

**HEAVY VEHICLE PRICING
OPTIONS: DEVELOPMENT AND
ASSESSMENT FRAMEWORK
DISCUSSION PAPER**

4 August 2010



Prepared by

**National Transport Commission
(as a contributor to the COAG Road Reform Plan Project)**

The purpose of this Discussion Paper is to stimulate comment and discussion. It does not reflect government (commonwealth, state or territory) policy or positions on the issue of road pricing

National Transport Commission

Heavy Vehicle Pricing Options: Development and Assessment Framework

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REPORT OUTLINE

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| Title: | Heavy Vehicle Pricing Options: Development and Assessment Framework |
| Address: | National Transport Commission Level 15/628 Bourke Street Melbourne VIC 3000 E-mail: ntc@ntc.gov.au Website: www.ntc.gov.au |
| Type of report: | Discussion Paper |
| Objectives: | To outline the process and methodology that will be undertaken to perform an economic assessment of heavy vehicle pricing reform options and stimulate comment and discussion. |
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| Abstract: | COAG is investigating the feasibility of alternative forms of pricing for road infrastructure access for heavy vehicles. These alternatives more closely relate prices to the actual usage of the road network by each vehicle as well as potentially providing a better link between road agency revenue and road expenditure. The Discussion Paper focuses on estimating road costs, outlining options for heavy vehicle pricing, describing the methodology for how prices will be developed and detailing the economic assessment framework that will be used to compare options. The economic assessment will be primarily based on understanding the impact that different pricing options have on road use behaviour. |
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| Comments by: | 14 September 2010 |
| Comments to be addressed to: | Matthew Clarke CRRP Pricing Stream Leader COAG Road Reform Plan 121 Exhibition Street Melbourne VIC 3000 |

FOREWORD

Transport is a major component of the Australian economy. Improved transport productivity can have a significant impact on the cost of freight and, ultimately, the cost to consumers for goods and services. With this in mind, the Council of Australian Governments (COAG) on 13 April 2007 set out an agenda for road infrastructure pricing reform to unlock more productivity from the road network and deliver more efficient pricing and investment through a market-based approach.

One of the first steps in this reform process was a new heavy vehicle pricing determination to ensure that heavy vehicles pay for access to the road network based on total recovery of historical road expenditures, with no cross-subsidies between different types of vehicles. The new prices that resulted from this determination were approved by the Australian Transport Council (ATC) in February 2008.

However, COAG recognised that the current charging framework, which consists of the combination of registration fees and a fuel-based road user charge, does not reflect the actual usage of the road network by an individual vehicle. Even with the new pricing determination, charges are based on averages that do not always accurately reflect the actual road wear that results from the mass of a vehicle, the distance travelled by a vehicle, or types of roads used by a vehicle (the location aspect of travel).

COAG also observed that there is a weak link between the revenue collected from heavy vehicle road charges and the expenditure on roads. In this light, COAG asked the ATC, which comprises all Australian transport ministers, to investigate the feasibility of an alternative system of pricing for heavy vehicles in which charges better reflect cost drivers (such as mass, distance and location) and in which the revenues from these charges are better linked to road expenditure.

The feasibility study is to be completed by the end of 2011. To undertake the feasibility study, governments established a COAG Road Reform Plan (CRRP) project. This project is governed by a project board (the CRRP Board), chaired by Gary Liddle (Chief Executive of VicRoads), which comprises senior representatives from governments around Australia. To support the development of the feasibility study, a number of streams of work were established. These include policy, pricing, business systems and legal and regulatory streams.

The policy stream has recently developed an Evaluation Framework Reference Guide and a Policy Framework Reference Guide, which outline the high-level principles that will guide the development of new alternative models as well as the framework within which the feasibility of different options will be assessed. These documents can be found on the CRRP website (www.roadreform.gov.au).

Following on from this, the pricing stream, led by the National Transport Commission (NTC), is evaluating the feasibility of pricing for the different components of road usage (e.g. mass, distance and location). The feasibility assessment will attempt to measure changes in road use behaviour that will result from application of alternative models and, based on these prospective changes, evaluate the high-level benefits from reform. This Discussion Paper will outline the approach and analysis that will be undertaken to support this evaluation.

NTC is therefore seeking public comment on the Discussion Paper as part of the pricing stream contribution to the CRRP project. Specific questions on which we are interested in

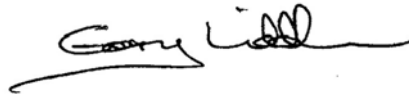
seeking feedback are at the end of most sections of the paper. These questions are focused on whether the approaches and methodologies that are outlined are sound and appropriate. It should be noted that the purpose of this Discussion Paper is to stimulate comment and discussion. It does not reflect government (commonwealth, state or territory) policy or positions on the issue of road pricing. In addition, the Discussion Paper addresses one aspect of the CRRP project and further discussion papers will be released on other aspects of the feasibility study in due course.

The NTC acknowledges the work of Matthew Clarke, Daniel Kelley, Emily Porter and Tony Xu in preparing this report, as well as the broader CRRP team.

The NTC would also like to thank Professor Kenneth A. Small, University of California-Irvine; Professor Christopher Nash, University of Leeds; and Professor Werner Rothengatter, Gernot Liedtke and Aaron Scholz from Karlsruhe Institute of Technology, Institute for Economic Policy Research in Germany, for their helpful comments on earlier drafts of this document. However, any errors within the document are the NTC's own and not the responsibility of the reviewers.



Greg Martin
Chairman
National Transport Commission



Gary Liddle
Chairman
COAG Road Reform Plan Board

Submissions to the Discussion Paper will be accepted until 14 September 2010. These can be made online at www.ntc.gov.au or by mail to:

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CRRP Pricing Stream Leader
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Melbourne VIC 3000

Submissions will be posted on both the CRRP web site (roadreform.gov.au) and the NTC web site (ntc.gov.au). Please note that confidential submissions will be made available to all government members of the CRRP Project.

The intention is to hold workshops on the Discussion Paper in August/September 2010. If you wish to participate in these workshops or would like more information about the report please contact Daniel Kelley, NTC Manager Economics on (03) 9236 5048 or dkelley@ntc.gov.au (or alternatively Matthew Clarke, CRRP Pricing Stream Leader and NTC Project Director Heavy Vehicle Pricing on (03) 9236 5028 or mclarke@ntc.gov.au).

If you wish understand more about the broader CRRP project please contact Neil Aplin, CRRP Project Director on (03) 9095 4408 or neil.aplin@transport.vic.gov.au.

EXECUTIVE SUMMARY

Background

An investigation into alternative heavy vehicle pricing models is being conducted as part of the Council of Australian Governments (COAG) Road Reform Plan (CRRP). The CRRP was established in April 2007 based on recommendations from the Productivity Commission's 2006 inquiry into Road and Rail Freight Infrastructure Pricing¹.

The Productivity Commission found that current road pricing and regulatory arrangements hamper the efficient use and provision of transport infrastructure, increasing costs for both industry and government. In particular, prices developed under the current system are highly averaged and are not sufficiently disaggregated.

The current system is designed to recover road agency expenditures, including maintenance expenditures to repair damage to the roads and expansionary capital expenditures to increase road strength and capacity. The current pricing model sets charges for all heavy vehicles through a fixed annual registration charge and a fuel-based road user charge (which is paid per litre of fuel consumed), using an allocation process that allocates road costs to different vehicle types.

The existing prices do not always accurately reflect the distance travelled, the mass transported or the type of road used by a heavy vehicle. As a result, some heavy vehicle operators pay more than the costs that road agencies incur when their vehicles use the road network, while others pay less.

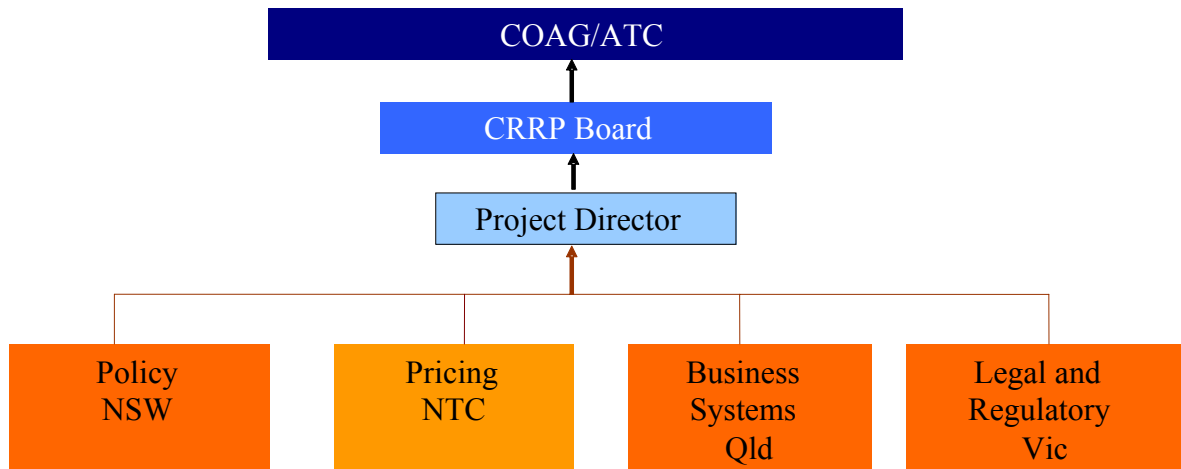
Prices that are more closely aligned to the actual costs of a heavy vehicle trip will encourage more efficient use of the road network. Heavy vehicle operators will be rewarded for choosing vehicle configurations and routes that impose fewer costs, leading to more efficient use of the road network. Some operators may have difficulty making adjustments in the short term. However, in the longer term, the vehicle fleet is likely to adjust to cost-based pricing and become more efficient as a result.

In addition to road wear, heavy vehicles impose social costs such as congestion, air pollution, greenhouse gas and accidents. Setting road prices equal to marginal social costs would allow these costs to be taken into account when freight transport decisions are made. The focus of this Discussion Paper will be on road wear and not social costs. The COAG Road Reform Phase 1 Report concluded that these 'externality' costs are best addressed locally at this time and would not be considered at this stage of the pricing reform process². The degree to which the preferred feasibility pricing options may provide the opportunity for pricing of some of these externalities at a later stage in the CRRP will be considered in the overall feasibility study.

As shown in Figure ES1, the development of the feasibility study is being led by a Project Director supported by four separate work streams under the direction of the CRRP Board.

¹ Productivity Commission, Road and Rail Freight Infrastructure Pricing, Inquiry Report No. 41, 2006. These recommendations are also broadly consistent with the recently completed Australian tax review (refer to Australia's Future Tax System, Final Report, Chapter E, www.taxreview.treasury.gov.au).

² COAG Road Reform Plan Phase 1 Report, May 2009.

Figure ES1. CRRP governance structure

The work streams and the organisations leading them are:

- **Policy (New South Wales):** establish the objectives and principles a new pricing framework must meet, and develop an assessment framework consistent with those objectives and principles.
- **Pricing (National Transport Commission):** identify, develop and assess pricing structure options to meet the policy framework and undertake the research required to assess the feasibility of different pricing approaches.
- **Legal and Regulatory (Victoria):** consider the legal constraints and implications of the various pricing options, as well as the required regulatory and institutional frameworks that would be required to optimise the benefits of the alternate pricing models.
- **Business Systems (Queensland):** consider the financial and compliance system and technology implications that result from the various pricing models and the associated legal and regulatory framework.

The policy stream has released two documents that will guide the development and evaluation of the reform across all of the work streams:

- The CRRP Policy Framework Reference Guide provides the context for undertaking the feasibility study, including an overview of the CRRP, the reasons for focusing on heavy vehicle charging and funding, the key functions of the heavy vehicle charging system and the reform objectives and principles³.
- The CRRP Evaluation Framework Reference Guide provides an overview of the framework, which will include a strategic merit test. The strategic merit test will consist of an assessment of the fit of the proposed reform options with the stated principles and objectives as well as a high level direct benefit cost assessment⁴.

³[COAG Road Reform Plan, Policy Framework Reference Guide, July 2010](#)

⁴[COAG Road Reform Plan, Evaluation Framework Reference Guide, July 2010](#)

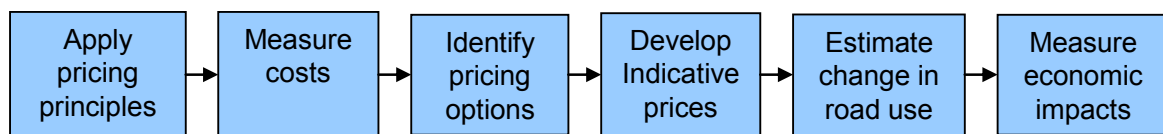
While this Discussion Paper is likely to raise a number of issues that will have implications for work being carried out through the other CRRP streams, the interactions between these issues and pricing options will be addressed by the CRRP team at a later stage in the reform.

Taking into consideration the pricing principles outlined in the CRRP policy framework, the focus for the pricing stream will be to develop alternative pricing models that seek to replace the existing registration and fuel charges pricing system and undertake analysis of the economic impact of these alternative models.

It should be noted that the economic assessment will be partial in that it will focus only on the impact of changes in the demand for road infrastructure resulting from alternative pricing models. Consideration of any institutional changes to funding and investment models, and any further benefits that will flow from these changes, will not be considered within the pricing stream. These supply side benefits of the reform, including the opportunity for better management of the road asset, will be assessed by other CRRP work streams as part of the broader CRRP program.

Therefore, the economic assessment in the pricing work stream will be focused on investigating the potential impact that the pricing models will have on road use behaviour. In this context, the paper follows the steps shown in Figure ES2. The alternative models have been developed taking into consideration the CRRP policy and pricing principles discussed below.

Figure ES2. Reform assessment process



1. ***Apply pricing principles:*** the overarching CRRP principles and objectives will guide the development and assessment process.
2. ***Measure costs:*** estimates of both the marginal cost of road wear and total road costs will be used to develop indicative prices. Marginal costs will be developed through the use of an engineering-economic cost model, which is under development. Alternative cost base approaches that could be used to measure total costs will be investigated as part of the reform. In the interim, the existing PAYGO cost base will be used for developing indicative prices.
3. ***Identify pricing options:*** five alternative pricing models will be investigated. These options are based on the principles of achieving improved economic efficiency and retaining total cost recovery.
4. ***Develop indicative prices:*** indicative prices will be developed for each of the pricing options as well as alternative supporting pricing structures.
5. ***Estimate change in road use:*** potential effects of these prices on road user behaviour will be estimated using demand elasticities that will be developed from surveys of operators and their customers. Potential operator and customer behavioural changes in terms of fleet mix, mass carried, routing choices and mode selection will be predicted.

6. **Measure economic impacts:** the economic assessment process will use the changes in road user behaviour to estimate transport sector impacts and potentially investigate broader economy-wide impacts on productivity, prices, employment, production etc.

Policy and pricing principles

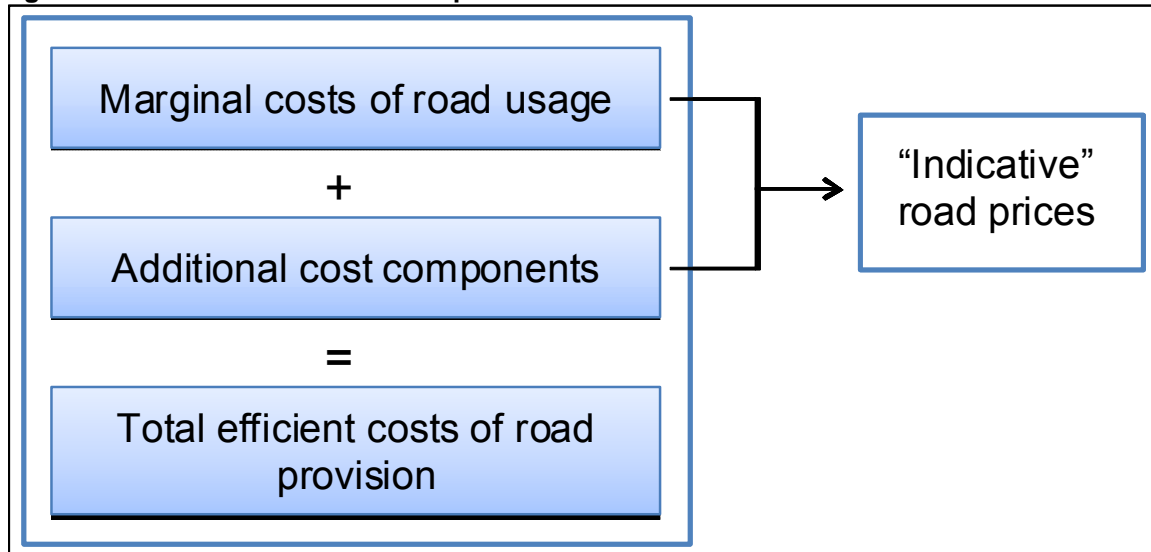
Two of the key CRRP pricing principles are that prices should, as far as possible, reflect marginal costs and that the prices should recover the efficient costs of providing roads. Marginal cost is an economic concept that measures the change in total cost resulting from one additional unit of output, such as one vehicle trip. Prices based on marginal cost are economically efficient because they provide signals for heavy vehicle operators to make operational choices that will reduce the costs that road agencies incur to maintain the roads. These principles aim to build upon COAG's existing agreed approach that heavy vehicle charging must ensure ongoing delivery of aggregate cost recovery and removal of cross subsidies between heavy vehicle classes⁵.

The pricing signals are expected to change the nature of road usage, with road users choosing the vehicle, the load transported and the roads travelled that are the most cost effective for their business needs. Given the existing freight task, the effect would be reduced road maintenance costs. However, if efficient road usage prices lead to an increase in the use of road freight (for example, through a shift in freight from other transport modes), total road maintenance costs could rise, but the road maintenance cost per tonne of freight should still fall.

In addition, if road agencies have better information regarding actual demand for road usage, there is potential for road agencies to make improved investment in the road network. This last point will be explored further in other CRRP work streams.

Heavy vehicle prices that are set at marginal costs will generally not recover the total heavy vehicle cost base, which includes, for example, the overhead costs associated with managing road networks. Overhead expenditures are not included in marginal costs. To recover total road agency costs from road user prices, additional cost components will need to be added to the marginal cost estimates. This could include using mark-ups on marginal cost-based usage rates and/or separate rate elements designed to ensure that the total cost base is recovered. A simplistic representation of this is outlined in Figure ES3.

⁵ COAG, COAG National Reform Agenda, Competition Reform April 2007 Response to Productivity Commission Rail Freight Infrastructure Pricing Report – COAG Response, 2007.

Figure ES3. Reform assessment process

Options for collecting total costs include multi-part tariffs that would include both fixed and variable rates or inverse elasticity (Ramsey) pricing that would apply variable mark-ups on usage rates, with the highest mark-ups placed on services with the least elastic demand. (Price elasticity of demand is a measure used to show the responsiveness, or elasticity, of the quantity demanded of a good or service to a change in its price.) In other words, mark-ups would be higher where there is a greater willingness to pay. While these tools would ensure cost recovery, they also have the potential to dampen the price signals offered by marginal cost-based prices and therefore need to be carefully constructed.

Measurement of marginal and total costs

Estimates of the marginal cost of road wear have been developed using an engineering - based marginal cost model developed with the assistance of the ARRB Group. The model estimates the marginal costs of road wear by identifying how the time stream of future road maintenance and repair expenses is affected by an increase in road usage, which is measured by additional units of mass carried on an axle group. The additional axle mass causes the road to deteriorate more rapidly, triggering an earlier intervention in the short run and possibly a strength upgrade of the road in the long run. The difference between the net present value of the cost stream to maintain the road with and without the additional trip represents the marginal cost of the trip.

Current heavy vehicle charges are set to recover the total allocated road costs based on the ‘pay as you go’ (PAYGO) cost base. PAYGO is based on a seven-year historical average of real road expenditure and road usage, with expenditure used as a proxy for cost. PAYGO assigns costs to several expenditure categories that can be broadly classified into road wear related costs, capacity related costs, corporate services costs and other costs.

The GHD Meyrick study⁶, completed in 2008 for Phase 1 of the CRRP, identified four alternative approaches to PAYGO for estimating the total costs that would be recovered from heavy vehicles. Developing alternative estimates of the cost base is not contemplated at this stage of the reform process since this would require substantial data collection.

Further research on how an alternative cost base model could be implemented, especially in the context of the road pricing approaches discussed later in this paper, will be

⁶ COAG Road Reform Plan (GHD Meyrick), Alternative Approaches to Estimating the Road Cost Base, July 2010.

undertaken as part of the feasibility study⁷. Pending completion of this research, the existing PAYGO approach used by the NTC will be applied to estimate the heavy vehicle cost base that will be used to develop indicative prices for analysis of the pricing models through the reform process. Therefore, the PAYGO expenditures will be considered as a proxy for total costs for purposes of the Discussion Paper.

Pricing models

Five pricing options have been identified that are broadly in line with the CRRP pricing principles, ranging from a fuel-based charge to full mass, distance and location (MDL) pricing. Table ES1 shows the base case and the five pricing model options that are proposed for assessment.

Option 1 would use fuel-based charges as a proxy for distance and mass, with less emphasis on registration charges than the current system⁸.

MDL pricing (Option 5) is intended to reflect the direct costs that heavy vehicles impose on the road network. Measuring mass and location may be expensive and technically challenging to implement and administer. Therefore, options short of full MDL, including distance only, distance-location and mass distance pricing options have also been considered (Options 3 and 4). These options are consistent with the array of pricing options that have been considered within Europe and the United States and also the options that were put forward by the Productivity Commission⁹.

⁷ It is not clear if alternative cost base approaches will deliver a higher or lower cost base than the current PAYGO system.

⁸ This option has been suggested by the Australian Trucking Association (ATA), see ATA's Fuel-based charging mechanism policy proposal overview v1.3.3, 2009.

⁹ Productivity Commission, Road and Rail Freight Infrastructure Pricing, 2006, pp. 232-239.

Table ES1. Pricing model options

| Model options | Explanation |
|--|--|
| Base case: Status quo | This is the base case and the current road pricing system that involves registration and fuel excise-based charges. |
| Option 1: Fuel-based distance price | The fuel excise system is used as the basis for road pricing. This is a proxy for pricing for distance and mass as fuel usage varies with distance travelled and the mass carried. |
| Option 2: Kilometre-based distance price | The road price is based on a system that attempts to measure the actual distance travelled. |
| Option 3: Distance-location-based price | The road price is based on a system that attempts to measure distance travelled taking into account the location of the vehicle. |
| Option 4: Mass distance-based price | The road price is based on a system that attempts to measure distance travelled taking into account the actual mass of the vehicle. |
| Option 5: Mass distance-location-based price | The road price is based on a system that attempts to measure distance travelled and vehicle mass taking into account the location of the vehicle. |

A preliminary Strategic Merit Test (as per the CRRP Evaluation Framework¹⁰) has been undertaken to ensure the proposed pricing options broadly align with the pricing principles, with a more detailed test to be undertaken following industry consultation.

Developing indicative prices

The fuel-based charge would recover all costs through a charge per litre of fuel consumed plus an annual registration charge. Under an MDL-based charge, there are a variety of pricing structures that can be considered to support the recovery of total costs while maintaining the efficiency benefits of setting prices equal to marginal cost. The marginal cost estimates must be adapted to fit with the four MDL pricing model options within a rate structure that is easy to understand and implement. Indicative prices will be developed based on four cost categories used in the PAYGO cost allocation model: road wear, capacity, corporate services (overhead) and an ‘other’ category that includes residual costs. The prices are indicative because they are considered preliminary in the context of any new pricing structure.

What is clear is that with a full MDL price (Option 5), operators travelling less than average distances on good quality roads at a lower than average mass level would pay less than the current prices, while an operator travelling with above average distances, higher than average mass and on poor quality roads would pay more than the current prices.

Road user behavioural changes






The objective of the pricing models is to send signals to heavy vehicle operators to change their road usage behaviour in ways that provide for more efficient road usage. Demand elasticity estimates will be used to measure behavioural changes in response to new road price signals to understand both long run and short run behavioural responses. Price elasticity of demand is a measure used to show the responsiveness, or elasticity, of the quantity demanded of a good or service to a change in its price. The elasticities are

¹⁰ COAG Road Reform Plan, Evaluation Framework, March 2010.

currently being developed through a survey of market of participants (transport operators, logistics providers, freight consignors etc.). The survey will be designed to gain an understanding of how road price changes will affect decisions regarding vehicle types, routing, modes, etc.

Each proposed high-level pricing model and associated scenario will generate a different set of price signals for heavy vehicles. These pricing signals will impact the behaviour of road transport operators, freight forwarders, freight customers and road owners in both the short run and long run. Some examples are illustrated in Figure ES4.

Figure ES4. Transport sector impact

| Type of impact | Examples |
|--|--|
| <ul style="list-style-type: none"> • Change in freight rates charged |  <ul style="list-style-type: none"> • road access price changes may or may not flow through to freight rates in the short term |
| <ul style="list-style-type: none"> • Change in road usage |  <ul style="list-style-type: none"> • distances travelled, loads carried by axle, and road types accessed |
| <ul style="list-style-type: none"> • Changes in vehicle and equipment used |  <ul style="list-style-type: none"> • more axles, different vehicle configuration (e.g. more or less trailers) |
| <ul style="list-style-type: none"> • Changes in mode |  <ul style="list-style-type: none"> • freight moving to/from road, rail and sea |
| <ul style="list-style-type: none"> • Changes to the supply chain |  <ul style="list-style-type: none"> • location and use of distribution centres and logistics operations |

Economic impacts

Once demand elasticities have been estimated, the economic impact of changes in road use behaviour will be evaluated. This will take into account road agency savings that may result from more efficient (less damaging) use of the roads by heavy vehicles as well as other economic impacts, such as the costs incurred by vehicle operators to switch vehicle types. The transport sector analysis will include an assessment of the impact of road use behaviour changes on different industry sectors, communities and geographic locations.

If there are net benefits from pricing reform, economy-wide productivity improvements may follow. Transport sector resources saved can be used to produce goods and services in other sectors of the economy. Possible productivity improvements resulting from improved pricing signals in the freight sector may also flow through to broader economy. Economy-wide impacts on prices, employment, production and even foreign trade may be assessed through the use of a computational general equilibrium model. These models, which are based on the input-output structure of the economy, can be used to show how changes in transport sector costs will affect other sectors of the economy.

Next steps

The next steps are to:

- Develop and refine indicative prices for each of the pricing models based on any refinements to the marginal cost model, taking into account feedback from government and industry consultation.
- Finalise the industry survey (elasticity study), due for completion by the end of 2010, and following this undertake analysis of the transport sector net benefits.
- Begin further analysis on alternative models for estimating the total cost base.
- Undertake further research on potential improvements to the road use data that is used in the modelling.

The next pricing Discussion Paper, due for release in early 2011, will provide preliminary results of the transport sector impacts based on results from the demand elasticity study.

CONTENTS

| | |
|--|-----------|
| REPORT OUTLINE..... | 1 |
| EXECUTIVE SUMMARY..... | I |
| 1. INTRODUCTION | 1 |
| 1.1 Background..... | 1 |
| 1.2 CRRP principles | 3 |
| 1.3 Pricing reform feasibility assessment | 5 |
| 1.4 Outline of the paper | 7 |
| 2. THE EFFICIENCY BENEFITS OF ROAD PRICING REFORM | 8 |
| 2.1 Road expenditures and costs | 8 |
| 2.1.1 Heavy vehicles and maintenance and repair expenditures..... | 8 |
| 2.1.2 Heavy vehicle road durability and capacity costs..... | 11 |
| 2.1.3 The social costs of heavy vehicle road use..... | 12 |
| 2.1.4 Road cost recovery..... | 12 |
| 2.2 Developing more economically efficient road prices..... | 13 |
| 2.2.1 Marginal cost | 14 |
| 2.2.2 The benefits of pricing at marginal cost..... | 16 |
| 2.3 Marginal cost and total cost recovery | 18 |
| 3. MEASURING ROAD COSTS | 21 |
| 3.1 Measuring the total cost base..... | 21 |
| 3.2 Measuring the heavy vehicle total cost base | 23 |
| 3.3 Marginal cost model..... | 25 |
| 3.3.1 Model description..... | 25 |
| 4. ALTERNATIVE PRICING MODELS..... | 27 |
| 5. DEVELOPING INDICATIVE PRICES | 30 |
| 5.1 Alternative pricing models..... | 30 |
| 5.2 Fuel-based charging model | 30 |
| 5.3 Developing prices for the mass-distance-location (MDL) based models | 31 |
| 5.3.1 Economic approach to pricing | 31 |
| 5.3.2 Designing rate structures to recover marginal and total costs | 32 |
| 5.3.3 Road wear marginal cost pricing for each pricing option..... | 33 |
| 5.3.4 Pricing structure for each of the non-road wear cost components..... | 35 |
| 5.3.5 Application of the MDL prices to vehicle characteristics | 37 |
| 5.4 Potential pricing outcomes..... | 38 |
| 5.5 Community service obligations/subsidies | 39 |
| 6. ROAD USE BEHAVIOUR..... | 41 |
| 6.1 The range of possible behavioural changes | 41 |
| 6.2 Demand elasticity analysis | 43 |
| 7. ECONOMIC IMPACTS | 44 |
| 7.1 Economic impact evaluation framework | 44 |
| 7.1.1 Transport sector costs and benefits | 45 |
| 7.1.2 Broader economic impacts | 45 |
| 8. CONCLUSION..... | 46 |
| REFERENCES..... | 47 |
| APPENDIX A MARGINAL COST MODEL METHODOLOGY, ASSUMPTIONS AND INPUTS..... | 49 |
| A1 Analytical approach | 49 |
| A2 Key assumptions | 51 |
| A3 Data inputs..... | 51 |

LIST OF TABLES

| | | |
|------------|---|-----|
| Table ES1. | Pricing model options..... | vii |
| Table 1. | Short run and long run marginal costs | 15 |
| Table 2. | Types of short and long run marginal costs..... | 16 |
| Table 3. | PAYGO cost allocators | 22 |
| Table 4. | PAYGO cost allocation rules..... | 23 |
| Table 5. | Alternative approaches to estimating the cost base..... | 24 |
| Table 6. | Pricing model options..... | 28 |
| Table 7. | Road type classification | 35 |
| Table 8. | Combination of fixed and variable charges by cost category..... | 36 |
| Table 9. | Application of rates to vehicle characteristics | 37 |
| Table A1 | Key ARRB model inputs | 51 |

LIST OF FIGURES

| | | |
|-------------|--|------|
| Figure ES1. | CRRP governance structure..... | ii |
| Figure ES2. | Reform assessment process..... | iii |
| Figure ES3. | Reform assessment process..... | v |
| Figure ES4. | Transport sector impact | viii |
| Figure 1. | CRRP governance structure | 2 |
| Figure 2. | Reform assessment process | 6 |
| Figure 3. | B-double axle groups..... | 9 |
| Figure 4. | Road wear is an increasing function of axle weight | 10 |
| Figure 5. | Road wear depends on road type | 11 |
| Figure 6. | The current system averages costs | 13 |
| Figure 7. | Pricing approach | 20 |
| Figure 8. | Allocation of costs to the new cost components | 25 |
| Figure 9. | Estimation of prices for road wear cost component..... | 34 |
| Figure 10. | Mass-distance-location model options | 36 |
| Figure 11. | Indicative prices examples..... | 39 |
| Figure 12. | Steps in road reform assessment..... | 44 |
| Figure A1 | Duration model..... | 50 |

ACRONYMS

| | |
|-------|----------------------------------|
| AGM | average gross mass |
| ATC | Australian Transport Council |
| COAG | Council of Australian Government |
| CRRP | COAG Road Reform Plan |
| EC | European Commission |
| ESA | equivalent standard axle |
| LCVs | light commercial vehicles |
| LRMC | long run marginal cost |
| MDL | mass distance-location |
| PAYGO | pay as you go |
| PCU | passenger car unit |
| SAR | standard axle repetitions |
| SRMC | short run marginal cost |
| VKT | vehicle kilometres travelled |

1. INTRODUCTION

This introduction provides:

- background on the COAG Road Reform Plan
- a summary of the policy principles that guide the reform
- an outline of this Discussion Paper

1.1 Background

The Council of Australian Governments (COAG) Road Reform Plan (CRRP) was established in April 2007 based on recommendations from the Productivity Commission's 2006 inquiry into Road and Rail Freight Infrastructure Pricing¹¹. These recommendations are also broadly consistent with the recently completed Australian tax review¹². The Productivity Commission found that current road pricing and regulatory arrangements hamper the efficient use and provision of transport infrastructure, increasing costs for both industry and government. Reforming the heavy vehicle pricing system has significant potential to address these issues and markedly improve the efficiency of the road network.

Based on the outcomes of an initial research phase, governments agreed to undertake a feasibility study of an alternative system of pricing for heavy vehicles as part of Phase 2 of the CRRP. The reform plan comprises three phases:

- Phase 1 comprised a new heavy vehicle pricing determination¹³ and a number of research projects including a review of externalities, community service obligations, the PAYGO cost base and incremental pricing trials. In addition, national guidelines for transport system management were introduced.
- Phase 2 will deliver a feasibility study of alternative heavy vehicle road infrastructure pricing models. This study will involve a detailed examination of the advantages and disadvantages of alternative heavy vehicle direct pricing options (eg, pricing based on mass, distance and/or location), and the associated reforms that will be needed to implement a preferred pricing option. Phase 2 is to be completed by December 2011.
- Based on the findings of the feasibility study, COAG will determine whether to proceed further with the reform program as part of Phase 3.

Importantly, the feasibility study will investigate the possible options and benefits from implementing a new heavy vehicle pricing model that better reflects the drivers of road costs (such as mass, distance and location) and where the revenues from road pricing are better linked to road expenditure. Specifically, heavy vehicles are responsible for a substantial portion of road agency and local government maintenance expenditures. Improved price signals can encourage heavy vehicle operators to make a range of choices

¹¹ Productivity Commission, Road and Rail Freight Infrastructure Pricing, 2006.

¹² The Australian tax review makes a number of suggestions for road reform, which are broadly consistent with the approach taken here. See Australia's Future Tax System, Final Report, Part 2, Volume 2, Chapter E, 2009, www.taxreview.treasury.gov.au.

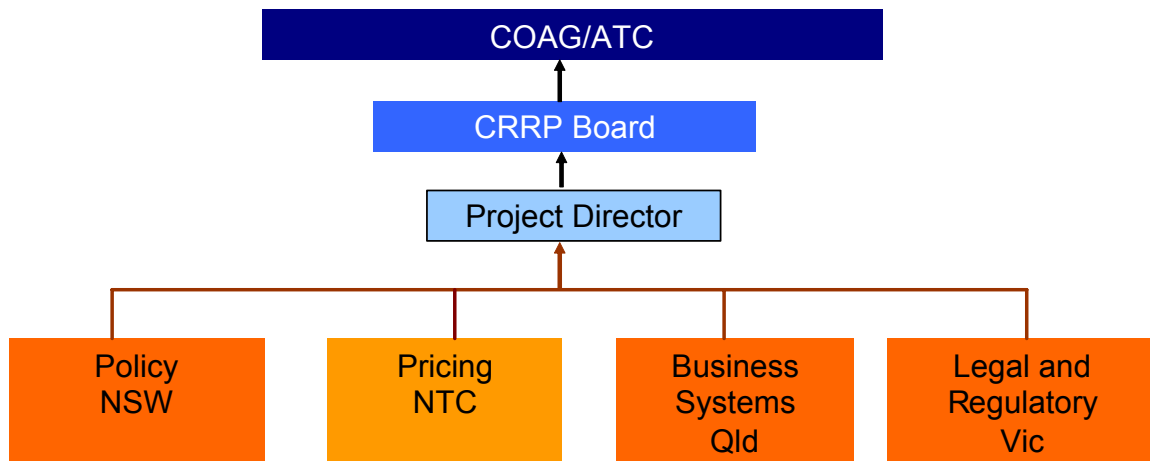
¹³ The determination reflected COAG's existing agreed policy that heavy vehicle charging must ensure ongoing delivery of aggregate cost recovery and removal of cross subsidies between heavy vehicle classes (COAG, COAG National Reform Agenda, Competition Reform April 2007 Response to Productivity Commission Rail Freight Infrastructure Pricing Report – COAG Response, 2007).

that will reduce maintenance costs. For example, as discussed in more detail in Section 2.1.1, switching to vehicles that spread the mass carried over more axles will reduce road damage. If the price of transporting mass is based on the actual costs imposed on the road network, heavy vehicle operators may find it economic to make the switch. A variety of other possible short term and long term responses to efficient price signals that could improve overall efficiency are described in Section 2.

Pricing reform can also contribute to more efficient road provision by road agencies. Eliminating the current disconnect between revenues and maintenance expenditures can provide information to road agencies about how their roads are being used and help to ensure that maintenance, repairs and possibly upgrades and new investments are undertaken at appropriate times.

As shown in Figure 1, the development of the feasibility study is being led by a Project Director supported by four separate work streams under the direction of the CRRP Board.

Figure 1. CRRP governance structure



The work streams and the organisations leading them are as follows:

- **Policy (New South Wales):** establish the objectives and principles a new pricing framework must meet, and develop an assessment framework consistent with those objectives and principles.
- **Pricing (National Transport Commission):** identify, develop and assess pricing structure options to meet the policy framework and undertake the research required to assess the feasibility of different pricing approaches.
- **Legal and Regulatory (Victoria):** consider the legal constraints and implications of the various pricing options, as well as the required regulatory and institutional frameworks which would be required to optimise the benefits of the alternate pricing models.
- **Business Systems (Queensland):** consider the financial and compliance system and technology implications which result from the various pricing models and associated legal and regulatory framework.

The policy stream has released the following two documents that will guide the development and evaluation of the reform across all of the work streams:

- **COAG Road Reform Plan Policy Framework Reference Guide:** provides the context for undertaking the feasibility study, including an overview of the CRRP,

and the reasons for focusing on heavy vehicle pricing and expenditure, the key functions of the heavy vehicle pricing system, and the reform objectives and principles¹⁴. These principles are outlined in Box 1.

- **COAG Road Reform Plan Evaluation Framework Reference Guide:** provides an overview of the evaluation framework. This includes a Strategic Merit Test, which will assess the fit of the proposed reform options with the stated principles and objectives and a high level direct benefit cost assessment. In addition, the paper contains a discussion of how the framework will operate and the approach that will be used to assess the potential macroeconomic benefits from the reforms¹⁵.

The CRRP Policy Framework articulates a compelling case for reform:

‘the rapidly growing freight task combined with continuing growth in the number of vehicles has placed considerable strain on Australia’s roads [...] Maintenance and expansion of the road network has not kept pace with increasing demand for road use, leading to road deterioration, reduced speeds, and constrained access – ultimately acting as a handbrake on Australia's economic prosperity’¹⁶.

This paper builds on the work of the policy stream by describing how alternative heavy vehicle pricing options will be developed and assessed to support the CRRP feasibility study. While this paper is likely to raise a number of issues that will have implications for work being carried out through the other CRRP streams, the interactions between these issues and pricing options will be addressed by the CRRP team at a later stage in the reform.

1.2 CRRP principles

As discussed above, the policy stream has developed a policy framework to guide the feasibility study development. The policy framework includes policy, pricing and funding principles for the development of a new heavy vehicle road charging system (see Box 1.)

¹⁴ [COAG Road Reform Plan, Policy Framework Reference Guide, July 2010](#)

¹⁵ [COAG Road Reform Plan, Evaluation Framework Reference Guide, July 2010](#)

¹⁶ COAG Road Reform Plan, Policy Framework Reference Guide, July 2010, p. 3-4.

Box 1: CRRP policy framework***Policy principles***

The feasibility study should:

1. Support the delivery of a national seamless economy.
2. Support efficient provision and maintenance of roads.
3. Support productive and efficient use of roads.
4. Support staged implementation of recommended reforms, where practical difficulties preclude near term implementation.
5. Be implemented with regard to the impacts on all road users and other affected parties.
6. Not foreclose or be conditional on possible additional future reforms in the road industry.

Pricing principles

1. Recover the efficient cost of providing, maintaining and operating roads for use by heavy vehicles.
2. Be forward-looking and provide incentives for efficient and effective 'life-cycle' road provision and maintenance.
3. Be determined with reference to:
 - the marginal cost of road provision, maintenance and operation.
 - the transaction costs associated with the charge.
 - the extent that heavy vehicle road users are able or likely to respond to price signals.
 - minimising distortions to the efficient pattern of use of the road network.
4. Be developed through continuously improving transparent and public processes.

Funding principles

1. Funding should finance the efficient provision, maintenance and operation of roads to meet current and future demand.
2. Revenue from heavy vehicle charges should be linked to heavy vehicle road expenditure.
3. Social obligations associated with the provision of roads should be explicitly and transparently defined and funded.

COAG Road Reform Plan, Policy Framework Reference Guide, July 2010.

The pricing principles listed in Box 1 are used to develop heavy vehicle road pricing options and to guide the methodology for developing the indicative prices that will be used in the feasibility study¹⁷.

There may be trade offs in applying these pricing principles to pricing options. For example, pricing principle 3 requires heavy vehicle prices to be set with reference to marginal costs, taking into account the transaction costs associated with the pricing model. However, accurate road pricing based on marginal cost may increase transaction costs (in the form of compliance and billing costs), creating a trade off. There is also a trade off between recovering total costs and pricing based on marginal cost. Prices set at marginal cost will generally not recover total costs. Therefore, in the application of these principles the aim is to develop prices that more accurately reflect the marginal costs of road wear, while acknowledging that prices set at marginal cost may not deliver all the outcomes sought from a pricing regime.

1.3 Pricing reform feasibility assessment

Taking into consideration the pricing principles, the focus for the pricing stream will be to develop alternative pricing models that seek to replace the existing registration and fuel charges pricing system and undertake analysis on the economic impact of these alternative models. The economic analysis in the pricing work stream will focus on:

- Determining the relative importance of pricing for the different elements that impact road usage costs (i.e. mass of the vehicle, the distance travelled and the location of travel) in terms of their impact on transport operator behaviour. In addition, the objective will be to determine the form of pricing that provides the greatest economic benefit (i.e. fixed vs variable charges, pricing by vehicle kilometre, axle kilometre, etc.). The ultimate assessment will consider the costs of the business systems required to implement the pricing options (these issues will be investigated in the business systems stream).
- Assessing the high-level benefits available from alternative pricing models as a result of changes in road use behaviour.

The analysis will be partial in that it will focus only on the impact of changes in the demand for road infrastructure resulting from alternative pricing models. Consideration of any institutional changes to funding and investment models, and any further benefits that will flow from these changes, will not be considered within the pricing stream. These supply side benefits of the reform, including the opportunity for better management of the road asset, will be assessed by other CRRP work streams as part of the broader CRRP program.

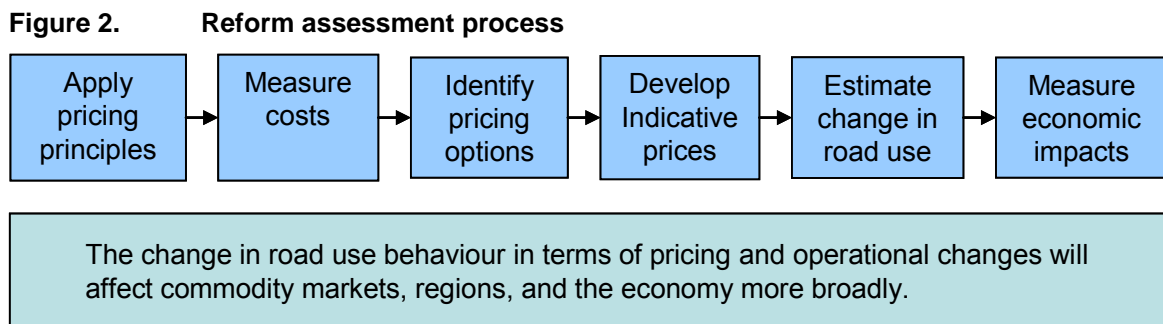
Following from development of the pricing principles, the analysis and assessment of the pricing models under consideration will be undertaken over the course of 2010 and the early part of 2011 as follows:

1. **Apply pricing principles:** the overarching CRRP principles and objectives will guide the development and assessment process.
2. **Measure costs:** total road costs to be recovered will be based on the existing PAYGO cost base while prices based on marginal costs will be developed through the use of an engineering-economic cost model, which is under development.

¹⁷ Prices developed here are indicative because work is continuing on refining the marginal cost model discussed in section 3.

3. **Identify pricing options:** five alternative pricing models will be investigated. These options are based on the principles of achieving improved economic efficiency and retaining total cost recovery.
4. **Develop indicative prices:** indicative prices will be developed for each of the pricing options. In addition, a number of alternative pricing structures for recovering total road costs will be explored.
5. **Estimate change in road use:** potential effects of these prices on road user behaviour will be estimated using demand elasticities that will be developed from surveys of operators and their customers. Potential operator and customer behavioural changes in terms of fleet mix, mass carried, routing choices and mode selection will be predicted.
6. **Measure economic impacts:** the economic assessment process will use the changes in road user behaviour to estimate transport sector impacts and potentially investigate broader economy-wide impacts on productivity, prices, employment, production, etc.

This process is illustrated in Figure 2.



The assessment will depend on developing a number of inputs, including:

- data on road usage by type of road and type of vehicle
- estimates of total and marginal costs
- specifications of alternative pricing structures and prices
- estimates of the likely changes in transport sector behaviour in response to pricing changes
- estimates of the savings in road maintenance costs that might result from pricing reform
- evaluation of transport sector and broader economic changes

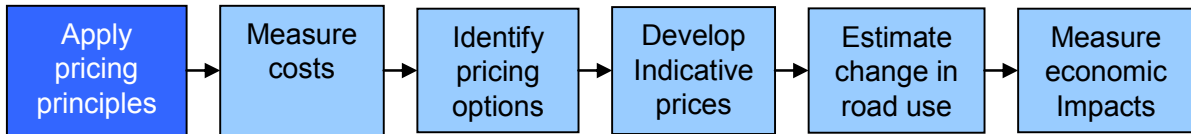
The Discussion Paper will describe the data, economic models and methodology necessary to assess the feasibility of alternative road pricing models.

1.4 Outline of the paper

The purpose of this paper is to explain how pricing options and the resulting indicative prices will be developed and how the potential effects of reform will be assessed for the feasibility study. The structure of this document is broadly in line with Figure 2 and is as follows:

- **Section 2 *Efficiency Benefits of Road Pricing Reform***: provides an overview of the potential benefits that application of the CRRP policy and pricing principles for heavy vehicle road user price reform may deliver.
- **Section 3 *Measuring Road Costs***: discusses the most economically appropriate methods to set road prices for heavy vehicles taking into account the pricing principles.
- **Section 4 *Alternative Pricing Models***: outlines the high-level pricing model options that will be considered.
- **Section 5 *Developing Indicative Prices***: provides an overview of how indicative prices will be developed for each of the pricing model options.
- **Section 6 *Road Use Behaviour***: provides an overview of how the changes in road use behaviour from the different pricing models will be estimated.
- **Section 7 *Economic Impacts***: provides the assessment framework that will be used to evaluate the economic effects of road use behaviour changes.
- **Section 8 *Conclusion***: summarises the paper and describes the next steps in the assessment process.

2. THE EFFICIENCY BENEFITS OF ROAD PRICING REFORM



This section discusses:

- the costs that result from heavy vehicle use of the roads
- the potential efficiency benefits from reforming the prices heavy vehicle operators pay for road use
- economic approaches to measuring road user costs and developing prices

The relationship between heavy vehicle use of the roads and road agency expenditures is discussed in Section 2.1. The way in which road reform can lead to more efficient use of the roads by heavy vehicles, and consequently increase economic efficiency, is described in Section 2.2.

2.1 Road expenditures and costs

There are four major types of road agency costs:

- Routine and periodic maintenance and rehabilitation – maintenance activities that restore/preserve the structural and functional integrity of the pavement, reduce future deterioration and remove safety hazards. For example, resheeting, overlays, (minor and major) patching, resealing, fixing potholes, crack sealing and shoulder grading would all be considered maintenance and rehabilitation activities.
- Capital improvements to existing roads – enhancements on existing roads that increase the traffic (volume) capacity and/or the mass carrying capability of a road (durability). For example, adding or widening lanes, widening intersections or deepening or strengthening pavements are all capacity enhancements.
- Construction of new roads – roads built to provide or improve access to remote or new communities as well as new highways to address urban congestion.
- Overhead – expenditures to support the overall road provisioning effort that do not fit into any of the first three categories (e.g. administrative costs).

These costs are incurred for the benefit of light and heavy vehicles.

2.1.1 Heavy vehicles and maintenance and repair expenditures

Routine and periodic maintenance is required to address road deterioration. Heavy vehicles are the primary source of road deterioration, with time and weather also impacting on pavement deterioration. Pavement engineers measure this deterioration in a variety of ways. Symptoms of deterioration include roughness, cracking and rutting. At some point intervention is required to repair the damage and restore the condition of the road. Importantly, if intervention to address road wear is postponed, the total maintenance and repair cost may increase¹⁸. For example, postponing repairs may lead to accelerated wear

¹⁸ Lindberg (UNITE), Marginal cost of road maintenance for heavy goods vehicles on Swedish roads, March 2002, p. 18.

and more rapid deterioration of the road, meaning that instead of a simple patch, a complete re-build may be necessary. The performance of most pavements is not affected by the mass applied to the road from passenger cars and light commercial vehicles, but the higher axle masses of heavy vehicles do cause road wear¹⁹. It is also important to note that the weight on each axle group is what matters, not the total weight of all axle groups. A vehicle weighing 10 tonnes may do less damage than one carrying eight tonnes, if the additional weight is distributed over a larger number of axles.

Essentially, a truck is made up of a number of axle groups. For example, a B-double truck is made up of four axle groups (Figure 3). Each axle group makes an independent contribution to road wear, with the amount of road wear depending on the configuration of the axle group. If the same weight is carried on each of the axle groups, a tri-axle group (the last two axle groups on the B-double in the illustration) will cause less damage than the tandem axle group (the second axle group in the illustration) as the weight is spread across a larger number of axles.

Figure 3. B-double axle groups

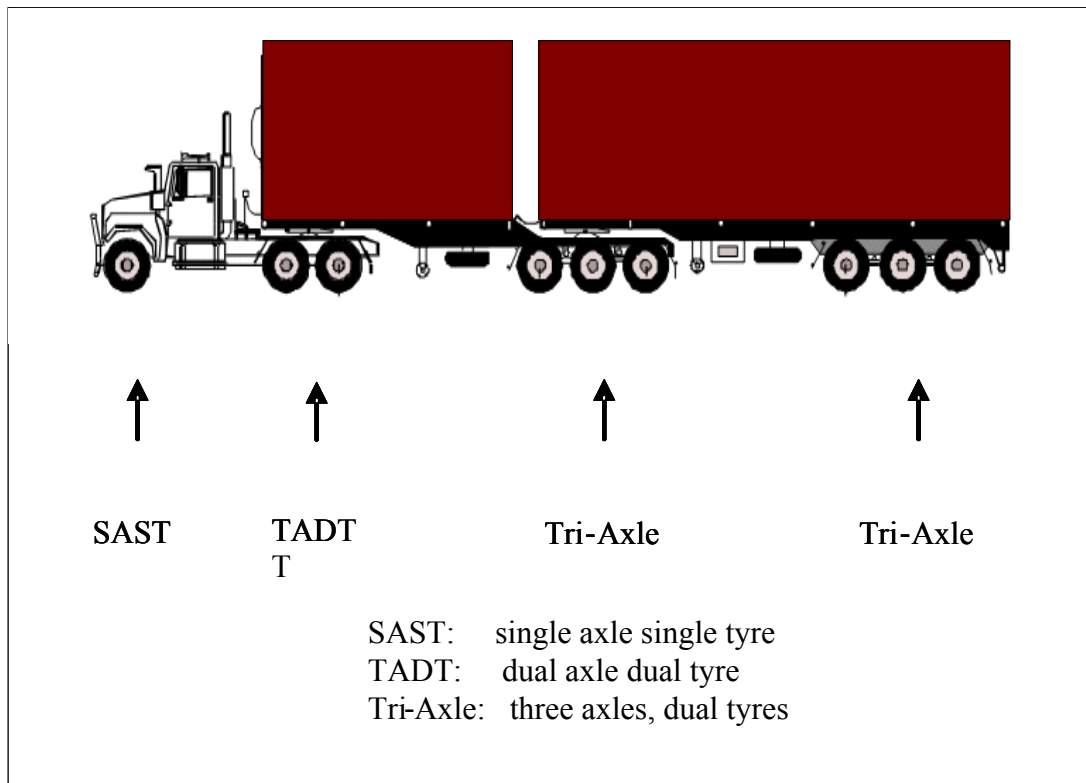
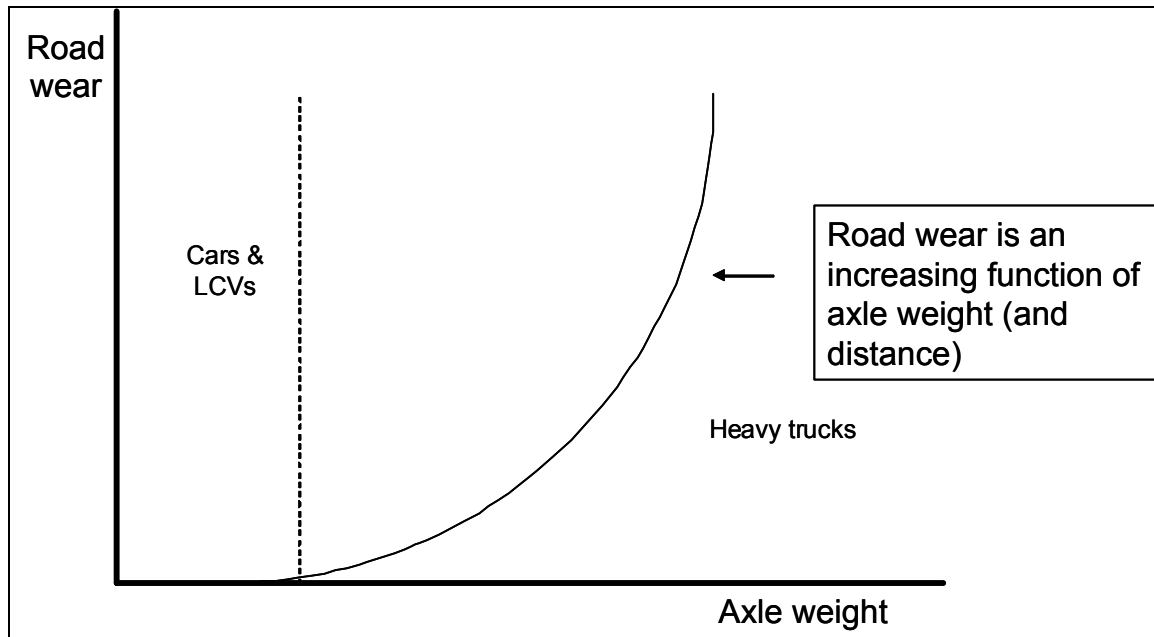


Figure 4 illustrates that cars and light commercial vehicles (LCVs) do little damage to the road, while heavy vehicles cause the majority of the road wear (the higher the mass on an axle, the greater the road wear). Figure 4 also illustrates that road wear caused by heavy vehicles increases more than proportionally to the increase in axle mass, meaning that a ten percent increase in axle mass leads to an even greater increase in road wear²⁰.

¹⁹ See Small, Winston and Evans, Road Wear: A New highway Pricing and Investment Policy, 1989, p. 11.

²⁰ The curve in Figure 4 illustrates the ‘fourth power rule’, an empirical finding that road damage increases exponentially with axle mass. Different roads may deteriorate at different rates. For a discussion of the derivation of the fourth power rule and an analysis of the empirical relationship between heavy vehicle road usage and road wear, see Small and Winston, Optimal Highway durability, American Economic Review, June 1988, pp. 560-69. Other maintenance cost drivers may be weather or the absolute number of heavy

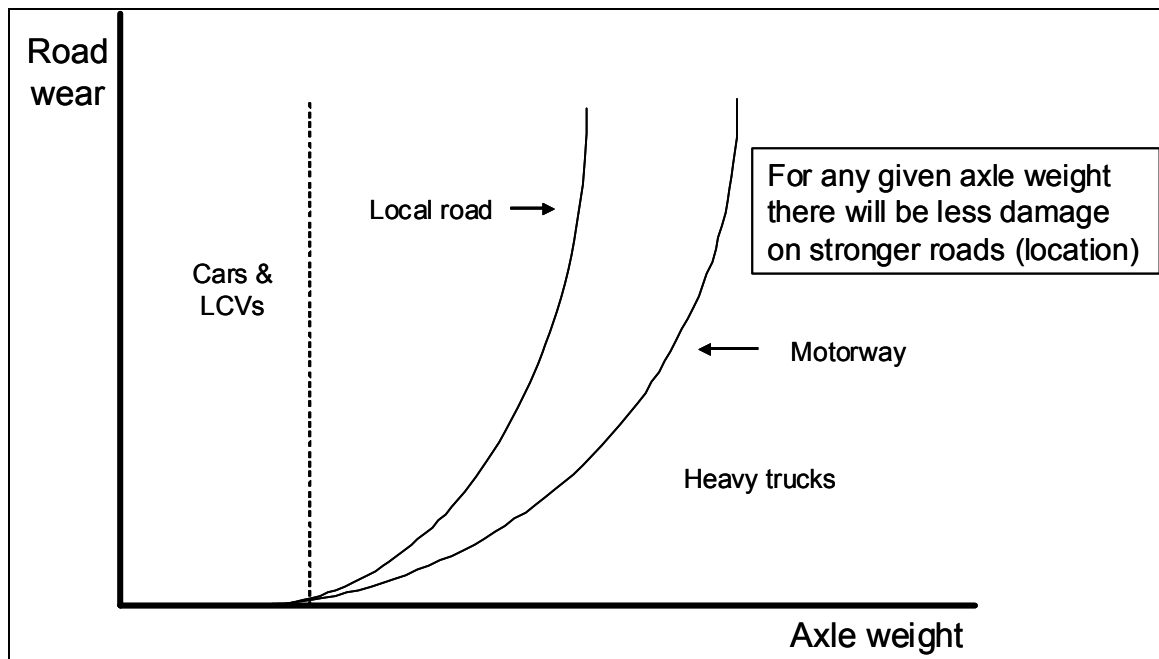
Figure 4. Road wear is an increasing function of axle weight

Roads built to a greater initial strength or durability (measured by the thickness of the pavement) are better able to accommodate heavier traffic. The greater strength slows down the deterioration of the road, resulting in lower road maintenance costs. Freeways and highways are typically built to the highest strength standards²¹. In contrast, local roads are generally built to withstand less weight than arterial roads and freeways or highways. Local roads are typically built to lower thickness standards because they carry smaller amounts of heavy vehicle traffic. As a consequence, they are more susceptible to damage from axle loads.

Figure 5 illustrates the relationships between road wear and vehicle mass and the type of road. This diagram shows that for any given axle mass, there will be more deterioration on a local road than on a freeway or highway. On both road types the costs imposed obviously increase with greater distances travelled.

vehicle trips on a road. See Lindberg, Gunnar, The marginal cost of road use – the fundamental theorem revisited, VTI, December 2004, Working Paper.

²¹ See Small, Winston and Evans, Road Work: A New Highway Pricing and Investment Policy, 1989, p. 41.

Figure 5. Road wear depends on road type

The conclusion is that road wear is a function of axle mass, distance travelled and road type.

2.1.2 Heavy vehicle road durability and capacity costs

Heavy vehicles are also responsible for a portion of road agency “expansionary” capital expenditures designed to improve or extend the road network.

- Road durability (or road strength) reflects the ability of the road to withstand high axle masses. Strength is related to the thickness of the road, but is also dependent on other variables such as the characteristics of the surfacing material and the underlying base. Road agencies often improve the strength of a road to allow for greater heavy vehicle access.
- Capacity refers primarily to the amount of peak hour traffic the road is capable of handling. Traffic capacity would be determined by the number and width of lanes as well as the presence or absence of medians and overpasses²².

Passenger cars, LCVs and heavy vehicle traffic all contribute to the need for capacity expenditures. Each heavy vehicle takes up relatively more space on the roads than LCVs and passenger cars due to their extra length and so use up more capacity on a per vehicle basis. This contribution of heavy vehicles to road expenditures can be captured by measuring heavy vehicle use in terms of passenger car units (PCUs). For example, a large B-double truck configuration may take up as much space on the road as four passenger vehicles or four PCUs. Heavy vehicles also contribute to capacity costs because their length requires larger intersections and turning circles.

²² See Small, Winston and Evans, *Road Work: A New Highway Pricing and Investment Policy*, 1989, p. 10.

2.1.3 The social costs of heavy vehicle road use

Heavy vehicles contribute to social costs such as congestion, air pollution, greenhouse gas and accidents²³. Economic theory suggests that optimal road prices would be set at marginal social cost, which would include the cost of road wear related to heavy vehicle travel plus any social costs imposed by the vehicle.

The European Commission (EC) for transport adopted a principle of charging at social marginal cost²⁴. In practice however, the EC directives on charging put forward an average cost approach, with differentiation allowed based on cost drivers. The most recent directive also strengthened the ability to differentiate charges based on the social costs of transport such as congestion²⁵. In Australia, some of these social costs may already be internalised, either wholly or partially, through other means such as insurance fees and safety and environmental regulations placed on vehicles and drivers.

The focus of the CRRP feasibility study will be on developing indicative prices that reflect the marginal costs related to road wear and not social costs. The COAG Road Reform Phase 1 Report concluded that these ‘externality’ costs are best addressed locally at this time and would not be considered at this stage of the pricing reform process²⁶. The degree to which the preferred feasibility pricing options may provide the opportunity for pricing of some of these externalities at a later stage in the CRRP will be considered in the feasibility study.

2.1.4 Road cost recovery

The current pricing model sets charges for all heavy vehicles through a fixed annual registration charge and a fuel-based road user charge (which is paid per litre of fuel consumed), using an allocation process that allocates road costs to different vehicle types. However, the COAG Phase 1 report noted that ‘the . . . system is poor at identifying particular vehicles that, through the nature of their activity, impose the greatest cost on the road system.’ Consequently, the existing fuel-based road user and registration charges based on the PAYGO model do not adequately reflect the differences in costs imposed by vehicles travelling with different mass levels on different road types. For example:

- Usage charges (based on fuel consumption) are not differentiated on the basis of location or road type even though a particular heavy vehicle will typically do more damage to a road with thin pavement than a road with thicker pavement.
- A substantial portion of heavy vehicle charges are from registration fees. All heavy vehicles in a given class pay the same vehicle registration fee even though some of those trucks may typically carry less mass than others, or travel different distances on different road types.

²³ Road wear increases vehicle maintenance costs and reduces amenity for all road users. Following Newberry, these costs will not be considered here given that appropriate road agency response to road damage will leave average road damage externalities constant. See Newberry, Road Damage Externalities and Road User Charges, *Econometrica*, March, 1988, pp. 295-316.

²⁴ Nash, Matthews and Menaz, Why Reform Transport Prices? An Overview of European Transport Infrastructure Charging Policy and Research, 2003.

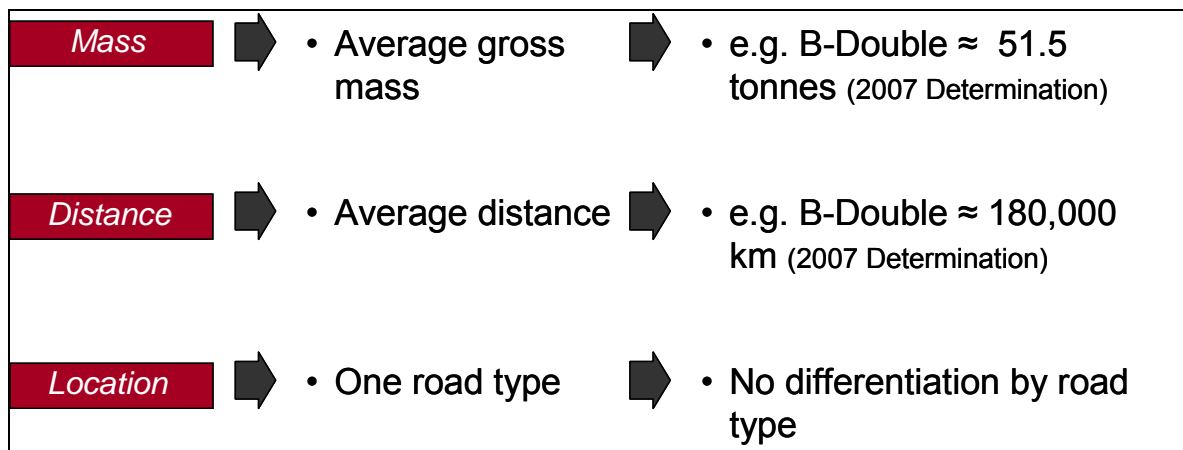
²⁵ Directive 2006/38/EC of the European Parliament and the Council amending Directive 1999/62/EC on the charging of heavy goods vehicles for the use of certain infrastructures.

²⁶ COAG Road Reform Plan Phase 1 Report, May 2009.

- The current pricing model also to some degree encourages fewer axles on a vehicle. For example, registration charges typically rise with the number of heavy vehicle axles even though for a given mass transported, a larger number of axles will cause less damage to the road.
- In addition, the requirement to maintain consistency among a large number of vehicle types and configurations leads to some pricing anomalies. The lead trailer of a B-Double is charged a substantial registration fee relative to the second trailer in order to maintain consistency with semi-truck trailer pricing requirements. This provides an incentive to use less efficient configurations, in terms of road wear damage.

In other words, as shown in Figure 6, the current charging system is based on allocating costs to each vehicle class based on averages and assuming one road type.

Figure 6. The current system averages costs



Therefore, a heavy vehicle that typically carries less than average mass (for its class of heavy vehicle) on stronger roads will pay more than the costs for which it is responsible. As discussed in the next section, prices that more directly reflect the costs imposed have the potential to increase economic efficiency, with resulting benefits to the economy.

2.2 Developing more economically efficient road prices

Economic efficiency refers to a situation in which resources are channelled to their most productive use (allocative efficiency) and goods and services are produced at the lowest possible cost (productive efficiency)²⁷. A vehicle pricing scheme that more closely aligns the prices charged for heavy vehicle access to the road network with the economic costs for road infrastructure provision has the potential to improve economic efficiency in the following ways:

- **Reduced heavy vehicle road costs:** price signals that more accurately align the costs of road provision with road usage will encourage heavy vehicle operators to make choices that reduce road wear and the resulting road maintenance costs. These changes may include short run changes such as the distances travelled, loads carried (by axle), roads used, rate of back loading and commodities carried as well as longer term changes such as reconfiguration of vehicle fleets. These changes

²⁷ Dynamic efficiency, which relates to the timely introduction of new products, services and cost-reducing innovations, is also an important efficiency driver.

have the potential to reduce the overall road wear caused by heavy vehicles, thus reducing the costs of maintaining and providing the road network.

- **Supply chain optimisation:** implementing more cost reflective road prices will allow freight customers to make supply chain decisions that reflect the true cost of providing transport along the supply chain. This may result in freight customers making adjustments such as changing the distribution or location of their logistics centres as well as changing inventory holding/delivery practices to take advantage of cheaper freight routes. The impact of these changes could be to reduce the number of kilometres travelled by their vehicle fleet.
- **Changes in mode:** improved price signals are likely to better direct shipments to the most efficient mode: road, rail, or sea²⁸.
- **Changes in road investment:** combining efficient road user prices with changes in the way pricing revenues are distributed to road agencies could provide opportunities for agencies to reduce overall road costs. For example, making adequate funds available for repairs when needed means that roads are less likely to be allowed to deteriorate to the point where they are ultimately even more expensive to repair. In addition, better price signals can allow road agencies to make more targeted investment in the road network to support freight needs.
- **Downstream productivity benefits:** the gains from improving allocative efficiency within the transport sector, through improved road pricing and funding, provide downstream productivity improvements across the broader economy. This may be achieved by reducing the overall cost of the freight task, leaving resources available for other productive activities.

Two fundamental changes are needed to increase economic efficiency. First, prices must provide signals to heavy vehicle operators that encourage them to make more efficient use of roads. Second, road agency revenues must be aligned with the costs that heavy vehicles impose on road networks. The next section discusses how to arrive at the correct price signals. Options for improving the way road agencies direct funds to the road network will not be investigated in the Discussion Paper. Rather, these options will be investigated as part of other CRRP work streams in the broader CRRP project.

2.2.1 Marginal cost

As the previous section demonstrates, prices based on average costs do not send the proper price signals to heavy vehicle operators. This section explains why basing prices on marginal costs, as reflected in the CRRP pricing principles, will send the correct pricing signals.

Marginal costs can be defined as the change in the total road costs resulting from a small increase in road usage. As Table 1 shows, marginal costs can be either short run (SRMC) or long run (LRMC). In the short run, the durability and traffic handling capacity of the road network is assumed to be fixed. In the long run, the cost of changes to accommodate additional demand for road network durability and capacity is included in marginal cost.

²⁸ Inefficient rail or road subsidies may produce pricing distortions that reduce the ability of price signals to improve the allocation of freight traffic to the most efficient mode.

Table 1. Short run and long run marginal costs

| Marginal cost | Definition | Cost implication |
|----------------------|--|---|
| SRMC | <i>The additional cost of maintaining a road within its defined roughness (or performance) level resulting from one unit of increased use, e.g. an additional vehicle trip.</i> In the short run both the durability and capacity of the road network is fixed. | An additional heavy vehicle trip, or an increased load on a vehicle will move forward the date at which intervention to address road wear is required. In any given year, road agency expenditures will have to increase to accommodate the increase in demand. |
| LRMC | <i>The additional cost resulting from an additional unit of traffic, allowing for road improvements to accommodate the increased demand.</i> These improvements could include the costs of pavement strengthening beyond the initial design strength to provide for higher traffic loadings as well as capacity changes, including stronger pavement, wider lanes, additional lanes or new roads. | Additional heavy vehicle traffic or increased loads on vehicles require expenditures to expand the traffic carrying capacity of the road or build stronger roads. |

Table 2 provides more detailed definitions of short and long run marginal costs²⁹. Essentially, in the short and long run there are two types of marginal costs: the first relates to maintaining or improving the durability of a road (SRMC and LRMC of road wear respectively) and the second relates to the impact of congestion and capacity improvements to accommodate additional traffic to alleviate congestion (SRMC of congestion and LRMC of capacity respectively)³⁰.

In practice, road agencies do not necessarily make maintenance and capital improvement decisions independently. For example, they may choose to address strength when they undertake road wear repairs or to address strength at the same time they address traffic handling capacity. This has complicated the marginal cost model analysis outlined later in the Discussion Paper.

²⁹ Based on definitions provided in Transportation Research Board, *Paying our Way: Estimating Marginal Social Costs of Freight Transportation*, Special Report 246, 1996.

³⁰ See Transportation Research Board, *Paying Our Way: Estimating the Marginal Social Costs of Freight Transportation*, 1996, pp. 39-44.

Table 2. Types of short and long run marginal costs

| Cost | Definition |
|-------------------|---|
| SRMC of road wear | The maintenance and repair expenses associated with additional heavy vehicle use of existing roads, keeping road durability constant. |
| SRMC congestion | The cost of an additional peak hour vehicle trip in terms of traffic congestion delays imposed on other users of the road, keeping road capacity constant. |
| LRMC of road wear | The cost of building and maintaining roads with the optimal durability (or strength) needed to accommodate additional heavy vehicle use of the roads. |
| LRMC of capacity | The cost of adding traffic handling capacity (number of lanes, width of lanes) to accommodate additional traffic. In the case of heavy vehicle traffic, this may include the costs of additional passing lanes, wider turning circles, larger intersections, etc. |

2.2.2 The benefits of pricing at marginal cost

Given the averaged pricing structure that currently exists, some operators may be charged less than marginal cost while others may be charged more than the costs they impose on the network. In an economic sense this matters because it leads to an inefficient outcome for the freight system as a whole. This can be illustrated by the following:

- If prices are set above marginal cost, then some truck trips may not take place because the cost of the trip may exceed what the shipper is willing to pay, even though the shipper may be willing to pay a rate that recovers society's actual resource cost. The freight may move to other modes or not be shipped at all even though the truck trips foregone are economic, i.e. they would cover their costs.
- If prices for access are lower than marginal cost, then trips are made that cost the economy more than their value. The goods are being shipped at a rate that does not recover the full costs of the shipment. Society incurs the direct cost of the trip in terms of fuel, labour costs and vehicle depreciation plus the additional cost associated with road deterioration.

From a social point of view some freight will be transported even though the costs would exceed the benefits and some freight will not be transported even though the benefits would exceed the costs. Pricing at marginal cost ensures that trips that generate net benefits are made and trips that cost more than the benefits they produce are not made.

For example, under current pricing, a B-double carrying less than average mass (because for example the load is large, but not heavy) over major highways will pay the same registration charge as a B-double operating at its full mass limit on less durable rural roads.

The implication is that the vehicle carrying the heavy load on rural roads will be subsidised by the lightly loaded vehicle travelling on highways due to the differences in road damage caused between the two types of travel. In the second case, the cost of carrying the freight incurred by the operator will be much lower than the actual price, with the operator in the first case paying higher than the true cost. This will flow on to the customer being charged a price that is too high in the former case and too low in the latter, reducing the efficiency of the freight sector overall. Some trips that add economic value will not be taken because price is greater than marginal cost. The freight may travel on other modes or may not be shipped at all. A trip that is taken when price is less than marginal cost also wastes

resources. The price paid for the trip in road user charges does not cover the cost of repairing the road. A pricing system more aligned with costs will discourage the expensive trips, or encourage supply chain changes that reduce the impact of vehicles on the road.

Efficient prices can also direct resources to the most productive mode of shipment for a given task. Road prices that more accurately reflect the infrastructure costs associated with each truck journey can guide freight customers and logistics providers to choose the optimal mix of road, rail and sea freight for a given transport task. This can result in a more efficient transport sector as customers and operators will be able to make decisions based on the true underlying infrastructure costs of carrying freight across all modes³¹.

If road transport operators pay directly for the road wear that they cause due to the kilometres travelled, the axle mass carried and the roads operated over, they would be encouraged to:

- use vehicles more productively (e.g. minimise travelling with empty loads)
- change to vehicles that cause less wear (e.g. use truck configurations that spread mass across more axles)
- where possible, choose to travel on routes that reduce the use of high cost roads and/or use less damaging vehicles on them

Given the existing freight task, the effect of these changes would be reduced road maintenance costs. However, if efficient road usage prices lead to an increase in the use of road freight (for example, through a shift in freight from other transport modes), total road maintenance costs could rise, but the road maintenance cost per tonne of freight should still fall. Alternately, it could free up funds to be used on other uses, such as beneficial capital upgrades.

Further benefits are likely from making changes to the way in which road agencies invest in the road network. For example, creating a better link between revenues received from heavy vehicle road use and road spending has the potential to provide better signals to road agencies about where to invest road dollars. Moreover, tying revenues to usage has the potential to provide greater certainty to road agencies that sufficient resources will be available to adequately maintain roads accessed by heavy vehicles.

This is likely to encourage better network maintenance practices, which will reduce maintenance costs. This should reduce road user prices in the long run because, as discussed above, allowing roads to deteriorate beyond a certain point can substantially increase the ultimate repair cost. Funding certainty for road maintenance activities may also encourage road owners to deliver greater access to heavy vehicles because the road owners can be assured that they will have the funds to make the repairs.

³¹ Some pricing distortions may still exist across other modes. For example, subsidies provided to rail infrastructure or other modes will also result in customers not paying the true infrastructure costs.

2.3 Marginal cost and total cost recovery

CRRP pricing principle 1 requires prices be developed to ‘recover the efficient cost of providing, maintaining and operating roads for use by heavy vehicles’³². Therefore prices should recover all of the major cost categories discussed in Section 2.1 including maintenance, enhancements of existing capacity, new roads and overhead, assuming spending to construct and maintain the road network is efficient.

However, if heavy vehicle prices for access are set only to recover the short run marginal costs of maintaining the roads, then road agency costs associated with increasing durability, capacity and system overheads will not be recovered. It can be shown using a theoretical model that pricing to recover both the short run marginal cost of road wear and the short run marginal cost of congestion can recover total road costs³³. This result depends on a number of assumptions that may not hold in practice.

For example, a number of studies have raised concerns about the ability of prices set at the short run marginal cost of maintenance plus congestion to recover total costs given marginal costs (maintenance and congestion) are generally less than average cost³⁴. If marginal is less than average cost, and price is set equal to marginal cost, then total revenues will not recover total costs. In any event, congestion pricing is not being considered in the development of indicative prices at this stage of the reform. Therefore, a means to recover the shortfall between marginal costs and total efficient road costs must be developed.

One answer is to price at average cost. Indeed, the difficulties of implementing marginal cost-based pricing while efficiently recovering total costs has led most international road pricing schemes to establish prices based on average costs with the use of accounting model cost allocations³⁵ rather than marginal cost studies³⁶. These approaches use total road costs to develop average road user charges which are then differentiated based on cost drivers so that prices in some way reflect the cost imposed by heavy vehicles.

However, this approach potentially sacrifices the efficiency benefits of marginal cost-pricing and is inconsistent with the CRRP pricing principles. Multi-part pricing, where different elements of cost might be recovered through separate rate elements, is often used to attempt to recover total costs while incorporating some elements of marginal cost based pricing.

As the Productivity Commission noted, ‘multi-part pricing structures allow common costs to be recouped via access or joining fees, incremental capacity costs via access charges and marginal costs via variable, use-related charges’³⁷. However, the Productivity Commission also notes that, ‘while the variable charge encourages appropriate consumption by those

³² COAG Road Reform Plan, Policy Framework, March 2010.

³³ Newbery, Cost Recovery from Optimally Designed Roads, *Economica* 56, 1988, p 165-185.

³⁴ IMPRINT, Verhoef, Marginal Cost Based Pricing in Transport Key Implementation Issues from the Economic Perspective, 2001.

³⁵ Note that the current charging system is a cost accounting approach that distributes the total heavy vehicle cost base to different vehicle classes. The Productivity Commission, Road and Rail Freight Infrastructure Pricing, 2006 refers to this as a fully-distributed (financial) cost approach. Box 3.5, p. 55.

³⁶ The accounting allocations can be informed by cost relationships, as the existing PAYGO system does. See Rommerskirchen, Rotthengatter, Greinus, Leyboldt, Liedtke and Scholz, Life Cycle Cost Analysis of Infrastructure Networks, the case of the German federal trunk roads, 2009.

³⁷ The Productivity Commission, Road and Rail Freight Infrastructure Pricing, 2006, Box 3.5; p. 55.

who pay the entry fee (subject to income effects of the access charge), those with a low willingness to pay for the service may be discouraged from consuming it at all³⁸.

This problem is encountered frequently in the pricing of services offered by government trading entities or regulated monopolies. Alternatives that provide for total cost recovery while still capturing at least some of the benefits of marginal cost pricing have been explored, with optimal departures from marginal cost pricing the subject of much discussion in the economics literature³⁹. There is wide agreement that if prices must deviate from marginal cost, they should do so in a way that minimises output distortions. This means that, as far as possible, the pricing structure should be designed to minimise any changes in the quantities that would be demanded under pure marginal cost pricing. Two alternatives have been developed to deal with the situation in which pricing at marginal cost would not result in full cost recovery. These are optimal multipart tariffs and inverse elasticity pricing:

- ***Optimal multi-part tariffs:*** use a combination of fixed and variable rates designed to keep the quantity demanded as close as possible to that which would occur under pure marginal cost pricing. Pricing structures using fixed and variable components as described by the Productivity Commission are used in a variety of industries. However, *optimal* multi-part tariffs, which are specifically designed to minimise distortions from pricing above marginal cost, have not been widely implemented because they require a great deal of information, including demand elasticity data.
- ***Inverse elasticity pricing:*** has the same goal to minimise output distortions, but full cost recovery is accomplished through variable mark-ups over marginal cost, with the highest mark-ups placed on services with the least elastic demand. (Elasticity of demand is a measure used to show the responsiveness, or elasticity, of the quantity demanded of a good or service to a change in its price.) Inverse elasticity pricing, which is often referred to as Ramsey pricing, also requires detailed demand elasticity data for implementation⁴⁰.

Applying either optimal multipart tariff structures or inverse elasticity pricing in a road pricing context requires extensive information regarding how road users would likely respond to different prices and pricing models, making these approaches difficult to implement in practice.

The approach that will be undertaken to develop indicative prices for the feasibility study (as outlined in Section 5) is similar to the average cost approaches (with accounting based cost allocation) in that total costs must be recovered. However, while these approaches use accounting based cost allocation to differentiate and structure prices, our approach will use the marginal costs of road wear (taking into account mass, distance and location) to develop and structure differentiated road wear prices.

³⁸ *ibid.*

³⁹ See Baumol and Bradford, *Optimal Departures from Marginal Cost Pricing*, *American Economic Review*, June 1970, pp. 265-283.

⁴⁰ See Viscusi, Vernon and Harrington, *Economics of Regulation and Antitrust*, 2000, pp. 344-353 for a textbook discussion of these issues.

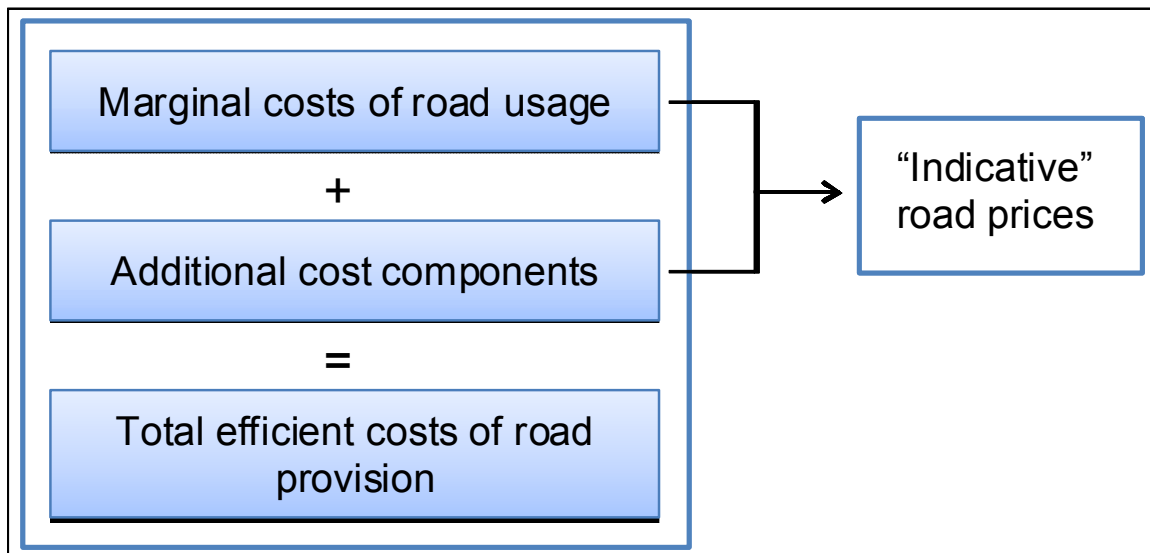
At this stage, the approach that will be used to develop indicative prices for the different pricing options will consider a range of multi-part pricing structures because it is not yet clear what structure will deliver the best economic outcome. The demand elasticity analysis that is currently being undertaken (as discussed in Section 6) should assist in the assessment of the relative economic merit of the alternative pricing options and structures.

Therefore, the approach that will be taken to develop indicative prices will need to determine:

1. the marginal costs of road usage (taking into account the marginal costs outlined in Table 2), and then
2. the most economically optimal way to recover the difference between marginal and total costs through the application of additional cost components.

This is outlined in Figure 7. Therefore, the starting point for developing indicative prices is to estimate marginal and total road costs.

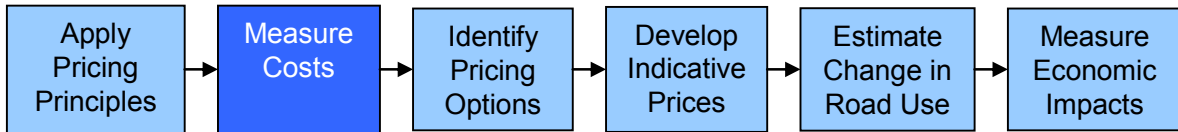
Figure 7. Pricing approach



Questions for Section 2

- 2.1 Are there efficiency problems with current road user charges that are not identified here?
- 2.2 Are there benefits from efficient road pricing beyond those described here?
- 2.3 Is the approach outlined above appropriate to accommodate the joint requirement to recover total costs and reflect marginal costs in the prices?

3. MEASURING ROAD COSTS



This section discusses how road usage costs will be estimated to provide a basis for implementing a more cost reflective road pricing model.

Topics discussed include:

- a description of how total costs are developed under the current PAYGO system and how these are used to calculate vehicle charges.
- a description of the marginal cost model that is being developed to calculate the marginal cost of road usage.

Section 2 demonstrated that prices set with reference to marginal cost would promote transport sector efficiency and explained how the requirement to recover total costs could be accommodated. In this section, the methodology for estimating the marginal cost of road use as well as the total road costs to be recovered from heavy vehicles is described. Both the total heavy vehicle cost base and marginal costs of road usage will be necessary inputs to developing prices under the reform options.

3.1 Measuring the total cost base

The current pricing model sets charges for all heavy vehicles through a fixed annual registration charge and a fuel-based road user charge (which is paid per litre of fuel consumed). The charges are set to recover the total road expenditures that have been allocated to heavy vehicles based on the PAYGO model. Several steps are required to develop the total cost base using PAYGO⁴¹:

- Road expenditure data are collected from all levels of government around Australia.
- The seven-year historical average of real road expenditure and road usage is used in order to smooth year-to-year changes.
- Some expenditures are then excluded from the cost base. This includes local government expenditure related to providing community access or amenity, or providing for non-motorised road users or expenditure that is recovered through other charges.
- The remaining government expenditure data is assigned to several categories broadly reflecting the four major cost categories discussed in Section 2.1 (maintenance, durability, capacity and overhead).
- Road expenditures are allocated to different light and heavy vehicle classes using cost allocation parameters that attempt to reflect the relationship between road use and road expenditure needs.

⁴¹ NTC, 2007 Heavy Vehicle Charges Determination, Regulatory Impact Statement Vol 1, 2007.

Table 3 outlines the cost allocation parameters that are used in the PAYGO allocation model to allocate costs within different expenditure categories (or cost categories) across different vehicle classes⁴². The cost allocation rules are shown in Table 4.

Table 3. PAYGO cost allocators

| Cost allocator | Definition | Basis for allocation |
|--|--|---|
| Vehicle kilometres travelled (VKT) | The vehicle kilometres travelled is the number of kilometres travelled by a vehicle class in a year. This is based on data collected in the Survey of Motor Vehicle Usage undertaken by the Australian Bureau of Statistics. | More vehicle kilometres travelled result in higher road maintenance and operating costs. The VKT also acts as a multiplier for the ESA, AGM and PCU cost allocators since they are expressed as ESA-km, AGM-km and PCU-km in the other cost allocators. |
| Equivalent standard axle kilometres travelled (ESA-km) | The ESA is a standard engineering measure of road wear which represents the damage to the road caused by load on an axle group. | Engineering principles and statistical studies show that higher ESA levels lead to pavement wear. |
| Average gross mass kilometres travelled (AGM-km) | A measure of the gross laden mass carried by vehicles on the roads. | Higher mass vehicles on the roads cause more pavement and bridge wear. |
| Passenger car unit kilometres travelled (PCU-km) | A measure of relative road space requirements based on the size of the vehicle. | Some road capacity costs depend on the length of the vehicle. |

Costs related to road wear are allocated using AGM and ESA parameters and include both short run maintenance costs and some costs associated with increasing durability, which is a long run cost. Costs related to capacity are allocated to vehicle classes using vehicle PCU kilometre data. Corporate services costs in PAYGO are considered unattributable to heavy vehicles and are allocated to all road users for cost recovery on the basis of VKT. All other PAYGO expenditures not assigned to the other three categories are allocated to road users for cost recovery on the basis of VKT as these cannot be directly attributed to a cost allocation parameter.

As an example of the allocation process, all periodic maintenance expenses reported by governments are allocated using a range of parameters shown in Table 4. PCU kilometres are used to allocated 10 percent of these costs across vehicle types, a further 60 percent is allocated on the basis of AGM kilometres and 30 percent are judged to be unattributable and are allocated on the basis of total vehicle kilometres travelled.

⁴² There are 34 vehicle classes ranging from light vehicles to small rigid trucks and articulated trucks (such as B-doubles and road trains), with 26 of these classes considered heavy vehicle classes (those vehicles equal or greater than 4.5 tonnes).

Table 4. PAYGO cost allocation rules

| Expenditure Category | | Percentage of cost that varies with: | | | | | |
|----------------------|---|--------------------------------------|--------|--------|--------|-------------------|-------------------|
| | | Attributable costs | | | | | Non-attrib. (VKT) |
| | | VKT | PCU-km | ESA-km | AGM-km | Heavy Vehicle VKT | |
| A | Servicing and operating expenses | 100 | 0 | 0 | 0 | 0 | 0 |
| B | Road pavement and shoulder maintenance | | | | | | |
| B1 | Routine maintenance | 0 | 38 | 0 | 38 | 0 | 24 |
| B2 | Periodic maintenance | 0 | 10 | 0 | 60 | 0 | 30 |
| C | Bridge maintenance and rehabilitation | 0 | 0 | 0 | 33 | 0 | 67 |
| D | Road rehabilitation | 0 | 0 | 45 | 0 | 0 | 55 |
| E | Low cost safety/traffic improvements | 80 | 20 | 0 | 0 | 0 | 0 |
| F | Asset extension/improvements | | | | | | |
| F1 | Pavement components | 0 | 0 | 45 | 0 | 0 | 55 |
| F2 | Bridges | 0 | 15 | 0 | 0 | 0 | 85 |
| F3 | Land acquisition, earthworks, other extension improvement expenditure | 0 | 10 | 0 | 0 | 0 | 90 |
| G | Other miscellaneous activities | | | | | | |
| G1 | Corporate services | 0 | 0 | 0 | 0 | 0 | 100 |
| G2 | Enforcement of heavy vehicle regulations | 0 | 0 | 0 | 0 | 100 | 0 |

3.2 Measuring the heavy vehicle total cost base

In its 2006 inquiry, the Productivity Commission found that ‘in principle, PAYGO charges will recover the financial and economic costs of providing and maintaining services over time, although intertemporal cross-subsidies could arise if road spending fluctuates’⁴³. Phase 1 of the CRRP subsequently involved a review of alternatives to the PAYGO cost base⁴⁴, which was completed by GHD Meyrick. This study considered four possible alternative approaches to estimating the total costs that would be recovered from heavy vehicles shown in Table 5.

⁴³ The Productivity Commission noted that PAYGO will only provide a reasonable approximation of the annualised (economic) costs of road provision in any period under the following conditions; the network is neither expanding nor contracting, nor is the pavement or bridge condition changing significantly; network wide expenditure does not fluctuate markedly over time; and traffic growth is relatively steady. Productivity Commission, Road and Rail Freight Infrastructure Pricing, 2006, pp. 74-86.

⁴⁴COAG Road Reform Plan (GHD Meyrick), Alternative Approaches to Estimating the Road Cost Base, July 2010.

Table 5. Alternative approaches to estimating the cost base

| Approach to measuring the cost base | Explanation |
|---|---|
| Cash accounting approaches (historical or forward looking) | Historical: similar to current approach, this method calculates total costs using actual historical expenditures. Forward looking: uses forecasts of future expenditure levels over a time frame. All forecast expenditures are treated purely as cash outlays and averaged over the time period. |
| Discounted cash flow approaches | This approach also requires explicit forecasts of future expenditure, with future expenditure treated purely as cash outlay, with the total forecast outlay for the life of the asset discounted to a present value. The present value is then converted to an equivalent smoothed cost stream. |
| Life cycle costing (building blocks or rate of return approaches) | This approach replaces historical expenditure data with explicit forecasts of operating and capital expenditures over a limited period. Annual costs would then be developed through expensing the operating costs in the year they are incurred and recovering the annual capital costs based on depreciation and return on capital. |
| Standardised cost or benchmarking approaches | Use standardised unit cost estimates to develop an estimate of total cost for the whole asset base. For example, a standard or benchmark annual cost per road kilometre or vehicle type would be developed. This would then be multiplied by the entire road network kilometres or number of vehicles to estimate total annual costs. |

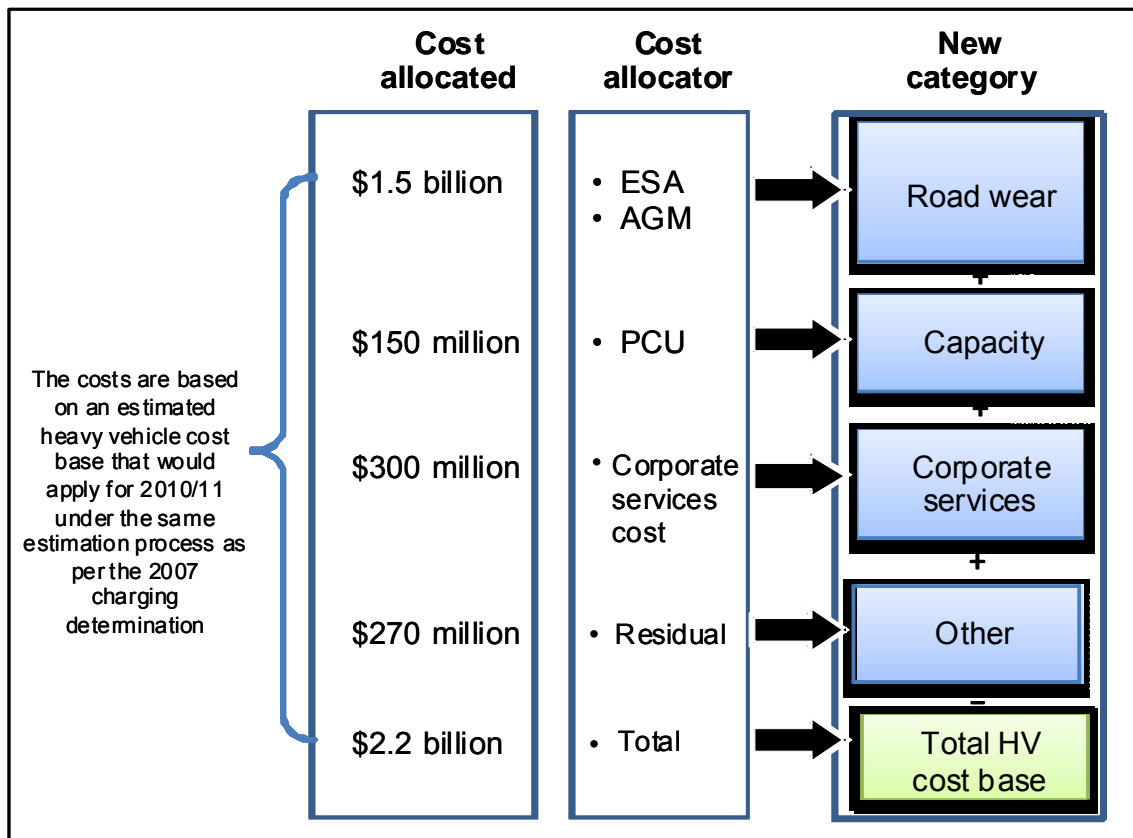
The GHD Meyrick study recommended building on the current cash accounting approach, whilst also giving consideration to the use of hybrid options such as incorporating the standard cost approach. Developing alternative estimates of the cost base is not contemplated at this stage of the reform process because substantial data collection would be required.

Further research on how an alternative cost base model could be implemented, especially in the context of the road pricing approaches discussed later in this paper, will be undertaken as part of the feasibility study⁴⁵. Pending completion of this research, the existing PAYGO approach used by the NTC will be applied to estimate the heavy vehicle cost base that will be used to develop indicative prices for the feasibility study. Therefore, the PAYGO expenditures will be considered as a proxy for costs for purposes of the Discussion Paper.

To support the development of prices using a more cost reflective heavy vehicle pricing model, the existing expenditure categories in PAYGO (Table 4) will be consolidated into the four categories identified in Section 2.1. These are: road wear, capacity, corporate services and other. The total costs included in each category and the basis on which these costs have been assigned are shown in Figure 8.

⁴⁵ It is not clear if alternative cost base approaches will deliver a higher or lower cost base than the current PAYGO system.

Figure 8. Allocation of costs to the new cost components



3.3 Marginal cost model

An engineering based model is being developed to estimate the marginal costs of road wear. This model only applies to road pavements. A separate project is underway to investigate the marginal cost of bridge use⁴⁶. Therefore, the focus of this section is on estimating marginal costs for road pavements.

The marginal road cost model is being developed through a joint NTC/Austrroads project, with the research being undertaken by the ARRB Group with oversight from the NTC. The model provides direct estimates of the impact of particular vehicles on road wear and transforms the resulting maintenance and repair expenses to a marginal cost of road wear. Preliminary results from the marginal cost model were outlined at the Heavy Vehicle Transport Technology conference⁴⁷. A high-level description of the model is provided in the next section. Further details are provided in Appendix A.

3.3.1 Model description

The model estimates both short run and long run marginal costs of road wear and works by identifying how the time stream of future road expenditures is affected by an increase in road usage. Road usage is measured by an additional unit of mass carried on an axle group. The additional axle mass causes the road to deteriorate more rapidly, triggering an earlier intervention in the short run and possibly an upgrade in the strengthening of the road in the long run.

⁴⁶ The bridge cost project is in its early stages and therefore not as progressed as the road pavement analysis. Results from this project are not expected until early 2011.

⁴⁷ Martin, Clarke, Thoresen, Hore-Lacey, Estimating the Marginal Cost of Road Wear on Australia’s Sealed Road Network, HVTT 11 symposium, 2010.

The difference between the net present value of the cost stream to maintain the road with and without the additional trip represents the marginal cost of the trip. This marginal cost is, in effect, the additional expense the road agency will incur due to the additional axle mass on the road.

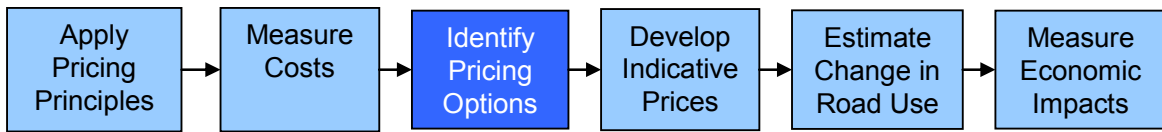
Preliminary results from the model are generally consistent with prior expectations and results from studies of road costs in other countries. However, the model is still under development. Ongoing research will subject model assumptions and underlying data to additional scrutiny and address a number of possible extensions or modifications. Further details of the model are provided in Appendix A.

Section 5 shows how the marginal costs generated using this model will be used to develop road usage prices based on marginal costs under the various pricing models.

Questions for Section 3:

- 3.1 Are the new cost categories in Figure 8 an appropriate segmentation of the types of road costs?

4. ALTERNATIVE PRICING MODELS



This section addresses the development of alternative pricing models building on the total and marginal cost approach outlined in Section 3.

The CRRP pricing principles described in Section 1 have been used to guide development of five high-level pricing options shown in Table 6.

The marginal cost model and the current PAYGO cost allocation model (described in Section 3) indicate that in order to best reflect the marginal cost of road wear, prices should take into account the mass of the vehicle, the distance travelled by a vehicle and the location of travel.

The pricing models were chosen to reflect the range of options being investigated, progressing from the status quo (PAYGO model) to distance-based pricing, mass distance-based pricing and mass distance-location (MDL) pricing. These options, if implemented, would entirely replace the existing charging system (comprising registration and fuel-based charges) rather than acting as an additional charge.

These options are consistent with the array of pricing options that have been considered within Europe and the United States and also the options that were put forward by the Productivity Commission⁴⁸.

The fuel-based charge (Option 1)⁴⁹, would use fuel-based charges as a proxy for distance and mass, while Option 2 would price based on the actual distance travelled by the vehicle. Options 3, 4 and 5 would apply a per kilometre distance price which would be varied based on the actual axle mass of the vehicle and/or the types of roads used by the vehicle location.

Options 2 to 5 could also be differentiated in a number of ways, which could have a large impact on the ability of prices to accurately reflect the costs a vehicle imposes. For example, Options 2 and 3 have no direct pricing component for mass. However, vehicles could pay a distance or distance-location fee that varies by axle group or total number of axles, which would act as a proxy for the weight carried by the vehicle and allow for a more accurate attribution of costs.

⁴⁸ Productivity Commission, Road and Rail Freight Infrastructure Pricing, 2006, pp. 232-239.

⁴⁹ This option has been suggested by the Australian Trucking Association (ATA), see ATA's Fuel-based Charging Mechanism policy proposal overview v1.3.3, 2009.

Table 6. Pricing model options

| Model option | Explanation |
|--|--|
| Base case: status quo | This is the base case and the current road pricing system that involves registration and fuel excise-based charges. |
| Option 1: fuel-based distance price | The fuel excise system is used as the basis for road pricing. This is a proxy for pricing for distance and mass as fuel usage varies with distance travelled and the mass carried. |
| Option 2: kilometre-based distance price | The road price is based on a system that attempts to measure the actual distance travelled. |
| Option 3: distance-location-based price | The road price is based on a system that attempts to measure distance travelled taking into account the location of the vehicle. |
| Option 4: mass-distance-based price | The road price is based on a system that attempts to measure distance travelled taking into account the actual mass of the vehicle. |
| Option 5: mass-distance location-based price | The road price is based on a system that attempts to measure distance travelled and vehicle mass taking into account the location of the vehicle. Vehicle mass is measured dynamically (as the vehicle travels). |

Options 1 to 5 increase both in complexity and their ability to directly recover the costs imposed by heavy vehicles on the road network. For example, Option 1 provides the least targeted pricing mechanism with a flat fuel charge for all heavy vehicles, while Option 5 would differentiate prices for vehicles based on their actual mass-distance and location.

The feasibility study will also consider whether hybrids of these options would produce beneficial outcomes. For example, full MDL charges could be applied to only the subset of heavy vehicles carrying mass above a certain level, with another option, e.g. distance only charges, applying to others.

Within these high-level pricing model options, there are a number of alternatives for how total costs (i.e. maintenance, capacity, administrative and other costs) can be recovered. For example, these can be recovered through either a fixed or variable price or a combination of the two. The prices can also be applied to vehicles in a number of ways, for example by vehicle, by module (trailer) or by axle group. This will be discussed further in Section 5.

One of the reasons for considering a spectrum of options is that pricing reforms that incorporate some, but not all, of the elements of full MDL pricing (Option 5) may result in substantial benefits without the added measurement and billing systems costs that MDL pricing would require. For example, many international pricing schemes that have driven a number of efficiency improvements are based on a simple price per kilometre.

However, it is acknowledged that there have been a number of other motivations for the introduction of a distance based road price in other countries. These include raising revenue for infrastructure investment (including investment in rail infrastructure), encouraging modal shift, collecting road charges from foreign transit vehicles, addressing congestion and better internalising externalities.

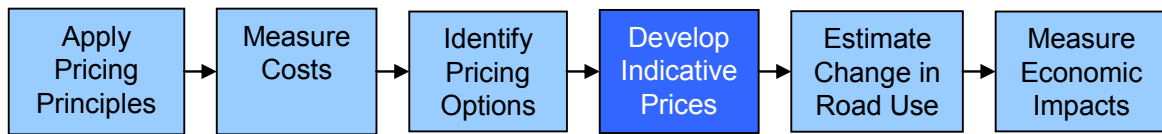
A preliminary strategic merit test (as per the CRRP Evaluation Framework Reference Guide⁵⁰) focused on ensuring that the proposed pricing options broadly align with the principles put forward by the policy stream. A more detailed strategic merit test will be undertaken following consultation on the Discussion Paper.

Questions for Section 4:

- 4.1 Are there any other pricing options that could be realistically considered that are consistent with the pricing principles?
- 4.2 Are there potential unintended consequences of any of the pricing models?

⁵⁰ COAG Road Reform Plan, Evaluation Framework Reference Guide, July 2010.

5. DEVELOPING INDICATIVE PRICES



This section outlines the approach that will be used to develop indicative prices for each of the alternative pricing models. The cost relationships discussed in Section 3 will be applied to the pricing models in Section 4 to demonstrate how indicative prices will be determined.

5.1 Alternative pricing models

The alternative pricing models in Table 6 can be placed into three broad categories:

- the existing heavy vehicle charging model using the PAYGO cost base (base case or status quo)
- a fuel-based charge (Option 1)
- mass-distance-location (MDL) based models (Options 2 - 5)

The development of PAYGO charges was described previously in Section 3. The way in which indicative prices will be developed for the fuel-based option are described in Section 5.2. Options 2 – 5 will represent a major shift from the current charging system (comprising the registration and fuel-based road user charge) to a charging system that is more aligned with actual vehicle usage. Section 5.3 shows how the MDL options (Options 2 – 5) will be priced.

5.2 Fuel-based charging model

The fuel-based pricing model will be based on a per litre heavy vehicle fuel charge, which will be set at a rate to recover the current heavy vehicle cost base. Under a fuel-based option, the prices paid by heavy vehicle operators will increase with distance travelled (via litres consumed) and with higher mass levels (because fuel consumption rises with the weight of the vehicle). There is no allowance for location based charging under a fuel-based charge.

To the extent that distance and absolute mass drive short run marginal cost, a fuel-based option can be considered a proxy for marginal cost pricing of distance and mass. The cost-price relationship is likely to be weaker than for the MDL options discussed next. On the other hand, implementation and operational costs will be lower as the need for sophisticated tracking and billing systems is eliminated. Fuel-based charging was also considered by the recently completed Australian tax review as an instrument for road user charging⁵¹.

⁵¹ Australia's Future Tax System, Report to the Treasurer, Part 2 Detailed Analysis, Volume 2, 2010.

The fuel-based pricing option will use a two-tiered structure consisting of variable and fixed charges:

1. **First tier: variable charge**

There are two sub-options for implementing the variable charge:

- Flat fuel charge per litre for all heavy vehicles.
- One fuel charge per litre for two axle rigid heavy vehicles and a different fuel charge for all other heavy vehicles. The charge for each of the two vehicle classes would be based on the costs allocated to each respective class under the current system. This option has been proposed by the Australian Trucking Association⁵².

2. **Second tier: fixed charge**

A fixed registration charge per vehicle will be incorporated into the charging structure in order to recover the corporate services cost component of the heavy vehicle cost base. The variable charge would therefore be calculated excluding the corporate service costs estimated using the PAYGO cost base.

5.3 Developing prices for the mass-distance-location (MDL) based models

Developing prices for the MDL models will be more complex. There are a variety of options, beginning with the choice of using SRMC or LRMC as a basis for pricing. Choices about how to recover the difference between marginal and total cost must also be made. Included in these choices are whether the difference between total costs and marginal costs should be collected through variable rates or fixed rates (per vehicle, per axle or per module). Variable charges are based on metrics such as vehicle kilometres or ESA kilometres travelled. Fixed charges do not vary with usage, for example, an annual fee per vehicle or vehicle module. These charges can also be applied to the vehicle characteristics in number of ways as both variable and fixed charges can be applied on the basis of vehicles, axle groups, axle numbers and vehicle modules. These pricing issues are discussed below.

5.3.1 Economic approach to pricing

Table 2 outlined the different types of marginal costs of road usage that are relevant for heavy vehicles (excluding social costs) including both SRMC and LRMC. The starting point for establishing indicative prices under the MDL models is to choose between using SRMC or LRMC as a basis for pricing.

Most economic studies of road pricing have focused on SRMC pricing. This reflects the view that heavy vehicles should pay for the actual damage incurred on the road network as it exists today. However, LRMC pricing has been considered in other sectors where government regulates or oversees pricing.

Some regulators, particularly in utilities, have been moving towards pricing at LRMC in order to better ensure total cost recovery as well as providing price stability⁵³. One of the

⁵² Australian Trucking Association (ATA), ATA's Fuel-based Charging Mechanism policy proposal overview v1.3.3, 2009.

⁵³ The Essential Services Commission (Victoria), in determining water prices, sets the variable (volumetric) component of the tariff to reflect the long run marginal cost of supply. This is to ensure consistency with the Water Industry Regulatory Order (WIRO) requirement that prices should signal the costs of providing

reasons is that “expansionary” capital costs, which are fixed in the short run and therefore do not contribute to SRMC, make up a substantial part of the total costs and would be measured in a LRMC setting. In some regulated sectors, for example telecommunications, SRMC are quite low.⁵⁴ Pricing at long run economic cost reduces the need to allocate, perhaps arbitrarily, the fixed capital costs and would not be subject to change as road agencies make road improvements.

To investigate the pricing options for this reform, indicative prices will be based on the marginal cost estimates developed through the marginal cost model as well as the PAYGO cost base. At present, the marginal cost estimates from the model that will be used to develop indicative prices incorporate short run costs as well as some long run components. Further work is being undertaken on the marginal cost model to expand and refine the range of short run and long run marginal cost estimates⁵⁵. When this work is completed, improved long run and short run cost estimates could be used to develop and assess alternative pricing models. As noted above, pricing the marginal costs of congestion and other externalities is not being considered at this stage of the reform.

Rate structure elements to recover the shortfall between total costs to be recovered and the SRMC/LRMC of road wear must be designed. These are explained in further detail below.

5.3.2 Designing rate structures to recover marginal and total costs

The MDL models (Options 2 – 5) are intended to establish road usage prices that are more closely aligned to marginal costs. The marginal cost model outlined in Section 3.4 is used as a basis for developing prices for the road wear component. However, two separate issues must be addressed in order to reflect the total cost base in pricing:

- First, prices based on the marginal cost model may not result in recovery of all of the PAYGO road wear costs (the \$1.5 billion in Figure 7).
- Second, the road wear costs in PAYGO are only around 70 percent of total costs. To recover total costs, the remaining capacity costs, administrative costs and common costs must be recovered through pricing. Therefore, additional variable and/or fixed rates for the non-road wear cost components will be necessary to ensure that full cost recovery is achieved. These additional charges will be set in a way that ensures that the cost recovered from these three components equals the total cost allocated under PAYGO in Figure 7.

These issues will be addressed as follows:

- Once marginal costs of road wear-based prices are developed from the marginal cost model for each of the pricing options, these will be scaled up uniformly using the marginal cost relativities so that the total revenue that would be recovered from applying the new prices equals PAYGO allocated costs (for the road wear cost component). The scaling used will retain the relativities between the different pricing parameters i.e. mass per axle group and roads used that have been estimated using the marginal cost model.

services including the cost of future supply augmentation. Essential Services Commission, Water Tariff Structure Review, Final Report, 2007.

⁵⁴ ‘in industries such as telecommunications, marginal costs are likely to be low and in some cases close to zero.’ Australian Competition and Consumer Commission, Bundling in Telecommunications Markets, August 2003, p. 16.

⁵⁵ At present there is some overlap between the short run and long run cost estimates developed. This is described further in Appendix A.

- Following further research on SRMC and LRMC through the marginal cost model, alternative approaches will be considered for scaling up road wear costs, taking into account the relationships between SRMC, LRMC and the total road wear costs to be recovered.
- The pricing structures will take into account a range of multi-part pricing options to ensure the recovery of the non-road wear components, for example through developing either a fixed or variable charge (or a combination of both). For example, corporate services, other (residual) costs and capacity costs can all be recovered through a fixed annual charge per vehicle (or other pricing parameter such as axle group) or can be recovered through a price per kilometre travelled.

The following three sections provide a more detailed description of how this approach can be applied to develop prices in terms of three key aspects of the pricing methodology:

- road wear marginal cost pricing for each of the five pricing options (5.3.3)
- pricing structure for non-road wear components (5.3.4)
- application of MDL prices to vehicle characteristics (5.3.5)

5.3.3 Road wear marginal cost pricing for each pricing option

The marginal cost model will develop estimates of the marginal cost of road wear, taking into account mass on each axle of a vehicle, the location of travel and distance travelled. The model estimates are based on the road wear cost per kilometre for different axle types on a 14 different road types⁵⁶.

The marginal costs must be adapted to create a pricing structure that can be easily applied to Australia's diverse road network and vehicle fleet. In addition, the estimates must be adjusted to fit with the four MDL pricing model options, which do not all contain the mass and location pricing parameters. Figure 9 provides an overview of how marginal costs of road wear from the marginal cost model can be adapted to develop prices.

For example:

1. Under a distance based pricing system (Option 2) the marginal cost of road wear will need to be applied, assuming that vehicles are operating at average mass and on one road type since there is no differentiation in the prices to allow for mass or location.
2. Under a mass-distance based pricing system the marginal cost of road wear will be applied assuming one road type. Therefore, marginal costs will need to be averaged across all different road types.

⁵⁶ Road wear costs are measured in terms of SAR (standard axle repetition) kilometres. SAR represents a measure of the pavement impact of an axle group or heavy vehicle on the pavement and is essentially a unit of road wear. This is calculated by taking the actual load of the axle in tonnes divided by the standard axle loading for that axle type raised to a power depending on the pavement type.

An axle carrying a standard load (which varies by axle group type) is responsible for a given amount of damage per kilometre. The damage caused by a vehicle carrying greater mass than the standard load level is measured as the number of standard axles that would do the same damage. The more heavily laden axle group may be responsible for multiple SAR kilometres of damage, depending on the mass carried, road type and vehicle type. For ease of understanding, all axle group costs will be converted to ESA (equivalent standard axle) which is a similar measure of pavement wear only with a constant exponent of 4.

Figure 9. Estimation of prices for road wear cost component

| Actual pricing parameters | | | Averaged pricing parameters |
|---------------------------|---------------------------|---|-----------------------------|
| Option 2 | Distance | cents/km | Mass, Location |
| Option 3 | Distance-Location | cents/km by road type | Mass |
| Option 4 | Mass-Distance | cents/unit of road wear-km | Location |
| Option 5 | Mass-Distance Location | cents/unit of road wear-km by road type | No averaging |

However, just because average mass is applied in Options 2 and 3 does not mean that these models cannot have a pricing structure that charges more for higher mass levels on the vehicle, albeit in an indirect way. Indeed, there are several ways in which a price per unit of road wear can be applied to a vehicle. This is outlined in Section 5.3.5. For example, a distance-based pricing structure could have a different rate per kilometre depending on the number of vehicle axles⁵⁷. This could be used as a proxy for axle mass, since there is potentially a relationship between the number of axles on a truck and the average mass carried by a vehicle (including trailers).

The prices for the location based pricing models (Options 3 and 5) will be developed based on road types or classifications. The 14 classifications in the marginal cost model have been aggregated for the purposes of developing prices for the feasibility study into five simple categories. These categories have been based on a combination of grouping together similar types of roads in terms of usage by heavy vehicles and also in terms of the preliminary estimates of marginal costs.

One additional category will be added to this to take into account unsealed roads, once further work has been carried out in costing these roads. This is outlined in Table 7. Further research on unsealed roads is being undertaken as an extension of the marginal cost modelling.

⁵⁷ For example, in Oregon the rate per mile varies according to the registered (or “declared”) vehicle weight and number of axles. Conway and Walton, Policy Options for Truck User Charging, Transportation Research Record: Journal of the Transportation Research Board, 2009, pp. 75-83.

Table 7. Road type classification

| Classification | Marginal cost model road categories |
|--------------------------|---|
| 1. Freeways | <ul style="list-style-type: none"> rural freeway granular pavement urban freeway concrete and asphalt cement stabilised pavements |
| 2. Major urban arterials | <ul style="list-style-type: none"> urban arterial concrete, granular and asphalt cement stabilised pavement |
| 3. Major rural arterials | <ul style="list-style-type: none"> rural arterial concrete, granular and cement stabilised pavement |
| 4. Local collectors | <ul style="list-style-type: none"> all local collector roads |
| 5. Local access | <ul style="list-style-type: none"> all local access roads |
| 6. Unsealed roads | <ul style="list-style-type: none"> still to be modelled |

There has been no further categorisation by climatic zone since the marginal costs of road wear were not deemed to vary for different climate regions. It is also acknowledged that this approach may underestimate or overestimate the total road wear costs that should be recovered in some geographical areas as total costs may vary by climatic zone. This is because the marginal costs presented above are not specifically differentiated by geographic region to take into account the economies of scale and scope from road construction in different parts of Australia.

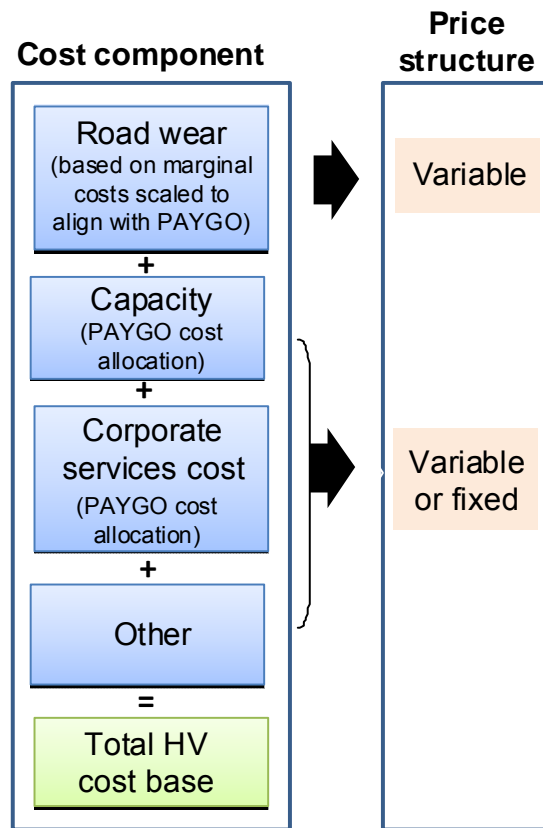
There are no other countries that have attempted to develop a pricing structure to apply to the entire road network that reflects the different underlying road wear maintenance costs associated with different road segments. For example, the German and Swiss pricing systems do not vary the price per kilometre based on the roads used for travel by vehicles within the scheme⁵⁸. Some toll roads in parts of Europe, and even in parts of Australia, could be considered location based pricing since they allow for different toll rates to apply at different toll points. However, this type of pricing is limited in scope given that toll roads make up only part of the road network and the prices do not vary based on the differing road wear that would be imposed by vehicles on different road types.

5.3.4 Pricing structure for each of the non-road wear cost components

As discussed in Section 5.3.2, the non-road wear cost components can be recovered through a multitude of ways including fixed or variable prices or a combination of the two. This process is outlined in Figure 10.

⁵⁸ The German cost accounting system does take into account differences road construction elements to develop the costs allocated on the basis of distance. See Rommerskirchen et al pp 58-94.

Figure 10. Mass-distance-location model options



Given the variety of fixed and variable charge combinations available, the following three scenarios in Table 8 will be considered for simplicity. Road wear is represented by a variable charge in all three approaches since it is considered the most directly related to the marginal costs of road usage. Both fixed and variable pricing options are considered for the other three categories. For example, corporate services charges could be collected on the basis of VKT or through fixed annual charge per vehicle.

The best way to recover these charges will depend on the pricing model option being considered and how it will be applied to the vehicle. For example, if the road wear charge is applied by vehicle, then it may make sense to apply the other charges per vehicle on either a fixed or variable basis. In addition, the responsiveness of road users to the different recovery options and the need to create a simple and technically feasible pricing structure would also need to be considered when determining how to price for the non-road wear components.

Table 8. Combination of fixed and variable charges by cost category

| New cost category | Combination 1 | Combination 2 | Combination 3 |
|--------------------|---------------|---------------|---------------|
| Road wear | Variable | Variable | Variable |
| Capacity | Variable | Variable | Fixed |
| Corporate services | Variable | Fixed | Fixed |
| Other | Variable | Variable | Fixed |

It is acknowledged that the non-road wear costs are likely to vary by geographic regions due to differing demand for road capacity (e.g. number of lanes) and the effect of weathering. These issues are not taken into account in the approach outlined above given that the heavy vehicle cost base is not currently differentiated by geographic region. Further work on estimating the total cost base as part of the feasibility study, as outlined in Section 3.2, may attempt to address these issues.

5.3.5 Application of the MDL prices to vehicle characteristics

To develop prices for each of the model options, a decision has to be made as to how the prices will be applied to the vehicle. For example, as shown in Table 9, the price can be applied on a per vehicle, per module, per axle group or per axle basis. The various options highlighted will have different implications for the ability of the price to reflect the marginal costs of road wear imposed by the vehicle and the complexity of applying the charge. In addition, the availability and cost of technology that would be needed to implement and monitor the pricing structure also needs to be considered.

Table 9. Application of rates to vehicle characteristics

| Classification | Description |
|-----------------------|--|
| 1. By axle group | The price is applied to each axle group. <i>Example:</i> The price per km could vary based on the type of axle group. It could also take into account the actual or registered mass on each axle group. |
| 2. By number of axles | The price is based on the number of axles on a vehicle. <i>Example:</i> The price per km could increase with the number of axles on the entire vehicle combination (that is, including trailers). |
| 3. By modular | The price is based in some way on the number of components that make up a vehicle. <i>Example:</i> the price is based, in some way, on the number of trailers in addition to a prime mover or rigid truck. |
| 4. By vehicle | The price is applied at the same rate to each vehicle regardless of its characteristics in terms of mass or axle configurations. <i>Example:</i> Under pricing model Option 2, each registered heavy vehicle would be charged a flat per kilometre based fee for every kilometre the vehicle travels. |

A variety of methods has been implemented in pricing schemes for countries that use a distance-based charge. Some examples are outlined in Box 2.

Box 2 Application to vehicles in other countries

New Zealand: The charge varies by a combination of a number of factors including number of axles, the type of axles and the number of trailers. (New Zealand Transport Agency, Road User Charges, October 2009).

Switzerland: The registered mass that is used in the pricing formula is the sum of the registered mass of each of the components – for example, the truck mass and the trailer mass. (Schibler, Swiss Federal Department of Finance, Swiss Heavy Vehicle Fee (LVSA), October 2009).

Germany, Czech Republic, Austria: The charge is applied on a per vehicle kilometre basis, with one charge for the whole vehicle (including trailers) with fees differentiated by the number of vehicle axles. (European Federation for Transport and Environment, Comparison of Eurovignette toll schemes in Europe, 2009).

(Gustafsson, Cardebring and Fiedler, Road User Charging for Heavy Goods Vehicles - an Overview of Regional Impact 2006).

Therefore, the German, Austrian and Czech schemes levy a distance charge by vehicle, with fees differentiated by the number of vehicle axles. In Germany a different per kilometre fee applies for vehicles with greater or less than 4 axles. In Switzerland charges are differentiated by the maximum allowable registered weight of a vehicle and by vehicle module — for example, a fee is levied for each vehicle module, and therefore, a vehicle with two trailers in essence pays the fee twice.

Development of the mass based pricing options will consider a number of alternatives for taking into account vehicle mass for charging purposes. For example, prices could be based on the registered vehicle weight or actual vehicle (or axle group) weight.

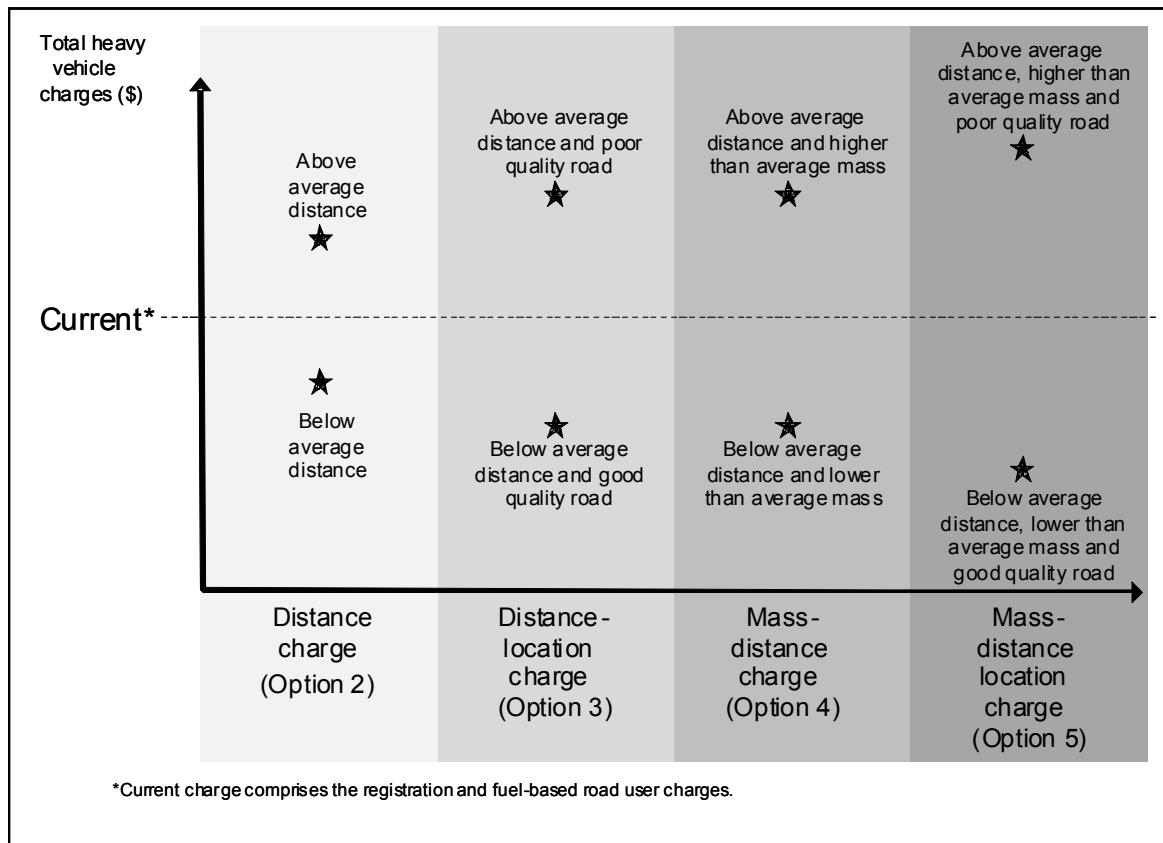
5.4 Potential pricing outcomes

As discussed in this section, the different pricing models and the manner in which they are implemented will result in different indicative prices and price signals for road users.

Figure 11 shows an example of how the indicative prices might vary for a number of MDL scenarios. For example, if a flat distance charge were applied (Option 2), those vehicles travelling above average distances may end up paying more, while those travelling fewer kilometres than average would pay less than current prices. Under an MDL price (Option 5) operators travelling less than average distances on good quality roads at a lower than average mass level would pay less than the current prices, while an operator travelling with above average distance, higher than average mass and on poor quality roads would pay more than current prices. It is not clear at this stage, however, what the net impact would be for an operator travelling with above average distance and higher than average mass on good quality roads.

Therefore, the pricing signals provided to operators, as a result of the new charges, would depend on the pricing model enacted and the actual vehicle usage characteristics.

Figure 11. Indicative prices examples



5.5 Community service obligations/subsidies

Depending on how it is implemented, road pricing reform could result in higher road user prices for heavy vehicles serving particular communities that are only accessible through low quality but high cost roads. Subsidies may be required to reduce the social impact of road pricing reform on the communities in question. A subsidy generally reflects financial assistance, either through direct subsidies (for example, payments in cash or in kind) or through indirect means (for example, governmental provision of goods or services at prices below the normal market price, governmental purchase of goods or services at prices above the market price and tax concessions) to a person or group in order to promote a public social objective.

One approach to subsidies is for governments to purchase services that benefit the community at large, or particular remote communities (so-called community service obligations, or CSOs) that would not be justified solely on commercially grounds. According to the Productivity Commission (2006), the costs of such services are more appropriately borne by the community at large⁵⁹. Alternatively, governments may wish to subsidise the cost of freight infrastructure use for some regional communities where it is deemed too costly to meet social objectives.

⁵⁹ Productivity Commission Report, 2006, p. 99.

The current cost allocation to heavy vehicles removes 50 percent of expenditure on rural local roads and 75 percent of expenditure on urban local roads from the cost base. This adjustment is undertaken for two reasons. First, it is assumed that local roads are generally provided for community access purposes and have limited heavy vehicle traffic. Second, local governments already recover a portion of expenditure on their roads from council rates. Therefore, the on-going funding and provision of these roads probably at least partially reflects an implicit CSO requirement for the provision of this infrastructure.

The PAYGO system also currently contains an explicit CSO for road trains. The recoverable allocated costs of road trains are reduced by five percent on the basis that they only travel in remote areas, where a portion of road expenditures are made based on community need for access rather than on levels of traffic⁶⁰.

This adjustment has been maintained in its current form for the purposes of developing indicative prices because the Phase 1 COAG research on community service obligations⁶¹ did not provide for an analytical framework that could be implemented in the short to medium term to improve upon the current adjustments. Nonetheless, further policy development and analysis may be undertaken in the feasibility study. This issue is still being scoped.

Other forms of subsidies can be more about equity considerations since there will be changes in the road infrastructure price and subsequently the road freight rates charged by freight operators to freight consignors and ultimately to end consumers. Therefore, an important aspect of assessing the impact of the alternative pricing models will be to consider the effect on different industries and communities in different geographic locations. Ultimately, this analysis would need to present options as to how some of the more extreme price changes can be addressed. For example, these might be addressed through the application of cross-subsidies (in the prices) or the application of mechanisms outside of the pricing system (such as direct payments to affected parties). The computable general equilibrium analysis discussed below has the potential to provide an indication of the likely adverse outcomes for different industries and communities.

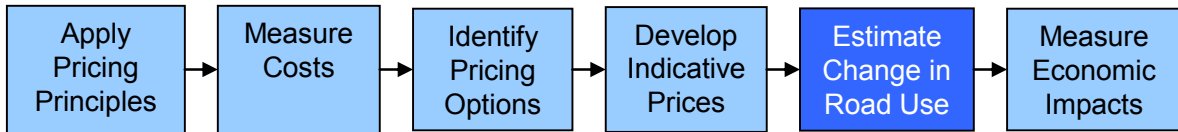
Questions for Section 5

- 5.1 Is the methodology outlined in this section appropriate for developing indicative prices for each of the pricing models, taking into account the pricing principles?
- 5.2 How could it be undertaken differently?
- 5.3 What cost categories should be charged at fixed versus variable rates?

⁶⁰ This is discussed in NTC, Third Heavy Vehicle Road Pricing Determination Draft Regulatory Impact Statement Summary, p. 3, October 2005, and in the Productivity Commission Report, pp. 101-102.

⁶¹ COAG Road Reform Plan Phase 1 Report, May 2009.

6. ROAD USE BEHAVIOUR



This section explains how pricing reform is expected to affect road use behaviour and how the behavioural changes will be estimated, including discussions of:

- the types of possible behavioural changes
- the methodology that will be used to estimate how road users will respond to different types of prices and price levels in the short and long run

The previous two sections described how a set of indicative road prices for various alternative pricing model options are being developed. Section 6 will investigate how road users will respond to the indicative prices associated with each pricing model. This will be referred to as ‘demand elasticity’ analysis since it involves assessing how the demand for road infrastructure will change under different pricing alternatives.

6.1 The range of possible behavioural changes

Each proposed high-level pricing model and associated scenario will generate a different set of price signals for heavy vehicles. These pricing signals will impact the behaviour of road transport operators, freight forwarders, freight customers and road owners at a number of levels.

The adjustments to more efficient pricing might include:

- ***Changes to road freight rates charged:*** heavy vehicle operators may choose to pass through road infrastructure price changes in the form of increases or reductions in freight rates charged to their customers (the freight consignors). If they are not passed through, due to fixed contractual arrangements or other reasons, then transport operators will have to accept lower profits, at least in the short term.
- ***Change in the nature and amount of road usage:*** for example, there could be an impact on distances travelled, loads carried by axle and road types accessed (with location pricing). In terms of the full MDL option (Option 5 in Table 6), heavy vehicle operators may be able to make adjustments to their loads or routes to take advantage of the new, more cost-reflective prices. It may become worthwhile, for example, to make fewer trips with higher loads to reduce kilometre charges and/or to change routes where possible to reduce the use of higher cost arterial roads in favour of freeways/highways.
- ***Changes in equipment used:*** loads may be consolidated on trucks with more axles over which to spread the heavier load because the total road charges to the transport operator will be lower if more axles are used for a given load on a heavy vehicle. The transport operator may also change to an entirely different vehicle configuration (e.g. more or less trailers). These changes may occur in the short term as operators make better use of their existing vehicle stock. In the longer term, more pronounced changes may occur as operators upgrade their fleets in line with the incentives offered by a new pricing structure.

- **Changes in transport mode:** road freight rate pass-throughs may affect the split between road and other types of freight transport. For example, lower road usage costs for heavy vehicles operating on freeways/highways may become more cost-effective compared to rail. On the other hand, freight may move to rail in areas served by high cost roads.
- **Changes to the supply chain:** a new structure of prices may encourage changes in the supply chain, especially over the longer term. More or less freight may be consolidated at terminals. Further, production sites for some goods may change to reflect potential cost savings in road freight transport.

Where the cost of road freight transport is significant in terms of the total cost of a good, new road prices could have a noticeable impact on the price of that good. Note that shipper adjustments are most directly affected by changes in road prices. It is possible that the other operator adjustments could have some second order impact on perceived quality of service and thus affect shipper behaviour.

Shipper adjustments will primarily be in response to changes in the price of shipping freight, although perceived quality of service changes due to routing choices may also influence their decisions.

Many of the potential responses to efficient pricing signals could vary by both the type of commodity shipped and the geographic regions through which the freight moves. Rail and sea freight alternatives, for example, vary by both the type of commodity and the geographic area in which it is to be shipped.

Some of these changes have also been seen with the introduction of kilometre based pricing in Europe (refer to Boxes 2 and 3). These case studies illustrate the potential significant impact road pricing can have on transport operator behaviour, and the importance of understanding how the transport industry could be affected by pricing reform:

- The German pricing scheme (which charges vehicles a flat per kilometre fee, differentiated by Euro class and number of axles) has encouraged a movement of vehicles towards higher Euro classes⁶² and a higher number of axles. In addition, empty running has been reduced and a small modal shift to rail has occurred.
- The Swiss scheme (which imposes a flat rate per kilometre charge differentiated by registered axle mass) has also experienced increased loading levels of vehicles, reduced growth in heavy vehicle traffic and movement to vehicles that have higher Euro classes.

Significant timing issues also exist in regards to behavioural changes. Some changes in shipper or heavy vehicle operator behaviour may occur in a relatively short period, while other changes may take affect many years after implementation. For example, supply chain changes may take place over the course of many years. Changes to the fleet mix may also take place over a number of years, depending on the expected remaining life of the current vehicle fleet and the potential benefits available from switching vehicles. Conversely, the

⁶² Euro class refers to the vehicle's emissions performance, with higher-class vehicles being more efficient in terms of air pollutants. The German situation is discussed in Rommerskirchen, Rotthengatter, Greinus, Leypoldt, Liedtke and Scholz, Life Cycle Cost Analysis of Infrastructure Networks, The case of the German federal trunk roads, 2009.

flow on impact to road freight rates could occur as soon as contractual constraints are relaxed or renewed.

Changes that occur over the long run may also reduce the magnitude of any short run impacts that occur. For example, if in the short run road freight rates rise, resulting in some reduced shipments and/or a move to rail, in the longer term changes to the fleet mix or supply chain reconfiguration may result in road freight prices decreasing and an increase in road freight.

In order to assess the impacts of alternative reform options on heavy vehicle operators, freight consignors of various commodities, end user customers and the economy more broadly, it will be necessary to quantify the adjustments described above.

6.2 Demand elasticity analysis

Demand elasticity estimates will be used to measure behavioural changes in response to new road price signals. Price elasticity of demand is a measure used to show the responsiveness, or elasticity, of the quantity demanded of a good or service to a change in its price. More precisely, it gives the percentage change in quantity demanded in response to a one percent change in price (holding constant all the other determinants of demand, such as income). Given the base quantity of a variable of interest, for example, kilometres travelled, the elasticity measure can be used to estimate how the variable will change as a result of a change in the current effective price per kilometre travelled.

NTC has a project underway (due for completion by the end of 2010) to develop the various road freight demand elasticities that will be needed to evaluate the impacts of the various pricing models. The study will focus primarily (but not exclusively) on survey data of market participants (transport operators, consignors etc.). The survey or 'stated preference' approach to demand elasticity estimation was deliberately chosen over a 'revealed preference approach' (which is based on historical observations of demand decisions) due to a lack of adequate historical data available to estimate revealed preference elasticities for road services.

The survey questions presented to operators will be designed to gain an understanding of how road price changes will affect operator decisions regarding vehicle types, routing, modes, etc. The elasticity estimates being developed will be estimated for both the short run and the long run.

The elasticities will be used to estimate the change in road usage behaviour induced by application of the alternative road pricing models. Two steps will be required to quantify transport sector adjustments (or changes in behaviour) to price reforms:

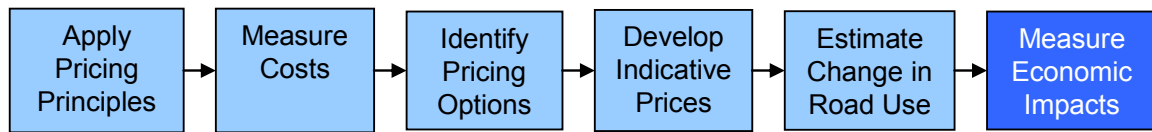
- quantify the impact of revised road prices on heavy vehicle operators
- estimate the short and long run adjustments to the new prices

Questions for Section 6:

6.1 The transport survey will be seeking feedback from the transport industry on likely changes in road use behaviour from different types of price changes. Are there any changes that might possibly not be picked up in the survey?

6.2 Have we identified all the likely behavioural changes that may occur?

7. ECONOMIC IMPACTS



This section explains how economic impacts will be measured and covers:

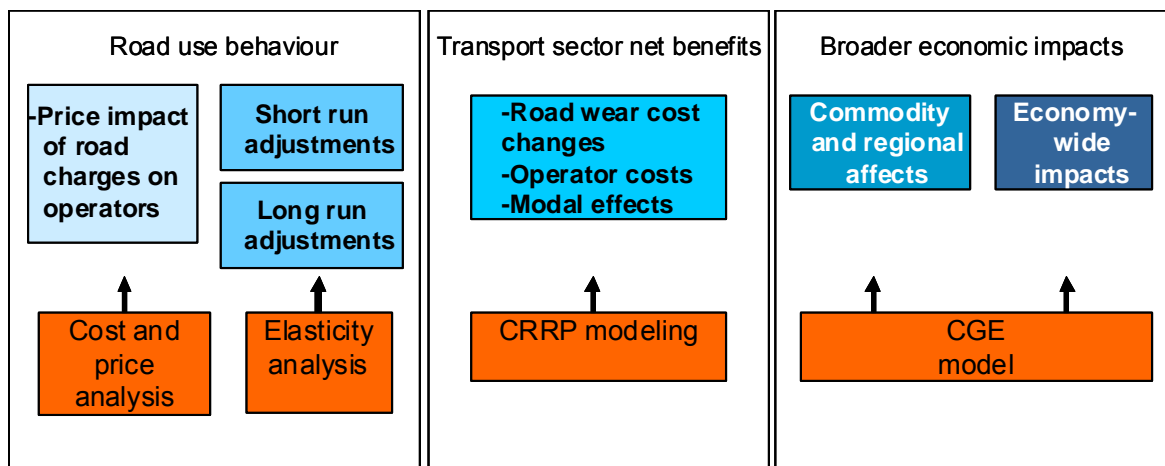
- transport sector costs and benefits
- broader economic impacts
- international assessment approaches

This section provides a broad overview of the assessment process to be conducted for the alternative pricing model options in terms of their potential impact on both the transport sector and the economy more broadly.

7.1 Economic impact evaluation framework

The changes in road use behaviour resulting from a new pricing model will form the basis for understanding and estimating the subsequent impacts on the transport sector and consequently the broader economy. As outlined in Section 1.3, a key objective of the reform process is to compare the relative economic impact of alternative pricing models as well as providing a high-level indication as to the overall benefits available from the different models. These will be determined based on the estimated changes in road use behaviour from the elasticities study. This process is summarised in Figure 12, which shows the progression of the analysis from using estimated changes in road use behaviour to help measure the impact of the reform on the transport sector and then using transport sector impacts to gauge broader impacts on the economy.

Figure 12. Steps in road reform assessment



Road use behaviour was the subject of the previous section, transport sector benefits are discussed in Section 6.1.1 and the broader economic impacts are discussed in Section 6.1.2. The costs of the potential new business systems and legal and regulatory structures that would be needed to support any of the new pricing models will be evaluated by the other work streams. The overall high-level costs and benefits (including those related to the changes in road use behaviour) from all work streams will be integrated as part of the feasibility study once all streams have been completed.

7.1.1 Transport sector costs and benefits

Road pricing reform is expected to have several impacts on the transport sector, which will be considered in evaluating the economic impact of a change in the pricing model:

- **Road maintenance cost savings:** as the road freight industry responds to price signals, it is likely to use roads more efficiently. As a result, heavy vehicle infrastructure prices would be expected to fall as the vehicle fleet imposes less road damage for a given quantity of freight moved resulting in maintenance expenses falling.
- **Change in heavy vehicle operating behaviour and costs:** heavy vehicle operators will face operational costs as they change their fleets to take advantage of the new pricing structure.
- **Change in transport modes:** as road user price changes flow through to freight customers, some demand may shift between freight modes.
- **Improved road funding opportunities:** assuming that appropriate road funding changes are made, road agencies may use direct pricing information to better target maintenance and repair strategies. They can also re-direct capital expenditures to more productive uses, or even increase capital budgets to generate even more downstream maintenance savings. This last economic impact will not be considered by the pricing stream. Rather it will be considered by the broader CRRP project.

7.1.2 Broader economic impacts

The transport sector economic analysis will enable a broader analysis of the impact of road use behaviour changes associated with alternative pricing models. This analysis will include assessing the impact on various industry sectors as well as communities in different geographic locations. It will also enable an assessment of broader economic outcomes such as employment, etc.

Implementing an alternative pricing model will result in changes to the prices and service characteristics offered to freight customers by the trucking industry. This will impact on the prices and costs faced by the various downstream product sectors and regions that use road freight as an input. Possible productivity improvements resulting from improved pricing signals in the freight sector may also flow through to broader economy, resulting in economy-wide impacts on prices, employment, production and even foreign trade.

Measuring these upstream and downstream impacts from reform is a complex undertaking. In particular, assessing sectoral, regional and macroeconomic impacts will be difficult. The use of computable general equilibrium modelling, which links product sectors, service sectors and regions through a complex set of input/output relationships developed from statistically derived empirical relationships, may be considered as part of analysing economy wide impacts.

8. CONCLUSION

This Discussion Paper has outlined the process and key inputs that will be used to develop and assess a range of alternative pricing models as part of the pricing stream. This process is summarised as follows:

- The overarching CRRP principles and objectives will guide the development and assessment process.
- Total road costs to be recovered will be based on the existing PAYGO cost base, while prices based on marginal costs will be developed through the use of an engineering-economic cost model, which is under development.
- Five alternative pricing models will be investigated. These pricing model options and the resulting indicative prices have been developed on the principles of achieving improved economic efficiency and retaining total cost recovery.
- Potential effects of these prices on road user behaviour will be estimated using demand elasticities that will be developed from surveys of operators and their customers. Potential operator and customer behavioural changes in terms of fleet mix, mass carried, routing choices and mode selection will be predicted.
- The assessment process will use the changes in road user behaviour to estimate transport sector impacts and potentially investigate broader economy wide impacts on productivity, prices, employment, production etc.

In this context the next steps are to:

- Develop and refine indicative prices for each of the pricing models based on any refinements to the marginal cost model, taking into account feedback from government and industry consultation.
- Finalise the industry survey (elasticity study), due for completion by end of 2010, then undertake analysis of the transport sector net benefits.
- Begin some further analysis of the alternative cost base models (which were outlined in the COAG Phase 1 GHD Meyrick report).
- Undertake further research on potential improvements to road use data which is used in the modelling.

The next pricing Discussion Paper, due for release in early 2011, will provide a draft of some of the results of the transport sector impacts based on the results of the demand elasticity study.

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APPENDIX A MARGINAL COST MODEL METHODOLOGY, ASSUMPTIONS AND INPUTS

This appendix provides further details on the marginal cost model being developed to estimate the marginal costs of road wear. The appendix describes the analytical approach used in the model, details the methodology used and provides a number of the key model assumptions.

A1 Analytical approach

The approach used by ARRB to measure road usage costs is known as a ‘duration study’⁶³. The basic logic of a duration study is illustrated in Figure A1 overleaf. A road is built to a given strength standard based on forecasts of heavy vehicle traffic measured in terms of standard axle repetitions (SARs). The roughness of the road will increase as heavy vehicles travel the road. Eventually roughness will reach a point requiring intervention in the form of patching, sealing, and/or resurfacing to bring the road back to its original condition.

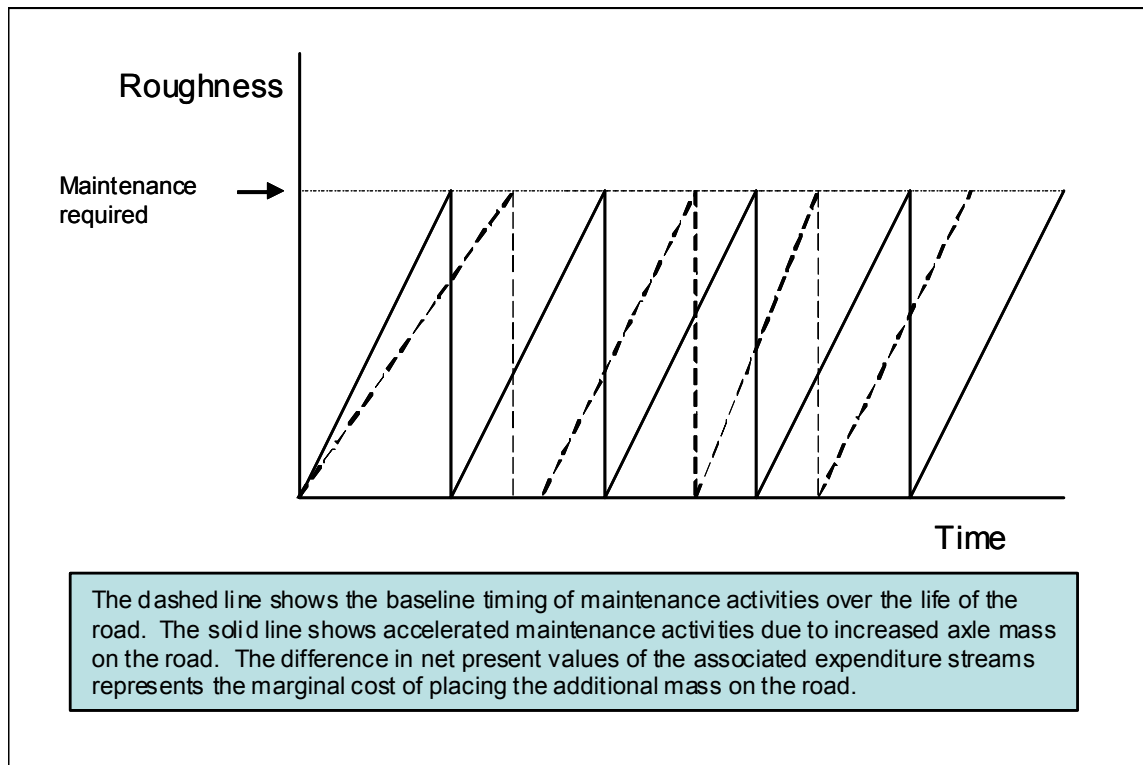
The stream of planned maintenance activities is represented by the dashed line in Figure A1. If heavy vehicle traffic increases beyond the initial estimates, the critical roughness level requiring maintenance intervention will be reached sooner, represented by the solid line. Over the course of its life the maintenance expenditures on the road will be larger than planned. The difference between the original and the accelerated maintenance cost streams, measured in present value terms, represents the marginal cost of the additional heavy vehicle traffic loads.

As discussed in Section 2, economic models make the distinction between short run marginal costs of maintenance and repair and long run marginal costs incurred to increase the strength of the road. This distinction is blurred in practice. At present the ARRB model has the ability to generate three different types of marginal cost estimate. SRMC1 provides for restoration of the original strength of the road when a maintenance intervention occurs. However, while strength measured in terms of durability is restored, this approach does not return roughness to its original state.

The maintenance strategy commonly employed by Australian road agencies is to increase the strength of the road by adding surface material on many roads when an intervention is required. This will restore the design roughness level. It will also restore the original maintenance interval on the road. Taking this practice into account, the ARRB model calculates SRMC2 to include both the maintenance and roughness aspects of the intervention. Although it is a hybrid of the economist’s notion of short and long run costs, the approach reflects practice that the road agency engineers consider to be efficient.

Finally, the model allows the estimation of the cost of intervening to both restore roughness and accommodate higher traffic loads through adding strength to the road (referred to as LRMC1). The three marginal cost measures are shown in Box A1 overleaf. It should be noted that these definitions are preliminary and are currently under review with the aid of additional modelling and research.

⁶³ Link et al, Cost Allocation Practices in the European Transport Sector. Deliverable D1 of CATRIN (Cost Allocation of TRansport INfrastructure cost), Funded by the European Commission, 2008.

Figure A1 Duration model**Box A1 Alternative marginal cost estimates**

- *SRMC1* used rehabilitation thickness needed (less than minimum rehabilitation thickness) to return pavement strength to no greater than initial strength. However, *SRMC1* used full reset roughness after rehabilitation (not realistic).
- *SRMC2* used minimum practical rehabilitation thickness, but pavement strength as a consequence was increased. *SRMC2* is not in accordance with the strict SRMC definition but is more realistic than SRMC1.
- *LRMC1* used rehabilitation thickness needed to strengthen pavement for future increased axle loads.

Econometric studies have also been used to measure marginal costs for some countries⁶⁴. These studies attempt to relate historical maintenance expenditures with road usage characteristics such as traffic and vehicle characteristics. However, the international econometric studies have focused on the relationship between historical road expenditure and a simple road use measure such as AADT (average annual daily traffic)⁶⁵. They have not used variables that are more aligned with the actual nature of road usage such as the mass of the vehicle or passenger car units because of the lack of appropriate road use data sets.

In terms of the econometric approach, NTC and Austroads recently undertook a joint project to investigate the relationship between historical road expenditure and different road use

⁶⁴ See Link, Estimates of marginal infrastructure costs for different modes of transport, August 2003.

⁶⁵ See Lindberg (UNITE), Marginal cost of road maintenance for heavy goods vehicles on Swedish roads, March 2002.

parameters for different road types⁶⁶. The robustness of the conclusions from this report was constrained by the quality of the road use data, which is consistent with international experience.

As a result, it has been concluded that given existing research and data issues, the engineering approach (compared to the econometric approach) provides for the best and relatively most robust approach to develop marginal costs due to many data and specification issues associated with the econometric approach.

A2 Key assumptions

The marginal cost model has been based, as much as is practical, on the actual maintenance practices of the road agencies and relies on empirical research regarding the effects of heavy vehicle traffic on road performance.

The model relies on a number of key decisions:

- **Intervention trigger levels:** in order to decide when to intervene, the ARRB model uses assumptions regarding the roughness and strength of the road. Once the strength or roughness of a road deteriorates below a predefined intervention point, the model undertakes a rehabilitation of the road.
- **Design life:** the ARRB model assumes that each road has a set design life.
- **Starting strength and roughness of roads:** the ARRB model assumes that each road has a starting strength, roughness and age. The starting strength, roughness and age will differ depending on the type of road under consideration.
- **50 year lifecycle:** the marginal costs are estimated using a 50 year lifecycle.

A3 Data inputs

Substantial information must be gathered and analysed to generate marginal costs. The key data inputs to the marginal cost model are outlined in Table A1.

Table A1 Key ARRB model inputs

| Input | Comment |
|--|--|
| Road deterioration models | Both rutting/roughness and strength roughness models are used. |
| Road asset information (e.g. strength, roughness, etc.) | Road asset information has been input for all of the different road types. |
| Road classifications and distribution | The marginal cost model has attempted to model all of the relevant sealed road types throughout Australia. |
| Road usage | The model contains assumptions on usage by road type and vehicle type (by axle group). |
| Axle mass carried by vehicle type and by road type | Assumptions about axle loading (given vehicle types and numbers) and the distribution and distance travelled of axle mass over road types are included in the model. |

⁶⁶ Austroads/NTC, Improving Cost Allocation by Road Type, 2009 (unpublished).

The ARRB model uses two alternative measures of road wear: strength-roughness and rutting-roughness. In effect, the two approaches provide different road condition measurements that would trigger intervention. The World Bank HDM4 Model, which is widely used around the world, provides the formulae for roughness deterioration in the strength/roughness model. The ARRB rutting-roughness model works in a similar way to the strength/roughness model, but considers rutting as a deterioration variable⁶⁷.

As discussed in Section 5, the road classifications used in the model have been refined into a smaller group for purposes of developing indicative prices.

⁶⁷ Martin, New Deterioration Models for Sealed Granular Pavements, Proceedings of the ICE - Transport, Volume 162, 2009, p215-226.