-urban trips than with urban trips. The objectives of Stage One would include:

  - an initial assessment of the charges per trip (by type, area, perhaps time of day) which would satisfy efficiency criteria,

  - outside urban areas, an assessment of whether existing charging mechanisms equate reasonably with the optimum, and

  - identification of the gaps in current information which could not adequately be filled by best estimates.

- **Stage Two** would focus on those areas covered least well in Stage one (i.e. external costs/benefits and urban areas) and would include **conceptual studies** to examine the effectiveness of road pricing (in the sense of congestion pricing) in Auckland and Wellington cities, and an assessment of the non-transport benefits of the rural road network. The objectives of these studies would include:

  - the implications of pursuing different pricing objectives throughout the land transport system (for example, pricing for economic efficiency, pricing to maximise revenue, pricing to restrain a volume of traffic sufficient to ameliorate defined traffic-related problems);

  - an assessment of the economic case for road pricing in, say, Auckland and Wellington;

  - the basis of a system design (for example, a cordon-based or a continuous pricing system, and, if cordon-based, the number and pattern of cordons); and

- the practicality of road pricing (dealing with such matters as the treatment of visitors, exemptions, enforcement, administration).

- **Stage Three** would be a **detailed research programme** to inform the final design and evaluation stages of a land transport pricing system and to pave the way for implementation.

This structure is similar to that followed by the UK Department of Transport in respect of road pricing in London. That research programme, begun in late 1987 and due to be completed in late 1994, had the following stages:

- An initial literature review designed to give an overview of demand management mechanisms and their relevance to solving defined problems on the trunk road network in London (this cost around £20,000);

- A subsequent desk study which explored, in the space of a few months, the essential features of a road pricing system for London, focusing on the aspects of particular difficulty as well as the major areas of benefit (this cost around £80,000); and

- A current 3-year, £3 million programme researching all aspects of the introduction of road pricing in London.

## 2.4 Details of the Proposed Research Programme

The issues to be addressed and the decisions to be taken at each stage of the proposed research programme are now discussed.

### 2.4.1 Stage One: Preliminary Review

This is seen as a desk exercise which would draw on what is currently known and available, including:

- The current charging system,

- This report for its review of the principles which should underlie transport pricing policies,

- Recently commissioned studies of environmental externalities and road pricing technologies, and

- Other information available within New Zealand (e.g. speed/flow relationships and values of time would be required to analyse congestion costs: accident rates and costs would be required to analyse safety externalities).

The review should look at the transport system nationwide, and utilise case studies in rural, inter-urban and urban areas.

**Issues to be addressed** relating to the current charging system and internal costs in rural, inter-urban and urban areas would include:

- The performance of the current charging system, e.g. what is the balance between the sums of money spent and charges levied.

- The current allocation of internal costs to different trips or vehicle types. Is this broadly correct?

- Is there scope, therefore, for updating the system as it stands, in the allocation of costs, charging methods, and levels of charge?

- What are the costs of different types of trip by area?

- How would different objectives affect the system? For example, what are the implications of different approaches to the treatment of assets, are they sunk costs or are they assets on which a commercial return is to be earned?

To these internal costs must then be added the **principal externalities**:

- Can the environmental costs associated with different types of trip in different areas be quantified and valued? Can reasonable estimates be made?

- The congestion cost per trip, estimated perhaps form speed/flow relationships and values of time. How does this vary from area to area, or by road type?

- The safety externality per trip, by area and by type of trip.

The **analysis** should include:

- The derivation of the costs associated with trips by different types in different areas;

- An assessment of the effect on costs per trip of different objectives;

- A comparison with current charges;

- The application of elasticity values to predict demand responses to changes in charges;

- An assessment of total trips by type and area to give an indication of the revenue consequences of changes in pricing policies.

The **key decisions** to be taken would include:

- The pricing policies which should be taken forward for more detailed study (e.g. can prices based on full social costs be contemplated? are the expected revenue implications acceptable?);

- Would equity considerations or considerations of rural and urban impacts, for example, require modifications to pricing policies?

- Which cost estimates - internal or external costs - are particularly uncertain and potentially important, and need further research?

### 2.4.2 Stage Two: Conceptual Studies

These studies would build on the Preliminary Review, focusing on the priorities identified from that review. These are likely to relate to external costs rather than internal costs, and to urban areas rather than rural or inter-urban since efficient prices are likely to differ more widely from the current charges applied in urban areas.

Improvements to the procedures used in Stage one should include:

- The development of simple, strategic models based on postulated values (elasticity values, speed flow relationships). Such models would provide more robust means for estimating responses to charges, and variations in charges and, hence, better estimates of the benefit and revenue implications of different charging policies.

- Research, decided upon after Stage one, into key elements of valuation (external costs, perhaps) or predictive relationships.

- Attitudinal research and research into appropriate technologies should be undertaken.

The issues to be addressed in the Stage two analysis should be those addressed in Stage one subject to the decisions taken after Stage one, on, for example, the acceptability of some pricing policies. Again the analysis should address pricing issues in rural, inter-urban and urban areas.

The key decisions to be taken would include:

- Preferred pricing objectives (for example, pricing for economic efficiency, or pricing to meet a financial constraint, or pricing to meet an equity criterion) and hence pricing charges and mechanisms; and

- Whether or not there is an economic case for road pricing in, say, Auckland and Wellington, whether this is politically and practically acceptable, and the basis of a system design.

### 2.4.3 Stage Three: Detailed Research Programme

This programme would be a detailed assessment of the impact of the proposed pricing system. The emphasis of this stage is very likely to be on the urban areas and on the impact of road pricing (in the sense of congestion pricing) since it is in the urban areas that the change from current pricing policies will be most pronounced and the complexity of the transport system and the interactions within it are greatest.

A detailed research programme to inform the final design and evaluation stages of a road pricing programme and to pave the way for implementation would need to cover at least the research tasks set out below and very probably more. These tasks are identified under the following headings:

- Valuation,
- Measurement and Prediction,
- Road Pricing Instruments, and
- Attitudes to/Acceptability of Road Pricing.

#### 2.4.3.1 Valuation

The objective would be to establish the current marginal social costs of travel by vehicle type, by road type and by time of day. Principal research requirements will be:

- The **values of time** for all groups affected. Changes in the generalised costs of travel and in the responses to these changes, expressed as model parameters or elasticities, are crucial in evaluating the impact and effectiveness of any pricing policy. The two key unknowns are values of time and elasticities. Together they will determine the travel behavioural response to changes in prices, thereby determining the efficiency gains from pricing policies. They also indicate the efficiency loss if prices are set at levels other than MSC (if, for example, Ramsey pricing is followed to satisfy a financial constraint). Values of time are likely to be affected by incomes, by attitudes and by lifestyles suggesting that imported values should not be relied upon. Original research in New Zealand is likely to be required, if only to provide a check on imported values.

- The **value of changes** in the reliability of travel time. This is currently being researched in the UK and specifically in London. It will be useful to derive from this work the value of changes in mean travel times and, in comparison, the value of changes in the variation in travel times. If the latter is small relative to the former in the London context it is likely to be smaller in the New Zealand context. It would be sensible for New Zealand to learn from research elsewhere before embarking on its own.

- **Environmental costs.** The environmental impacts of roads and traffic, and their magnitudes, in the New Zealand context have to be established. A research exercise to establish these is underway. For pricing purposes it will be useful to establish the magnitudes of impacts which are related closely to fuel consumption, and those which are more closely linked to congestion.

- **Safety costs.** The safety impacts of traffic (their magnitudes and values) in the New Zealand context are required. The relationship of current accident levies to safety costs would need to be established.

#### 2.4.3.2 Measurement and prediction

For the detailed evaluation of road pricing proposals, it would be necessary to know current travel patterns and to have an appropriate model to reproduce them and provide a basis for prediction as follows:

- by origin and destination, at a suitably disaggregate spatial level,
- by mode,
- by purpose,
- by person type,
- by vehicle type, and
- by small time period, to allow the effects of varying charges by time period on the time of travel to be modelled.

Predictive relationships, for use in this model, may have to be developed from original research or it may be possible to import suitable relationships in key market segments. The following relationships will be required:

- Responses to changes in the generalised costs of travel (i.e. the more usual responses including changes of mode and destination and less usual responses including trip chaining, trip generation/suppression and change in the time of travel). This last is being specifically researched during the current London road pricing research.

- Responses to changes in the reliability of travel time, which is also being investigated in the current London work.

- Responses of businesses and goods vehicle movements to change in costs. These may include locational changes, in warehousing and distribution activities, as well as changes in times, modes and methods of delivery.

- Other potential locational changes in response to higher costs associated with city centre and urban activity. There may be a tendency for activities to move out of the cities, potentially leading to undesirable lengthening of trips and greater car dependency. The potential for such locational responses needs to be research in the New Zealand context. Such locational responses may also be prompted by attempts to impose costs directly on land owners and property developers.

#### 2.4.3.3 Road pricing instruments

The requirements will be to identify the merits of different pricing instruments in different locations and to ascertain individual and network responses to different instruments. This research activity has therefore to embrace all issues related to technology and all those of the design of the road pricing system. There is much research into technology issues currently underway. While some of the principles of system design could be imported to New Zealand, location specific systems ultimately have to be designed.

#### 2.4.3.4 Attitudes to/Acceptability of road pricing

Research will be required to ascertain the attitudes of different types of user, both individual and business users, and to develop an appropriate public awareness programme. An important consideration will be to identify the pitfalls which have to be avoided if a road pricing programme is to be successfully implemented. The attitudes research clearly has to be conducted locally but equally clearly should be informed by experience elsewhere.

#### 2.4.3.5 Summary

The principal requirements of the Stage 3 detailed research programme, as far as they are identifiable at this stage, drawing on Sections 2.4.3.1 - 2.4.3.4 are summarised in Table 3.1. Attention is drawn to the possibility of New Zealand being able to benefit from research conducted elsewhere. Those elements which appear to be of particular priority are identified, though the preliminary review and conceptual studies would allow these proposals to be more fully assessed.

#### 2.4.3.6 Decisions

This final stage of the research programme will have produced a fully defined land transport pricing system, embracing charging levels, charging mechanisms and technologies, for all vehicle and trip types in all areas. The key decision will be to implement the defined system.

## 2.5 Research Priorities

The three stages of the research programme proposed here are seen as essential, sequential activities, with subsequent stages dependent on preceding stages. In that sense all three stages are essential research activities.

**Stage One** does not involve new research. It consists of transport economists utilising whatever information is to hand together with their judgement. An output of Stage one will be a list of research requirements.

**Stage Two** will require research in the following areas:

- Into the attitudes of people and businesses to road pricing, to inform the decision on preferred pricing objectives. This has a high priority.
- Into technologies, to ensure that charges can be levied as envisaged through defined pricing mechanisms. This has a high priority.
- Possibly, into areas of particular importance and weakness (in, for example, valuing particular impacts or predicting responses) identified in Stage one. Research into such areas should be kept to a minimum at this stage. It should only be undertaken if robust decisions on preferred pricing objectives or a decision to introduce road

**Table 3.1 Summary of detailed research programme at Stage Three.**

| Research Topic | Comment | Potential Priority |
|---|---|---|
| **Valuation** | | |
| Values of time | • New Zealand research required | High |
| Values of changes in reliability of travel | • May not be important in New Zealand context | Low |
| Environmental costs | • Have to be researched in New Zealand context: work is currently underway | High |
| Safety costs | • Have to be researched in New Zealand context: there may already be appropriate information | Medium |
| **Measurement and Prediction** | | |
| Travel patterns and traffic model | • Expensive model development will ultimately be inescapable | High |
| Responses to changes in generalised cost | • Should be possible to combine existing New Zealand information, imported values, some supporting local research to confirm key values | High |
| Responses to changes in reliability of travel time | • Research in UK should inform New Zealand applications | Low |
| Responses of businesses and goods vehicles | • Local research will be required | Medium |
| Other potential locational changes | • Local research will be required | Low |
| **Road Pricing Instruments** | | |
| Merits of different pricing instruments | • Much research around the world should be drawn on | Low |
| Responses to different instruments | • Imported responses supported by limited local research may be appropriate | Low |
| **Attitudes to/Acceptability of Road Pricing** | | |
| Attitudes of individual and business users | • Local research will be required<br>• Research programmes should be informed by experience elsewhere | Medium |
| Public awareness programme | • Local research will required<br>• Research programmes should be informed by experience elsewhere | Medium |

pricing in the urban areas cannot be reached without such research. This research therefore has a low priority.

**Stage Three** research priorities are addressed in Table 3.1. There are three categories:

- **High** indicates values or prediction methods of fundamental importance to the development of an efficient land transport pricing policy. A high priority is given to these activities.

- **Medium** indicates values of or responses to pricing systems which are likely to be of less importance in the evaluation of pricing policies, but which nevertheless ought to be included in an appraisal and for which reliable estimates are required. Research into public attitudes towards and the acceptability of road pricing are included in this category.

- **Low** indicates the lesser impacts of or responses to road pricing or, in the case of road pricing instruments, issues which have been researched in the New Zealand context and which are being explored thoroughly elsewhere.

## 2.6 Research Timetable

The duration of the London road pricing programme research, from beginning to end which is from late 1987 to late 1994, is seven years. The actual research time during that period amounts to approximately four years, as follows:

- An initial literature review lasting around three months,
- A subsequent desk study of around eight months, and
- A 3-year detailed research programme.

The proposed research programme for New Zealand ought to allow elapsed times as follows:

- Stage One: Preliminary Review - up to 6 months
- Stage Two: Conceptual Studies - up to 1 year
- Stage Three: Detailed Research Programme - up to 2 years