

A new methodology for setting fares

Public transport fares in Sydney and surrounds

Transport — Methodology Paper
September 2015

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Invitation for submissions

IPART invites written comment on this document and encourages all interested parties to provide submissions addressing the matters discussed.

Submissions are due by 9 October.

We would prefer to receive them electronically via our online submission form <www.ipart.nsw.gov.au/Home/Consumer_Information/Lodge_a_submission>

You can also send comments by mail to:

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Late submissions may not be accepted at the discretion of the Tribunal. Our normal practice is to make submissions publicly available on our website <www.ipart.nsw.gov.au> as soon as possible after the closing date for submissions. If you wish to view copies of submissions but do not have access to the website, you can make alternative arrangements by telephoning one of the staff members listed on the previous page.

We may choose not to publish a submission—for example, if it contains confidential or commercially sensitive information. If your submission contains information that you do not wish to be publicly disclosed, please indicate this clearly at the time of making the submission. IPART will then make every effort to protect that information, but it could be disclosed under the *Government Information (Public Access) Act 2009* (NSW) or the *Independent Pricing and Regulatory Tribunal Act 1992* (NSW), or where otherwise required by law.

If you would like further information on making a submission, IPART's submission policy is available on our website.

Contents

Invitation for submissions	iii
1 Introduction	1
1.1 What is our broad approach for determining fares?	1
1.2 What is our process for this review?	5
1.3 What is outside the scope of this review?	6
1.4 The structure of this paper	7
1.5 What issues do we seek comment on?	7
2 What is our proposed approach to setting fares?	11
2.1 Estimating socially optimal fares	12
2.2 Developing alternative fare options	13
2.3 Assessing all fare options against criteria	14
2.4 Considering what form our determination should take	15
2.5 Why is our proposed approach different from the approach we have used in the past?	15
3 How will we estimate socially optimal public transport fares?	18
3.1 What are socially optimal fares?	18
3.2 How will we estimate socially optimal fares?	19
3.3 Why do socially optimal fares differ for different types of journeys?	20
3.4 How do socially optimal fares differ over the medium run and the long run?	21
4 How will we estimate the marginal financial costs?	25
4.1 What is the marginal financial cost of a public transport journey?	25
4.2 How does the marginal financial cost differ between the medium run and the long run?	26
4.3 How does the marginal financial cost differ between peak and off-peak periods?	29
4.4 How does the marginal financial cost vary with journey distance?	30
5 How will we estimate the marginal external costs and benefits?	32
5.1 What are the relevant marginal external benefits and costs?	32
5.2 How are marginal external costs and benefits different between peak and off-peak?	38
5.3 How do marginal external costs and benefits differ by journey distance?	40
5.4 How are marginal external costs and benefits different in the long run compared to the medium run?	40

5.5	Why are we not measuring social inclusion as a marginal external benefit?	42
6	How will we estimate demand for public transport?	45
6.1	Expected levels of demand	45
6.2	Price elasticity of demand	46
7	How will we estimate the marginal excess burden of taxation?	51
7.1	What is the marginal excess burden of taxation?	51
7.2	What is our preliminary estimate of the marginal excess burden of taxation?	52
7.3	What did submissions say about our original proposal for the excess burden of taxation?	52
8	How will we incorporate our fare decisions into the legal determination?	54
8.1	Determine a maximum price for all individual fares	54
8.2	Determine maximum average Opal fares	57
	Appendices	59
A	Minister's referral	61
B	What are socially optimal fares?	64
C	Public transport fare optimisation model	70
D	Submissions to our Draft Report on the external benefits of public transport	77
E	Available literature on public transport elasticities	84

1 | Introduction

The Independent Pricing and Regulatory Tribunal (IPART) is conducting a major review of public transport fares in Sydney and surrounding areas. We have been asked to determine the maximum fares to apply from July 2016 to June 2019 for all public transport services on which the Opal card can be used, including:

- ▼ train services operated by Sydney Trains and NSW TrainLink Intercity
- ▼ government and private bus services in Sydney, Newcastle, the Central Coast, Wollongong, the Blue Mountains and the Hunter regions
- ▼ ferry services operated by Sydney Ferries and the Stockton Ferry in Newcastle, and
- ▼ light rail services in Sydney.

This is the first time we are reviewing fares for all modes of public transport together.

In July, we released an Issues Paper that mainly focused on whether changes should be made to the fare structure for Opal. It also explained our proposed assessment criteria for identifying the best fares option for Opal services, and sought stakeholder feedback on these and other key issues related to fare structure.¹

This Methodology Paper focuses on how we are proposing to determine fares. It also seeks comment on our proposed approach.

1.1 What is our broad approach for determining fares?

Fares recover only a small proportion of the total cost of providing public transport services. NSW taxpayers pay the bulk of this cost through a Government subsidy. Given this, one of our key decisions in determining fares is how much of the total cost should be paid by public transport passengers (through fares) and how much by the NSW community (through the Government subsidy).

¹ IPART, *Finding the best fare structure for Opal – Issues Paper*, July 2015.

For the past five years, we have made this decision by considering, for each mode individually, two key inputs – the estimated total efficient cost of providing the services, and the estimated total value of the ‘external benefits’ associated with the services. The largest external benefits are reduced traffic congestion and pollution savings when people use public transport instead of driving. We considered that the taxpayer contribution to funding the costs of public transport should reflect the estimated value of these external benefits. Therefore, the passenger share of funding was set based on the difference between the estimated efficient costs and the external benefits.

We then determined the maximum average fare increase required to achieve the passenger share by dividing the passenger share by the forecast demand for services. This approach reflects the need to provide a subsidy to public transport passengers, taking into account the benefit to the community.

However, as indicated above, for this review the Government has asked us to consider several issues that we have not considered in the past. In particular, the Minister’s referral (see Box 1.1) asked us to consider:

- ▼ whether fares should be used to encourage more efficient delivery and use of the public transport network
- ▼ whether fares should be used to spread demand across different time periods, and
- ▼ whether there should be more integration of fares across the different modes of transport.

This means that in determining fares for this review, we must consider a broader range of pricing objectives than we did in the past, and take a network-wide perspective in considering the implications of our decisions.

In addition, the Government is expanding the public transport network over the next 10 years. For example, it is constructing the CBD and South East Light Rail, and the Sydney Metro, including a second harbour rail crossing.² These projects will change the way people use public transport services, improve the operation of the current network, and provide for future growth in demand for services in Sydney, particularly during peak periods.

The first step in our proposed approach will be to use a mathematical model to estimate ‘socially optimal’ fares – that is, the fares that maximise the overall welfare (net benefit to both the individual and society as a whole) generated by the use of public transport services in Sydney and surrounds. This model requires a number of inputs and simplifying assumptions. While we will develop our best estimates for each of these inputs, there may be a degree of uncertainty associated with some of them and so the estimated socially optimal fares may involve ranges rather than point estimates of fares.

² NSW Treasury, Infrastructure Statement 2015-16, Budget Paper No. 2, p 3-3, Available from: http://www.budget.nsw.gov.au/__data/assets/pdf_file/0003/126372/BP2_Infrastructure_Statement_2015-16_dnd.pdf

It is our view that fares should be set at the socially optimal levels. However, our estimates of socially optimal fares could be higher or lower than current fare levels and it may be necessary to apply a transition path towards the estimated socially optimal fares to minimise impact on passengers or on taxpayers. In addition, we also need to consider options for more integrated fares across modes (to encourage greater use of public transport and be more logical and predictable).

Therefore, our second step will be to develop alternative fare options that assist with any transition as well as options for more integrated fares across modes to encourage greater use of public transport.

Box 1.1 Matters we must consider for this review

In making our decisions and recommendations for this review, we must consider the legislative requirements set out in section 124(3) of the *Passenger Transport Act 2014*. These include:

- ▼ the cost of providing the services
- ▼ the need for greater efficiency in the supply of services so as to reduce costs for the benefit of consumers and taxpayers
- ▼ the protection of consumers from abuses of monopoly power in terms of prices, pricing policies and standards of service
- ▼ the social impact of the determination or recommendation
- ▼ the impact of the determination or recommendation on the use of the public passenger transport network and the need to increase the proportion of travel undertaken by sustainable modes such as public transport
- ▼ standards of quality, reliability and safety of the services (whether those standards are specified by legislation, agreement or otherwise)
- ▼ the effect of the determination or recommendation on the level of Government funding
 - any matter specified in the referral to IPART
 - any other matter IPART considers relevant.

In addition, we must consider a range of additional matters specified in the referral from the Minister for Transport and Infrastructure. These include:

- ▼ the benefits of fare structures that support network integration to increase network efficiency and reduce overall costs
 - ▼ the benefits and costs of spreading demand for public transport to increase efficiency in service delivery and the likely impact of different fares on the travel behaviour of customers, including whether current concession arrangements for peak and off-peak travel support the optimal use of the network
 - ▼ whether there are strong arguments for or against full integration of fares across all Opal Services, given that some modes have significantly different costs and/or externality benefits
 - ▼ the relative contributions that customers and taxpayers should make to the cost of delivering Opal Services, including light rail as an Opal Service
 - ▼ the technical feasibility of making changes to the current fare structure, given the features of the Opal system and the contracts in place for its implementation and operation
 - ▼ the most appropriate method or methodology for determining maximum fares for Opal Services, including the need for sufficient flexibility to implement any changes to the current fare structure (where relevant)
 - ▼ where relevant, transitional arrangements from the current fare structure to a new fare structure, assuming that new fares would apply from 1 July 2016 and including any customer impacts and technical limitations, and
 - ▼ the need to ensure consistency between the structure of fares in the final determination of appropriate maximum fares for Opal Services and the NSW Government's announced policy position on the structure of fares for Opal Services.
-

1.2 What is our process for this review?

In conducting this review, we are undertaking our own research, analysis and modelling as well as public consultation. As noted above, as the first step in our consultation process we released an Issues Paper in July 2015, which focused mainly on the set of options for fare structure (see Box 1.2). We have received over 1,900 submissions and survey responses.

Box 1.2 Finding the best fare structure for Opal

In July 2015, we released our Issues Paper *Finding the best fare structure for Opal*.

The roll out of the Opal electronic ticketing system provides the opportunity for more significant changes to fare structure, including a range of fare options that were not practical with paper tickets. One of these options is full integration of fares across all Opal services.

The level of integration is one element of the fare structure. It relates to how the fare for a journey is calculated, including what happens if the journey involves more than one trip (eg, three separate bus trips) or more than one mode of transport (eg, a train and a ferry trip). Under the current distance-based fare structure, full fare integration would mean that fares vary by distance, but not by the number of trips or the modes taken. For example, the fare for a 5 km train journey would be the same as for a 5 km bus, ferry or light rail journey, and the same as a 5 km journey comprising trips on different modes (eg, a 2 km bus ride and a 3 km train ride).

Full fare integration could lead to lower fares for some passengers. However, like other potential changes in fare structure, it could also impose costs on other passengers and taxpayers. The Minister's referral asks us to weigh up the benefits and costs of the potential fare structure changes and recommend the fare structure that best balances the matters we have been asked to consider.

This Methodology Paper is the second step in our consultation process and focuses on how we will set fares. We invite all interested parties to make submissions in response to this paper by 9 October 2015. (Details on how to make a submission are provided on page iii at the front of this paper.)

We will also hold a public hearing and workshop to provide a further opportunity for stakeholders to make comments on both areas of this review.

In addition, we released a draft report on the external benefits of public transport in late 2014.³ As part of this fares review, we have considered submissions to this draft report. The values of the external benefits and costs by mode are a key input into estimating the fares that will maximise welfare across the community.

³ IPART, *Review of external benefits of public transport - Draft Report*, December 2014.

In December, we will release a Draft Report outlining our draft decision on what fares should be from July 2016.

Following consultation on the Draft Report, we will make our final decisions on the maximum level of fares. At this stage, we expect the Government will have considered our recommendations and announced its fare structure policy.

An indicative timetable for the review is shown in Table 1.1 below. We will update the timetable on our website (www.ipart.nsw.gov.au) as the review progresses.

Table 1.1 Indicative review timetable

Event	Date
Released Issues Paper on fare structure	21 July 2015
Released Methodology Paper on fare levels	8 September 2015
Public Hearing	15 September 2015
Submissions on Methodology Paper due	9 October 2015
Release Draft Report and Draft Determination	December 2015
Submissions on Draft Report due	February 2016
Release Final Report and Determination	March 2016
Determinations to take effect	July 2016

Note: For the most up to date timetable information please see our website: www.ipart.nsw.gov.au

1.3 What is outside the scope of this review?

Our review will not consider the following matters, which are determined by the NSW Government and are not covered by the referral:

- ▼ The actual fares that will apply from July 2016. The Government may choose to set fares below the maximum determined by IPART but must not set fares above this level.
- ▼ Changes to the fare structure for paper tickets. As the Government has announced that it is progressively phasing out paper tickets, we are not considering the fare **structure** for paper tickets.⁴ However, we will consider fare **levels** for any remaining paper ticket products that can be used on public transport services where the Opal card can be used.
- ▼ The airport station access fee. Currently people entering or exiting the rail network at either of the Sydney Airport stations are charged a station access fee. This fee is subject to contractual arrangements between Transport for NSW (TfNSW) and the company that operates the airport stations.

⁴ Transport for NSW, *Ticket retirement*, Available from <http://www.transportnsw.info/en/tickets/ticket-retirement.page> Accessed 25 June 2015.

- ▼ The public transport network and timetable – including network coverage, service frequency and proposed changes to services. Transport planning decisions are made by TfNSW.
- ▼ Fares for regular private ferry services provided under contract to TfNSW in the Sydney, Central Coast and North Coast areas of NSW.

1.4 The structure of this paper

The rest of this paper provides information and analysis to assist you in making your submission on our proposed methodology for determining fares:

- ▼ Chapter 2 provides an overview of our proposed approach for determining fares and why this approach differs from what we have done in the past.
- ▼ Chapter 3 discusses the first step and main focus of our proposed approach – estimating socially optimal fares. It explains what we mean by optimal fares, and how we propose to estimate them.
- ▼ Chapters 4 – 7 discuss each of the key inputs for estimating socially optimal fares – the efficient marginal financial costs, the marginal external benefits and costs, the marginal excess burden of taxation and the forecast demand for the services – and our proposed approach for estimating each input.
- ▼ Chapter 8 focuses on the form our determination should take – in particular, whether we should continue to set the average fare change or set maximum fares for all individual products.

1.5 What issues do we seek comment on?

Each of the chapters in this paper highlights one or more questions on which we particularly seek comment. These questions are listed below. Stakeholders are also welcome to provide input on any issue within the scope of the review.

- 1 Do you agree with our proposed approach to setting fares? There are four broad steps: 17
 - Estimate socially optimal fares – that is, fares for each mode that will encourage the most efficient use of public transport and promote the most efficient delivery of public transport. 17
 - To assist with transitioning current fares to optimal levels, we will develop additional fare options that would allow us to consider impacts on passengers and taxpayers. In addition, we also need to consider options for more integrated fares across modes. 17
 - Assess all these fare options against the full set of assessment criteria. 17
 - Decide what form our fare determination should take. Our preliminary view is that we should determine set maximum fares for each individual fare. 17

- 2 According to economic theory, a certain number of journeys will maximise the welfare (or net benefits to the wider community) generated by the service. This is known as the socially optimal level of consumption. Fares set to achieve this level of consumption are known as the 'socially optimal fares'. 24
 Do you agree with our proposed approach to estimating socially optimal fares across modes (rail, bus, ferry and light rail) and for different times of the day (peak and off-peak), reflecting the different costs of providing these services, and the different benefits generated from their use? 24
- 3 We also propose to estimate socially optimal fares from a medium-run perspective (ie, three years which corresponds with our determination period) and a long-run perspective (eg, 10 or more years). For this reason, we refer to: 24
 - The medium run as when the capacity of road and public transport infrastructure is fixed, but public transport service frequency and vehicle fleets could expand or contract in response to demand changes within the determination period. 24
 - The long run as when the capacity of road and public transport infrastructure could expand, and service frequency and vehicle fleets could expand or contract in response to long-term demand changes. 24
 Do you agree with our proposed time frames for estimating the socially optimal fares? 24
- 4 We propose to distinguish between efficient marginal financial costs for peak and off peak as follows: 31
 - b in the off-peak period, and 31
 - $b + \beta$ in the peak period 31
 where: 31
 - b is the efficient marginal financial usage costs per journey, and 31
 - β is the efficient marginal financial capacity costs per peak journey. 31
 Do you agree with this proposal? 31
- 5 Which types of financial costs do you consider vary depending on the distance of the journey, and which do you consider depend more on the journey simply being made? 31
- 6 Do you agree with our proposal to estimate efficient marginal capital costs for the medium run and for the long run as follows: 31
 - For the medium run, including efficient costs associated with: 31
 - additional buses, ferries, and light-rail train sets 31
 - wharf and station upgrades 31

– upgraded and additional bus priority lanes on existing roads	31
– upgraded and additional bus depots.	31
For the long run, including efficient medium-run capital costs plus efficient costs associated with:	31
– additional ferry wharves	31
– new light-rail tracks and stations (eg. The Sydney CBD and South East light rail)	31
– new heavy rail tracks and stations (eg, the Sydney Metro including the second harbour rail crossing)	31
– additional heavy rail train sets	31
– priority bus lanes that form part of new road projects.	31
7 Do you agree with our proposal to consider productivity adjustments to identify efficient operating costs in the long run? How do you consider we should identify and estimate the appropriate productivity adjustments?	31
8 Do you agree with our proposed approach for estimating marginal external benefits and costs? Have we identified all the relevant costs and benefits?	43
9 Do you agree with our proposed approach to estimating scale benefits in the medium run for buses, ferries and light rail? Because the train network is currently at capacity in peak times, this benefit will only be considered in our long term analysis. Do you agree with this approach?	43
10 What is your view on how we should measure crowding costs of public transport, particularly in peak times? Options include:	43
– Including an estimate of the cost equal to what that displaced passenger would have been willing to pay to make the journey.	43
– Measuring the amount of crowding and placing a cost to users of this crowding.	44
11 Do you agree with our view on which externalities are likely to be materially different in peak and off peak times?	44
12 Is using the Bureau of Transport Statistics' Strategic Travel Model the best approach available to estimate the differences in externalities in peak and off-peak periods?	44
13 Do you agree with our proposed approach to determining how external costs and benefits vary with distance or result simply from the trip being taken?	44
14 Do you agree with our proposed approach for capturing longer term external costs and benefits?	44

- 15 Do you agree with our proposal not to measure social inclusion as a marginal social benefit for setting fares? 44
- 16 We propose to estimate the demand and price elasticities having regard to the estimates we derive from the outputs of the Bureau of Transport Statistics' Strategic Travel Model, and estimates from available literature. Do you agree with this approach? 50
- 17 How should we estimate the peak/off-peak cross-price elasticities for all public transport modes? For example, this could include: 50
 - examining the effect of past changes to the difference between peak and off-peak rail fares on the height and width of the peaks in demand, and 50
 - examining the impact of changes in peak pricing for the Sydney Harbour Bridge and Harbour Tunnel over time. 50
- 18 Do you agree with our preliminary view to include an estimated marginal excess burden of taxation equal to 8% of the size of the subsidy in our fare optimisation model? 53
- 19 Once we have decided on the fares that strike the best balance between our assessment criteria, we need to translate these decisions into a legal determination. Do you agree with our preliminary view that IPART should determine individual fares for our legal determination? 58

2 What is our proposed approach to setting fares?

As Chapter 1 discussed, in making our decisions on fares we must consider legislative requirements and the matters specified in the Minister's referral (see Box 1.1). To ensure we consider all the relevant requirements, we have developed a set of criteria that encapsulates these requirements and matters, as well as the principles of good regulatory practice. Box 2.1 sets out our proposed assessment criteria (which are the same as those we proposed in our July Issues Paper). These criteria can also be seen as our pricing objectives (ie, what we aim to achieve through the fare levels and fare structure we set).

Box 2.1 Proposed assessment criteria for this review

We propose to use the following criteria to guide us in developing a range of fare options, and then assessing these options:

- ▼ encourages the efficient use of public transport
 - ▼ promotes the efficient delivery of public transport
 - ▼ encourages greater use of public transport
 - ▼ minimises impacts on passengers
 - ▼ is logical, predictable and stable over time, and
 - ▼ increases farebox revenue or cost recovery.
-

Our proposed approach for deciding on fares involves four broad steps:

1. Estimate fares that target the first two assessment criteria – that is, fares for each mode that will encourage the most efficient use of public transport and promote the most efficient delivery of public transport. In economic theory, these options are the 'socially optimal' fares. It is our view that fares should be set at the socially optimal levels. However, it may be necessary to apply a transition path towards the estimated socially optimal fares to minimise impact on passengers or on taxpayers
2. To assist with transitioning current fares to optimal levels, we will develop additional fare options that would allow us to consider impacts on passengers and taxpayers. In addition, we also need to consider options for more integrated fares across modes (to encourage greater use of public transport and be more logical and predictable).

3. Assess all these fare options against the full set of assessment criteria.
4. Decide what form our fare determination should take - in particular whether we should continue setting average fare changes, or set maximum fares for each individual fare.

The sections below explain the four steps in our proposed approach in more detail, and discuss the benefits of this approach compared to the one we have used for previous fare determinations. The rest of this methodology paper explains and seeks feedback on the first step – estimating socially optimal fares – and the fourth step – deciding on what form our fare determination takes. The second and third steps depend on the outputs produced by the first step, and will be set out in more detail in our draft report, due to be released in December.

2.1 Estimating socially optimal fares

Broadly speaking, when a passenger decides to use a public transport service there are costs and benefits to that passenger, and to the wider community (including other users of public transport). The relative sizes of these costs and benefits depend to a great extent on the overall level of capacity and use of the service, and how this compares with the level of capacity and use of alternative transport options.

In theory, a certain number of journeys on a service will maximise the welfare (or net benefits to the wider community) generated by the service. In economics, this is known as the socially optimal level of consumption. Fares set to achieve this level of consumption are known as the ‘socially optimal fares’. Socially optimal fares encourage both efficient use of public transport and efficient delivery of public transport – our two ‘efficiency’ criteria.

Our first step in setting fares will be to use a mathematical optimisation model to estimate fare options that are ‘socially optimal’. To estimate socially optimal fares, the model uses estimates of the following for each mode:

- ▼ estimates of the financial costs (the additional financial cost of one additional passenger journey)
- ▼ estimates of the external costs (the costs imposed on other people by one additional passenger journey)
- ▼ estimates of the external benefits (the additional benefit enjoyed by third parties as a result of one additional passenger journey)
- ▼ estimates of the excess burden of taxation (the cost to society of raising taxes to provide a government subsidy), and
- ▼ forecasts of demand for public transport services and estimates of price elasticity (how demand varies in response to price).

Socially optimal fares vary for different types of journeys, depending on which mode of public transport (train, bus, ferry or light rail) is used, whether the journey is in the peak or in the off peak, and the distance travelled. This is because the costs, benefits, and demand differ for each of these types of journeys.

Therefore, we propose to estimate a set of socially optimal fares for each mode of transport, for:

- ▼ journeys taken in the weekday peak and off-peak periods, and
- ▼ journeys taken over different typical distances (eg, short-distance journeys less than 5 km, medium-distance journeys between 5 km and 25 km, and longer-distance journeys of more than 25 km).

In addition, we propose to estimate these sets of fares from a medium-run perspective (ie, the 3-year pricing period) and a long-run perspective (eg, longer than 10 years), as the period of time considered also results in different costs, benefits and demand.

It is our view that fares should be set at the socially optimal levels. However, it may be necessary to apply a transition path towards the estimated socially optimal fares to minimise impact on passengers or on taxpayers .

Arriving at each of the inputs to our estimation of the socially optimal fares in Step 1 also involves an estimation process. While we will develop our best estimates for each of these inputs, there may be a degree of uncertainty associated with some of them. We may therefore estimate socially optimal fares as ranges rather than point estimates of fares.

We recognise that this is a highly technical step, and explaining it is therefore a key part of this methodology paper. To assist stakeholders' understanding, Chapter 3 provides a more detailed explanation of what we mean by socially optimal fares and how we propose to estimate them. Chapters 4 to 7 explain how we propose to estimate the key inputs to be used in this estimation.

2.2 Developing alternative fare options

Our estimates of socially optimal fares could be higher or lower than current fare levels and it may be necessary to consider a transition towards estimated optimal fares to minimise impact on passengers or on taxpayers.

The second step in our fare-setting process will therefore to develop additional fare options that would allow us to consider impacts on passengers and taxpayers. For example, the alternative fare options during transition might involve:

- ▼ Fare levels that are lower than our estimates of the socially optimal fares (to encourage greater use of public transport and minimise impacts on passengers).

- ▼ Fare levels that are higher than our estimates of the socially optimal fares (to improve cost recovery).

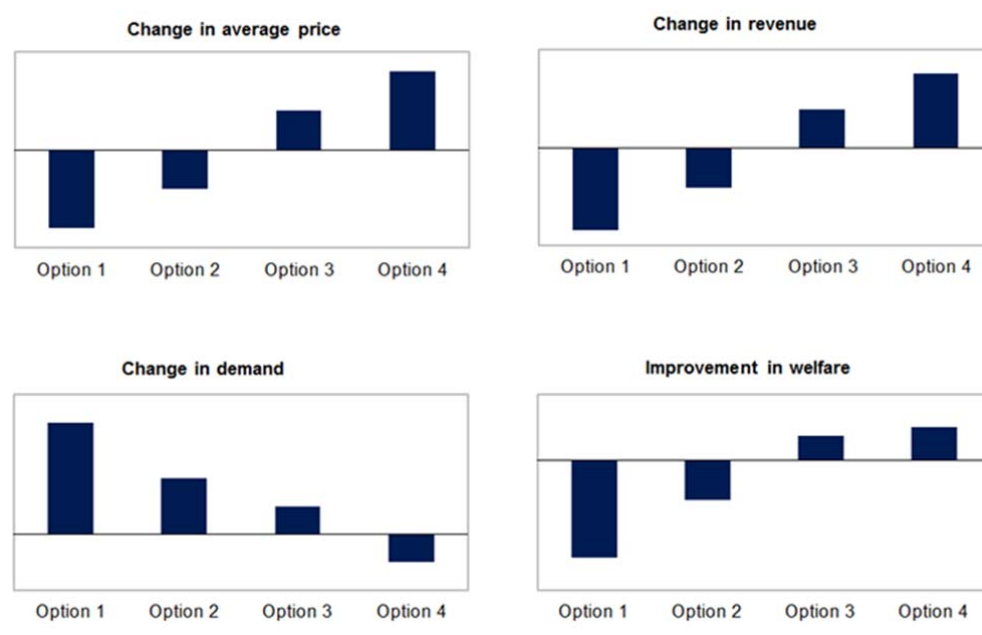
We will also consider options for more integrated fares across modes (to encourage greater use of public transport and be more logical and predictable).

2.3 Assessing all fare options against criteria

Our third step will be to assess all of our fare options against the assessment criteria. We will do this by estimating the likely outcomes of moving from current fares to each set of fare options, including the impacts on:

- ▼ the number of passenger trips for each mode
- ▼ social welfare (net benefits to society)
- ▼ farebox revenue and cost recovery, and
- ▼ how much passengers would pay.

Figure 2.1 Comparing fare options against assessment criteria



We know that socially optimal fares will result in the greatest increase in welfare (efficiency), by definition, and so will best meet the first two assessment criteria. However, as discussed above, we need to consider how we would transition from current fares to our estimates of the socially optimal fares. We also need to consider pricing objectives that relate to matters other than efficiency.

We cannot yet assess how the estimated socially optimal fares will perform against the other criteria as this depends on the values of the different inputs to the mathematical optimisation model. For example:

- ▼ If our estimates of the socially optimal fares are lower than current fares, moving to them could potentially lead to large losses in farebox revenue for a relatively small increase in welfare (for example, if demand is not very responsive to price).
- ▼ If our estimates of the socially optimal fares are significantly higher than current fares, moving to them would have large impacts on passengers, and could lead to significantly lower use of public transport (if demand is responsive to large price increases).

2.4 Considering what form our determination should take

Once we have selected our preferred fare option, we will consider what form our determination should take – in particular, whether we should continue setting average fare increases, or set maximum fares for each individual fare. In doing this, we will also have regard to the technical limitations of the Opal system and the contracts in place for its implementation and operation. Our preliminary view is that IPART should determine individual fares for our legal determination.

Chapter 8 sets out our considerations on the form of the determination in more detail.

2.5 Why is our proposed approach different from the approach we have used in the past?

While it builds on the approach we have used in making previous fare determinations, our proposed approach has a number of important differences and advantages.

We consider the main advantages to be that our new approach:

- ▼ allows us to make a judgement about which fare outcomes best balance competing pricing objectives
- ▼ enables us to make a more accurate estimate of efficient fare levels, and
- ▼ considers the relationship between demand for transport services and their price.

This section explains the differences and advantages of our proposed approach compared to our previous approach.

2.5.1 Our proposed approach allows us to better balance competing pricing objectives

As Chapter 1 discussed, we previously set fares by considering, for each mode individually, two key inputs:

- ▼ the estimated total efficient cost of providing the services, and
- ▼ the estimated total value of the net external benefits associated the services.

We took the view that the taxpayer contribution to the total costs should be in line with the total estimated value of the external benefits. Therefore, we set the passenger contribution based on the difference between the total efficient costs and the total net external benefits. We then divided the passenger share by the forecast demand for services to set the average fare.

This approach resulted in a single fare outcome for each mode. Depending on the total costs, total external benefits, and total demand, this outcome could lead to significant fare increases or decreases – neither of which would be consistent with our pricing objectives for this review. In particular, large fare increases would be counter to minimising impacts on customers, and encouraging greater use of public transport. Large fare decreases would be counter to increasing farebox revenue or cost recovery.

As discussed above, our proposed approach will consider several fare options that we will compare and assess against the assessment criteria (or pricing objectives) for this review. This allows us to make a judgement about the fares that produce the best outcomes using transparent criteria.

In addition, our proposed approach will enable us to produce a better estimate of the socially optimal (or efficient) fare levels by using a marginal cost approach (rather than average cost) and by considering the relationship between fares and demand.

2.5.2 A marginal cost approach enables a more accurate estimate of efficient fare levels

Under our previous approach, we used an ‘average cost’ approach to set fares – that is, we divided the passenger share of total costs by the forecast number of passenger journeys over the review period. This approach meant that, all else being equal, higher patronage led to lower fares. In addition, higher patronage led to higher external benefits, which reduced the passenger share of the total costs and thus led to even lower fares.

Given that many services in Sydney and surrounds are reaching capacity, this average cost approach may not result in efficient fare outcomes. In this context, the efficient level of fares rises when patronage increases, rather than falls. This is because higher fares will encourage efficient use of the services (as the available capacity will be allocated to those that value it more), and promote efficient delivery of the services (by signalling the need for new investment).

Under our proposed approach, we use a ‘marginal social cost’ approach rather than an average cost approach. As Chapter 3 explains, a marginal social cost approach focuses only on the efficient costs and external benefits of serving **additional** passengers. If patronage increases on a service close to capacity, the marginal social costs will increase (either because crowding costs are increasing, or because new services need to be added), resulting in higher (and more efficient) fares.

2.5.3 Considering the relationship between fares and demand

Under our previous approach, we forecast the demand for services over the determination period without taking account of how changes in price may affect demand. This is consistent with the way we forecast demand for other regulated industries. However, the demand for public transport services is likely to be more responsive to changes in price than the demand for other regulated services (such as water). This is because substitutes for public transport services are available and relatively affordable (eg, many public transport users already own cars).

Under our proposed approach, we will consider the impact of price changes on demand to improve our estimates of the efficient fare levels, and our estimates of revenue outcomes under our preferred set of fares.

IPART seeks comments on the following

- 1 Do you agree with our proposed approach to setting fares? There are four broad steps:
 - Estimate socially optimal fares – that is, fares for each mode that will encourage the most efficient use of public transport and promote the most efficient delivery of public transport.
 - To assist with transitioning current fares to optimal levels, we will develop additional fare options that would allow us to consider impacts on passengers and taxpayers. In addition, we also need to consider options for more integrated fares across modes.
 - Assess all these fare options against the full set of assessment criteria.
 - Decide what form our fare determination should take. Our preliminary view is that we should determine set maximum fares for each individual fare.

3 How will we estimate socially optimal public transport fares?

As Chapter 2 discussed, the first step in our proposed approach is to estimate socially optimal fares for each mode of public transport services. This chapter discusses this step in more detail, including:

- ▼ What we mean by socially optimal fares?
- ▼ How we propose to estimate these fares?
- ▼ How socially optimal fares are different for different types of journeys?
- ▼ Why we are proposing to consider socially optimal fares from a medium-run and long-run perspective?

3.1 What are socially optimal fares?

As explained in Chapter 2, there is a certain number of journeys on a public transport service that will maximise the net benefits to society generated by the use of that service, and which therefore also maximises welfare. This is known as the socially optimal level of consumption, and fares set to achieve this level of consumption are known as the ‘socially optimal fares’.

At the socially optimal number of journeys, the cost of providing the service to the last passenger is equal to the benefit of the service to that passenger and to the wider community. This last passenger is known as the ‘marginal’ passenger, and the costs and benefits associated with serving the marginal passenger are known as ‘marginal costs’ and ‘marginal benefits’.

At the socially optimal number of journeys, the costs to society of any additional journeys would outweigh the benefits to society from the additional journeys. At the same time, if there were fewer journeys than the socially optimal number, welfare could be improved by encouraging additional journeys. Setting fares at the level that ensures the socially optimal level of journeys will therefore maximise the net benefits to society of public transport use.

There is a well-established economic framework for describing the socially optimal level of consumption and price for any good or service, which underpins our approach for estimating the optimal fares. Appendix B provides an overview of this framework.

3.2 How will we estimate socially optimal fares?

We have developed a mathematical optimisation model that we will use to estimate the socially optimal fares for each mode. This model takes account of the context in which we are setting fares, including the competition between private and public transport modes, the existing and planned public transport capacity, the current utilisation of this capacity, and taxpayer subsidisation of public transport. It aims to identify the fare levels that will balance the following two effects:

1. Setting fares above the socially optimal level would lead to excessive use of private cars and underutilisation of existing and planned public transport capacity, leading to higher external costs associated with road congestion, emissions and road accidents.
2. Setting fares below the socially optimal level would lead to excessive crowding on public transport, underutilisation of existing and planned road capacity, and excessive public transport operating losses which must be funded from taxation.

The optimisation model requires a significant number of inputs and several simplifying assumptions. For each mode, we will need to estimate the following key inputs:

- ▼ **The marginal social cost**, which is the full cost to society of one additional passenger journey. This cost is equal to:
 - **the marginal financial cost** (the additional financial cost of one additional passenger journey) *plus*
 - **the marginal external cost** (the additional cost imposed on third parties as a result of one additional passenger journey) *less*
 - **the marginal external benefit** (the additional benefit enjoyed by third parties as a result of one additional passenger journey).
- ▼ **The marginal excess burden of taxation**, which is the cost to society of raising taxes for the purpose of providing a Government subsidy for one additional passenger journey.
- ▼ **The forecast demand for the services** during the peak and off-peak periods, and for journeys of a few different distances, taking into account how demand would change in response to changes in prices.

Chapters 4 to 7 explain how we propose to estimate these inputs, and seek stakeholder comments. Appendix C provides more technical detail on our fare optimisation model.

3.3 Why do socially optimal fares differ for different types of journeys?

As Chapter 2 indicated, the socially optimal fares vary for different types of journeys. They vary depending on which mode of public transport is used, on whether the journey is in the peak or in the off peak, and on the distance travelled. Therefore, we propose to estimate different fares for each different type of journey.

We also propose to estimate these socially optimal fares from a medium-run perspective and a long-run perspective. In section 3.4, we explain how the socially optimal fares differ between the medium- and long-run perspectives. We will consider both the medium-run and the long-run sets of fares, but we have not decided whether we will give equal weighting to both sets. We are interested in stakeholders' views on this issue.

3.3.1 Socially optimal fares differ between the weekday peak and off-peak periods

The socially optimal fare for a journey will differ depending on whether it is taken during the weekday peak period or the off-peak period because the demand for transport and the marginal costs and benefits of public transport use differ between these periods. First, the capacity of the public transport network is driven primarily by the need to meet peak demand, which tends to be much more concentrated both time-wise and geographically than off-peak demand. Much of the costs associated with establishing the capacity of the public transport network, such as vehicle fleet size and infrastructure capacity, can therefore be attributed to peak demand.

Second, the private benefit of a journey is likely to differ between the peak and off-peak periods. For example, during peak times, people are often travelling to work or study and place a high value on short journey times and on being able to arrive at their destination on time. But travelling by car during peak often means long and unpredictable travel times as a result of congestion, plus high costs and difficulties finding parking near their work or place of education. Therefore, travellers would often be willing to pay much more for reliable and reasonably fast public transport, even if this means having to walk a little further and possibly having to interchange between transport modes.

During the off peak, people often travel for purposes that are less time-critical, such as shopping, social and recreational activities. In addition, during the off peak there is often less road congestion, and it may be easier to find parking. Since using public transport during the off peak might mean longer travel times and is likely to be less convenient, the traveller's willingness to pay for public transport is likely to be lower during the off peak than during the peak.

Finally, the external costs and benefits of a public transport journey differ between the peak and off-peak periods. For example, given the lower levels of road congestion during the off peak, the benefits of an additional traveller making the journey by public transport instead of by private transport is smaller.

Chapters 4, 5 and 6 discuss in more detail how the inputs required to identify the socially optimal fares vary between the peak and off-peak periods.

3.3.2 Socially optimal fares differ depending on the distance travelled

The socially optimal fare will differ depending on the distance travelled because the marginal social cost of a public transport journey depends partly on the distance travelled. In particular, some of the items that make up the marginal financial cost vary by the distance travelled. These include labour costs, fuel costs, and vehicle and infrastructure wear and tear.

In addition, the marginal external costs and benefits of a public transport journey depend partly on the distance travelled. For example, the benefits of avoided emissions and accident costs from a journey made by public transport instead of by car also depend on the length of the journey. On the other hand, the avoided road congestion associated with a public transport journey is less dependent on the length of the journey, and depends instead more on the location of the journey.

We are proposing to estimate the socially optimal fares for journeys taken over different typical distances (eg, short-distance journeys less than 5 km, medium-distance journeys between 5 km and 25 km, and longer distance journeys of more than 25 km). However, our ability to differentiate between the financial costs of journeys of different lengths will depend on the information available from Transport for NSW on the costs of providing each mode. Chapter 4 discusses the marginal financial costs in more detail. Chapter 5 discusses the marginal external costs and benefits in more detail.

3.4 How do socially optimal fares differ over the medium run and the long run?

As noted above, we intend to estimate the socially optimal fares for each mode over two different timeframes:

- ▼ the medium run (ie, three years which corresponds with our determination period), and
- ▼ the long run (eg, 10 or more years).

We want to consider the socially optimal fares for both the medium-run and the long-run, since both the marginal social costs and the demand for public transport are likely to depend considerably on the timeframe being considered.

There are advantages and disadvantages of estimating the socially optimal fares using either a medium-run or a long-run approach.

3.4.1 Marginal social costs differ between the medium run and the long run

Economists differentiate between short run and the long run, where the difference between the two is the timeframe under consideration and the degree to which inputs into production could be varied in that timeframe. Typically, in the short run, production capacity is considered fixed, while in the long run, all inputs into production, including production capacity, could be varied.

The shortest relevant period for our purposes is the full 3-year determination period for public transport. A 3-year period could permit some changes to capacity, mainly in terms of service frequency and the size of the public transport vehicle fleets. However, public transport infrastructure capacity could, for the most part, not be altered in response to demand changes *within* the period. Given there is some but not full flexibility in relation to varying public transport capacity within the determination period, we consider this period to be more akin to a 'medium-run' period. We therefore define Medium-Run Marginal Social Cost (MRMSC) and Long-Run Marginal Social Cost (LRMSC) as follows:

- ▼ MRMSC is the additional social cost of one additional passenger journey or passenger kilometre⁵ when the capacity of road and public transport infrastructure is fixed, but public transport service frequency and vehicle fleets could expand or contract in response to demand changes within the determination period.
- ▼ LRMSC is the additional social cost of one additional passenger journey or passenger kilometre when the capacity of road and public transport infrastructure could expand, and service frequency and vehicle fleets could expand or contract in response to long-term demand changes.

In the medium run, when public transport infrastructure and road capacity are fixed, the marginal social cost of a passenger journey depends largely on the current use of the relevant public transport service. If there is plenty of spare capacity, the additional financial costs (eg, fuel and labour) and external costs (eg, crowding and pollution costs) of one additional passenger journey are very low. And, if the roads are congested (and the passenger would otherwise have travelled by car), the additional external benefits of this journey are high. This means the MRMSC of the passenger journey is low.

On the other hand, if the public transport service is at or is approaching its capacity limit, the additional financial costs of one additional passenger journey might still be very low, but the additional external costs (eg, crowding) could be significant. And, if the roads are not particularly congested, the additional external benefits of the journey are likely to be small and would not offset much

⁵ A passenger kilometre is equal to one kilometre travelled by a passenger.

(if any) of the extra external costs. This means the MRMSC of the passenger journey is high.

In the long run, both public transport and road infrastructure capacity can be adjusted to best service expected demand now and in the future. The decision to invest in transport infrastructure to expand capacity is a trade-off between the social cost of the investment and the social cost of continued and likely increasing crowding and congestion if the investment is not made. The LRMSC reflects the least socially costly way to service the expected demand over the long run, including the cost of infrastructure investments. Importantly, the social benefits of a particular public transport infrastructure investment, such as the second harbour rail crossing, also reflect the benefit of **delaying** the need for investments in other transport infrastructure, including publicly funded roads.

3.4.2 Demand differs between the medium run and the long run

Demand for public transport services also depends on the timeframe being considered. For example, 20 years from now, growth in the population, employment and incomes will have significant implications for the overall level of demand for public transport services. Also, the particular locations where people choose to live and work will likely change considerably over this period, affecting the demand for services along various transport corridors. Moreover, such structural changes would become more and more significant the longer is the timeframe being considered.

3.4.3 Pros and cons of estimating socially optimal fares using a medium-run or a long-run approach

We propose to calculate the socially optimal fares using both a medium-run approach and a long-run approach because there are advantages and disadvantages associated with both approaches.

In the medium run, when public transport infrastructure and road capacity are fixed, setting prices equal to the MRMSC would encourage the socially optimal use of existing capacity. That is, it would help ensure allocative efficiency in the medium run. But, the resulting usage pattern would not be a useful indicator of **long-run** infrastructure investments.

In the long run, when supply capacity can be altered in response to demand changes, setting prices equal to the LRMSC would signal to users the cost of varying long-run capacity and so would ensure allocative efficiency in the long run. This would also ensure users contribution to the costs of expanding the transport network, and would allow users to take these costs into account when making their usage decisions. But there are a number of limitations with the long-run approach that make it a less attractive approach in practice. In particular, the long-term forecasts of the inputs required for the optimisation

model, such as long-term costs, benefits, and demand, will have a higher degree of uncertainty.

IPART seeks comments on the following

- 2 According to economic theory, a certain number of journeys will maximise the welfare (or net benefits to the wider community) generated by the service. This is known as the socially optimal level of consumption. Fares set to achieve this level of consumption are known as the 'socially optimal fares'.

Do you agree with our proposed approach to estimating socially optimal fares across modes (rail, bus, ferry and light rail) and for different times of the day (peak and off-peak), reflecting the different costs of providing these services, and the different benefits generated from their use?

- 3 We also propose to estimate socially optimal fares from a medium-run perspective (ie, three years which corresponds with our determination period) and a long-run perspective (eg, 10 or more years). For this reason, we refer to:
 - The medium run as when the capacity of road and public transport infrastructure is fixed, but public transport service frequency and vehicle fleets could expand or contract in response to demand changes within the determination period.
 - The long run as when the capacity of road and public transport infrastructure could expand, and service frequency and vehicle fleets could expand or contract in response to long-term demand changes.

Do you agree with our proposed time frames for estimating the socially optimal fares?

4 How will we estimate the marginal financial costs?

As Chapter 3 discussed, the first key inputs into the model we will use to estimate the socially optimal fares are the marginal social costs of each mode – that is, the full costs to society of one additional passenger journey on each mode. To derive these costs, we need to estimate the efficient marginal **financial** costs of each mode. In line with our proposed approach for calculating the socially optimal fares, we will need to estimate these financial costs:

- ▼ for journeys in the weekday peak period and the off-peak period
- ▼ for journeys of different distances, and
- ▼ over a medium-run timeframe and a long-run timeframe.

The sections below explain what we mean by the marginal financial cost, and how this cost differs for different journeys and over the medium run and the long run.

4.1 What is the marginal financial cost of a public transport journey?

The financial costs of providing public transport services include both capital costs and operating costs. The marginal financial cost is the sum of the marginal capital cost and marginal operating cost, where, as explained in Chapter 3, ‘marginal cost’ refers to the additional cost associated with serving one additional passenger.

Capital costs refer mainly to the one-time up-front costs of the physical assets that comprise the public transport network. These include land; infrastructure (eg, rail tracks and stations, roads, bus depots, light rail tracks and stations and ferry wharves); vehicles (eg, train sets, bus fleet and ferry fleet); and equipment (eg, signals, ticketing machines, and Opal card readers). Operating costs refer to the ongoing costs of operating the network, such as labour costs, maintenance costs and other costs (such as fuel).

We consider only efficient financial costs should be taken into account in setting fares. Any inefficient costs should be borne by the Government, as it is the Government’s role to ensure public transport is delivered efficiently.

4.1.1 How do we measure the cost of serving one additional passenger?

The marginal financial cost can be measured by reference to one passenger journey, one passenger kilometre, or an increment of a group of journeys or passenger kilometres.⁶ It could also be estimated by examining the reduction in cost that results from a reduction in demand.

However, since public transport is not delivered to just one passenger at a time, measuring the marginal financial cost of just one additional journey would not be very meaningful for the purpose of pricing public transport. In particular, if measured only for a single journey, the marginal financial cost would be very different depending on whether a service is full or empty. On a nearly empty bus, the additional cost of carrying one additional passenger would be very low - only the slight increase in fuel cost to carry that passenger's negligible additional weight plus the extra vehicle service time required for picking up and dropping off that passenger.

On the other hand, if the service is completely full, and a new service would be required to serve the additional passenger, the marginal financial cost of that journey would be the full cost of providing the new service. Clearly, running an additional service for only one passenger would mean the marginal financial cost of that passenger's journey would be very high. And it would be even higher if providing the service meant that an additional vehicle or additional infrastructure augmentation was required.

Therefore, we instead measure the marginal financial cost by reference to an increment of a group of additional journeys or passenger kilometres. We explain this approach further in section 4.3 below.

4.2 How does the marginal financial cost differ between the medium run and the long run?

As Chapter 3 discussed, there is less scope to change the capacity of public transport (and road) services in response to changes in demand in the medium run (the 3-year pricing period) compared to the long run (eg, 10 years or more). Similarly, there is less scope for operational efficiencies to be made in the medium run compared with the long run. Therefore, the financial costs associated with changes in services delivered will differ depending on whether we are considering the medium run or long run.

⁶ A passenger kilometre is equal to one kilometre travelled by a passenger. It is calculated as the number of passengers aboard a vehicle multiplied by the distance travelled.

4.2.1 Marginal capital costs in the medium run and in the long run

We have defined the medium run to align with the 3-year pricing period. A 3-year period is too short to construct large transport infrastructure to cater for changes in demand within the 3-year period, but it is sufficiently long to permit some changes in public transport fleet capacity and service frequency. Therefore, we will assume that in the medium run:

- ▼ Rail track and road capacity are fixed.
- ▼ Vehicle fleets for bus, ferry and light-rail services can expand or contract, and service frequencies can change, in response to changes in demand.
- ▼ While in principle the rail fleet could expand, there is no spare track capacity to accommodate more train sets during the peak. If peak demand increased, we would instead see an increase in costs associated with crowding, such as reduced reliability and longer travel times. Chapter 5 discusses the costs of crowding further.
- ▼ Rail service frequency during the off-peak could increase or decrease in response to demand changes.

In the medium run, there might also be significant investments in non-fleet assets that can improve the capacity of public transport services, such as:

- ▼ wharf and station upgrades
- ▼ upgraded and additional bus priority lanes on existing roads, and
- ▼ upgraded and additional bus depots.

In the long run, capital costs would also include costs associated with major infrastructure projects, including:

- ▼ additional ferry wharves (eg, the Barangaroo Ferry Hub)
- ▼ new light-rail tracks and stations (eg, the Sydney CBD and South East light rail)
- ▼ new heavy-rail tracks and stations (eg, the Sydney Metro including the second harbour rail crossing), including additional train sets, and
- ▼ priority bus lanes that form part of new road projects.

Due to the very long lifespans of public transport infrastructure, there would be considerable uncertainty around the marginal capital cost estimates for the long run. Moreover, such major infrastructure projects will have considerable external benefits, which also need to be accounted for. Our current framework for estimating external costs and benefits does not capture some of these longer-term costs and benefits (see Chapter 5). We are considering whether we should:

- ▼ include only a component of the financial costs of major new infrastructure investments, on the basis that these provide external benefits that we have not accounted for in our external costs and benefits framework, or

- ▼ seek to directly measure the external benefits from these major infrastructure investments, recognising the inherent uncertainties in any such estimates.

Chapter 5 provides more detail on our current external costs and benefits framework, and the external benefits that could be expected from large public transport infrastructure projects.

4.2.2 Marginal operating costs in the medium run and the long run

To estimate marginal operating costs both for the medium run and for the long run, we need to estimate efficient operating costs and identify which cost categories would vary with changes in services (eg, fuel, labour and maintenance costs). The efficient operating costs of providing public transport services may differ from the actual costs incurred by the operators. In previous reviews, we have benchmarked the actual costs of providing services in Sydney to those in other jurisdictions. We found that actual costs are higher than efficient levels for rail, bus and ferry. As part of this review, we have engaged a consultant to examine and make recommendations on the current efficient operating costs for each mode.

As noted above, in the long run there is greater opportunity for service providers to improve their operational efficiency and reduce operating costs for each service. For example, over the long run, technological advances would likely result in improved fuel efficiency, lower maintenance costs and lower labour costs. In addition, large infrastructure investments could also produce operational saving, for example by shortening journey times and reducing labour costs per service kilometre.⁷ Once we have established current efficient operating cost, we will consider what further productivity adjustments should be applied to identify the efficient operating costs in the long run, taking into consideration important future infrastructure projects.

⁷ A service kilometre is equal to one kilometre travelled by a public transport service vehicle.

4.3 How does the marginal financial cost differ between peak and off-peak periods?

To understand how the marginal financial costs differ between peak and off-peak periods, it is useful to consider financial costs as either capacity-related costs or usage-related costs. We are proposing to adapt an approach developed by Steiner⁸, where we define capacity-related costs and usage-related costs as follows:

- ▼ Capacity-related costs are the costs associated with providing capacity to meet the largest peak demand at any time. These costs include capital costs of infrastructure and vehicle fleet assets, as well as recurring operating costs that, for the most part, do not depend on usage, such as maintenance of ticketing system equipment and software contract costs.
- ▼ Usage-related costs are the costs that, once capacity has been established, vary with either the total number of passengers served or the number of passenger kilometres provided. These costs consist largely of operating costs, such as vehicle maintenance costs, fuel costs and crewing costs.

Under this approach, peak demand is assumed to be the driver of capacity. It is therefore appropriate that peak fares include the marginal financial capacity costs. Additional usage-related costs are incurred both during the peak and off-peak, and should therefore be reflected in both peak and off-peak fares. The marginal financial costs per journey in peak and off-peak can therefore be represented as:

b in the off-peak period, and

$b + \beta$ in the peak period

where:

b is the efficient marginal financial usage costs per journey, and

β is the efficient marginal financial capacity costs per peak journey.

Augmentations to public transport capacity can typically only be made in significant increments – for example, by running an extra daily service (which could require the acquisition of an additional bus or train set); or by investing in infrastructure assets.

⁸ Steiner, P.O., (1957), "Peak Loads and Efficient Pricing," Quarterly Journal of Economics; 71 (November): 585-610, as summarised in Crew, M.A., Fernando, C.S. and Kleindorfer, P.R. (1995), "The Theory of Peak-Load Pricing: A Survey," Journal of Regulatory Economics; 8: 215-248. The application of this approach requires that: (1) only one type of production technology is in use in both the peak and off-peak periods; and (2) there is no (or minimal) peak-shifting in response to price-signals. The first condition is clearly satisfied for each mode separately. The second condition appears to be true, given the durability of the peaks despite rising generalised costs of peak travel (including such factors as travel delays, road congestion, crush loading on trains, premium peak road tolls and rail fares).

Therefore, we propose to estimate the marginal financial capacity costs for both the medium run and the long run using an 'average incremental cost' (AIC) approach. The AIC approach is frequently used by regulators when setting prices for utility services such as electricity, gas and water, where the investments to augment capacity are of a similar nature to those in transport. That is, they are characterised by large upfront costs and by assets that have very long lifespans and which are intended to serve a large number of current and future users. The AIC measures marginal cost by dividing the full cost of the capacity augmentation, including the relevant capital and operating costs, by:

- a) the increment in production output or supply capacity over the lifetime of the asset, or
- b) the expected increment in demand that would be served over the lifetime of the asset.

Under our medium-run approach, these variants of the method for calculating the AIC are equivalent. We assume that capacity will be adjusted to precisely meet any changes in demand, and that the average cost per additional passenger served is the same regardless of how many additional passengers are served.

Under our long-run approach, our preliminary view is to first identify the share of the financial costs of capacity augmentations that should be borne by passengers, and then divide this share by the total number of peak passengers expected to be served over the lifetime of the relevant assets. This gives us a measure for marginal capacity cost that is equal to the average financial capacity cost for each additional journey made over the lifetime of the relevant assets.

4.4 How does the marginal financial cost vary with journey distance?

Some types of costs are driven by the number of passenger journeys, irrespective of the distance each passenger travels. The clearest example is costs associated with establishing peak capacity, which depends on the number of passenger journeys during the peak in the peak direction. Other cost types are driven by the total number of service kilometres, irrespective of whether this total comprises many short trips or fewer long trips. Vehicle operating costs provide an example of this type.

We are in the process of analysing data provided by Transport for NSW on various cost categories for each of the public transport modes. For each of these categories, we will consider whether they vary by the number of passenger journeys or by the number of service kilometres. It is likely that some cost types will vary by both the number of journeys and by the number of service kilometres. A quantitative assessment of these costs will permit us to gauge how marginal financial costs differ by journey distance.

IPART seeks comments on the following

- 4 We propose to distinguish between efficient marginal financial costs for peak and off peak as follows:

b in the off-peak period, and

$b + \beta$ in the peak period

where:

b is the efficient marginal financial usage costs per journey, and

β is the efficient marginal financial capacity costs per peak journey.

Do you agree with this proposal?

- 5 Which types of financial costs do you consider vary depending on the distance of the journey, and which do you consider depend more on the journey simply being made?

- 6 Do you agree with our proposal to estimate efficient marginal capital costs for the medium run and for the long run as follows:

For the medium run, including efficient costs associated with:

- additional buses, ferries, and light-rail train sets
- wharf and station upgrades
- upgraded and additional bus priority lanes on existing roads
- upgraded and additional bus depots.

For the long run, including efficient medium-run capital costs plus efficient costs associated with:

- additional ferry wharves
- new light-rail tracks and stations (eg. The Sydney CBD and South East light rail)
- new heavy rail tracks and stations (eg, the Sydney Metro including the second harbour rail crossing)
- additional heavy rail train sets
- priority bus lanes that form part of new road projects.

- 7 Do you agree with our proposal to consider productivity adjustments to identify efficient operating costs in the long run? How do you consider we should identify and estimate the appropriate productivity adjustments?

5 How will we estimate the marginal external costs and benefits?

Once we have estimated the marginal financial cost, to derive the marginal social cost of each mode of public transport we need to estimate the marginal external cost and the marginal external benefit of each mode.

In line with our proposed approach for calculating the socially optimal fares, we will need to estimate these inputs:

- ▼ for journeys in the weekday peak period and the off-peak period
- ▼ for journeys of different distances, and
- ▼ over a medium-run timeframe and a long-run timeframe.

The sections below explain what external costs and benefits are relevant to setting fares for public transport, and how these costs and benefits differ for journeys in the peak and off-peak, for journeys of different distances and over the medium run and the long run.

5.1 What are the relevant marginal external benefits and costs?

Externalities are the costs and benefits to third parties that are not reflected in the price of travel, and therefore are not accounted for by motorists and public transport users in their decisions to drive or use public transport.

IPART has previously examined the externalities associated with public transport. Our December 2014 Draft Report on the external benefits of public transport presented an estimate of the marginal external benefits associated with public transport use but not the benefits associated with investing in additional capacity.⁹ This section provides an overview of these externalities from our Draft Report. It also summarises our draft decisions on how we intend to measure these externalities and the additional analysis that we intend to do. We received eight submissions in response to our Draft Report and they are discussed in Appendix D.

⁹ IPART, *Review of external benefits of public transport - Draft Report*, December 2014.

Figure 5.1 shows that the external benefit of public transport includes:

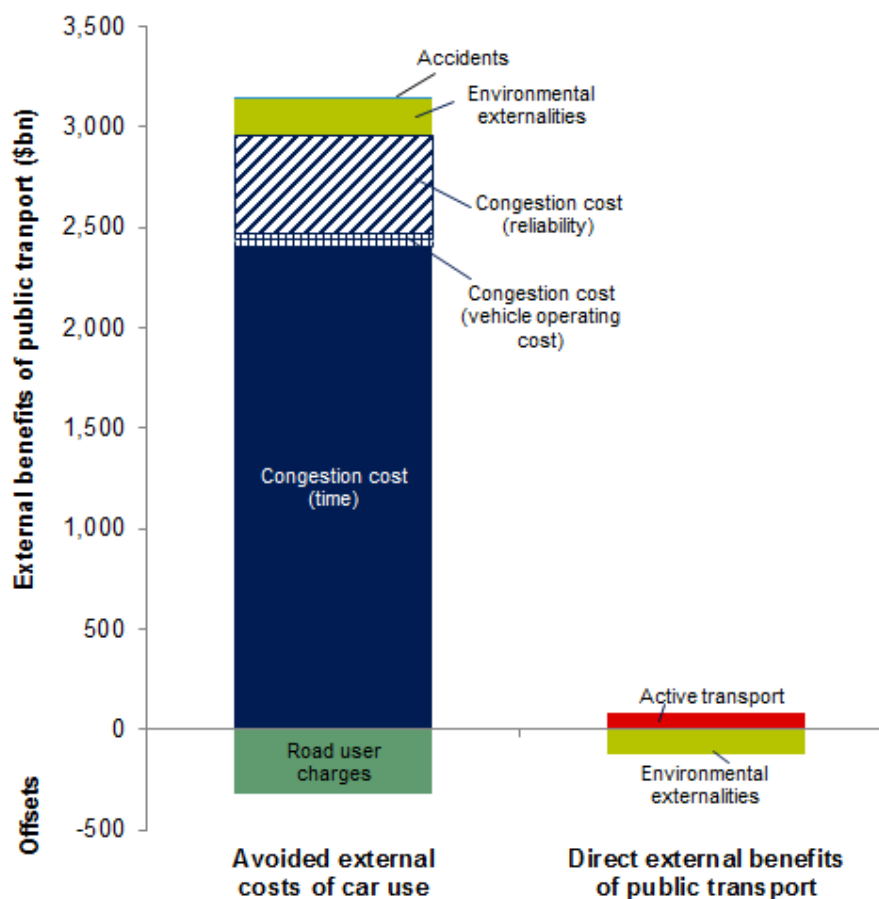
- ▼ the benefits from avoided road use, less the road user charges that ‘internalise’ the external costs of road use, and
- ▼ the direct benefits of public transport, less the direct external costs of public transport.

Figure 5.1 provides an indication of the relative value of each of the externalities that we have already been able to measure (but does not yet include crowding costs and scale benefits) based on the total values in our Draft Report.

Our draft report explained that we estimate the value of net external benefits of public transport using our own in-house model that is consistent across each mode of transport. Our model calculates very specific estimates of each of these because it is based on modelled outcomes from the Sydney Strategic Travel Model (STM), which predicts public transport and road usage under a given scenario and values from Transport for NSW’s *Principles and guidelines for the economic appraisal of transport investment and initiatives*.¹⁰ A number of the sources of data that we used to calculate the indicative external benefits in our Draft Report have now been updated.

¹⁰ The updated version is available from Transport for NSW’s website at <http://www.transport.nsw.gov.au/publications/economic-appraisal-transport-investments-initiatives>

Figure 5.1 Estimate of total externalities of public transport use (for those externalities measured in our Draft Report, \$2014-15)



Note: This chart only includes externalities that are generated with the existing network.

Data source: IPART, *Review of external benefits of public transport - Draft Report*, December 2014, p 28.

Our Draft Report indicated that we would like to consider additional external benefits associated with changes in service frequency and/or levels of crowding that would occur over the determination period. We discuss these further in this section.

Our Draft Report also discussed other external benefits that result from capacity expansions to the network in response to higher levels of demand. These include wider economic benefits from agglomeration and increasing land values that accrue to third parties. We considered that these external benefits would not be relevant to setting fares for the existing network. We are now also proposing to estimate socially optimal fares over a long-run timeframe, where network capacity can be expanded. As a result, we would also need to include external benefits that are associated predominantly with the network expansion undertaken in response to higher demand. We discuss the externalities associated with long-term investments in Section 5.4.

5.1.1 External benefits from avoided road use

Most of the external benefits from using public transport are the avoided external costs of driving if that journey was instead made by car. These external benefits will not be generated from all public transport journeys taken – only those that would have otherwise been made by car. Benefits include:

- ▼ **Avoided traffic congestion.** We intend to measure three aspects to this benefit:
 - **Time** – the value of time saved by existing drivers when a person uses public transport instead of adding to road congestion.
 - **Vehicle operating cost** – the value of vehicle operating costs, such as fuel, avoided by existing drivers when a person uses public transport instead of adding to road congestion.
 - **Reliability** – the benefit of more predictable travel times for existing drivers when a person uses public transport instead of adding to road congestion.
- ▼ **Environmental externalities.** This is the benefit to others of avoided air pollution and greenhouse gas pollution when a person uses public transport instead of driving.
- ▼ **Accidents.** This is the benefit to others associated with avoided road accidents when a person uses public transport instead of driving.

Motorists pay for some of these costs through road user charges, such as tolls, fuel excise, and parking levies. A portion of these charges offset the marginal financial costs associated with car use, such as road maintenance and parking space provision. However, the charges that exceed these financial costs mean that some of the external costs are ‘internalised’ because they form part of the price when deciding to drive. Therefore, we subtract this portion of road user charges when measuring external benefits of avoided road use.

5.1.2 Direct external benefits of public transport

Other external benefits are not the result of avoided car use, but are generated from public transport itself. Relative to the external benefits from the avoided costs of driving these are small. The main external benefit that accrues directly from public transport use is the avoided cost to the health system as a result of greater levels of physical activity when people walk or cycle to or from public transport. Note that the health benefit to the public transport user is not an externality.

Our Draft Report also considered the external benefit of additional services being added as more people use public transport. These scale benefits are known as the Mohring effect. If there is a strong link between the frequency of public transport services and demand, each new public transport passenger increases the frequency of the service, therefore decreasing average waiting times.

We are proposing to include a value of scale benefits in our estimate of medium-run optimal fares for buses, ferries and light rail, because services can be added during the determination period in response to increasing patronage. Because the train network is currently at capacity in peak times, for trains, this benefit will only be considered in our long-term analysis. Box 5.1 proposes how we will estimate scale benefits.

Box 5.1 Approach to incorporating scale benefits

Using the Sydney Strategic Travel Model we can estimate waiting time for public transport passengers. Our preliminary view is that we would estimate the change in waiting time for bus, ferry and light rail passengers from additional services by:

- ▼ Assuming services increase proportionally to demand across the Sydney network. We will have to make sure this is consistent with our approach to estimating costs.
- ▼ Reducing the amount of waiting time proportionally to the increase in services.
- ▼ The value of time would be based on the value of in-vehicle time, multiplied by a factor of between 1.2 and 1.5, as recommended by Transport for NSW Guidelines.^a

^a TfNSW recommends a value of 1.2 for platform/bus stop waiting time and 1.5 for transfer waiting time. Transport for NSW Guidelines for Economic Appraisal of Transport investments and initiatives, p 235.

5.1.3 External costs of public transport

There are also external costs associated with public transport use. These are much lower than the external costs of driving. However, these relatively small external costs need to be subtracted from our estimate of external benefits. These include

- ▼ the pollution created by the public transport services themselves, and
- ▼ road congestion that is caused by public transport where applicable (such as for buses and light rail).

When the transport network is at or approaching capacity, crowding on public transport can also generate external costs, particularly during peak times. The decision of a traveller to board a crowded train can have implications for on time running, and the ability of another passenger to board the train. Therefore, severe crowding can lead to the following external costs:

- ▼ the cost of delays to services as a result of long dwell times at platforms
- ▼ the costs to passengers who are not able to travel when they would like to, including:
 - the time costs of having to adjust their travel patterns
 - the costs to that passenger of not making the trip at all.

We are seeking comment on how to measure these crowding costs in the medium run. Our preliminary view is that the lost value of a passenger who is not able to board (a “displaced passenger”) is part of the marginal external costs of the trip taken by the last passenger who did board that train. Box 5.2 discusses two approaches to estimating crowding costs.

Box 5.2 Approaches to measuring crowding costs

We propose to measure changes in the level of crowding as a result of different levels of public transport use using the STM.

We consider that the cost for a journey that is not able to be made would be equal to what that passenger would have been willing to pay to make the journey. Using the STM and the existing train capacity, we could estimate the number of lost journeys, and assume a value of the fare that would have been paid.

We could also consider the Wang and Legaspi 2012 estimates of crowding.^a They estimated AM peak costs of \$52 million in the AM peak and \$30 million in the PM peak for 2010-11. Their estimates were based on stated preference surveys of train users (which show how much people dislike crowded seating and standing) and a detailed train loading model. We would then convert these into a marginal crowding cost per additional passenger and additional passenger kilometre.

^a Wang, B and Legaspi, J, ‘Developing a train crowding economic costing model and estimating passenger crowding cost of Sydney CityRail network’, *Australian Transport Research Forum 2012 Proceedings*, 26-28 September 2012, Perth Australia, p 11.

In the longer term, services should be added when the net costs (costs minus benefits) of doing so is lower than incurring these external crowding costs. This would mean that excessive crowding costs are avoided. Instead, there would be financial costs of adding services (discussed in Chapter 4), and external benefits of adding additional capacity, such as agglomeration (or wider economic benefits). The external benefits that would be produced in the long run are discussed in Section 5.4.

5.1.4 How we will update our externalities model

We have our own in-house model for estimating the value of the net external benefits of public transport that is consistent across each mode of transport. A number of the sources of data that we used to calculate the indicative external benefits in our Draft Report have now been updated. As part of our current review, we will:

- ▼ Incorporate data from the latest version of the BTS' Sydney Strategic Travel Model (STM version 3).
- ▼ Incorporate updated dollar values in the Transport for NSW *Principles and guidelines for the economic appraisal of transport investment and initiatives*, which we used as the basis for a number of our estimates (TfNSW released an updated version of the guidelines in March 2015¹¹).
- ▼ Incorporate other more recent data where this is available, such as updated crash statistics.
- ▼ Include estimates of all external costs of light rail.
- ▼ Update estimates for emission costs associated with heavy rail, after considering recommendations on emissions provided by an independent consultant (consistent with the work we had done for ferries and light rail). This report is now available on our website.¹²

5.2 How are marginal external costs and benefits different between peak and off-peak?

As explained in Chapters 2 and 3, we are proposing to estimate the socially optimal fares for peak and off-peak journeys for each mode.

Therefore, it is necessary to estimate the marginal costs and benefits for different times of the day. Congestion, which is the largest external cost of driving, will be different between peak and off-peak periods reflecting different traffic conditions and values of time between these periods. However, for many other externalities, such as pollution costs, the differences between them during peak and off-peak times are likely to be small (on a per-passenger or per-vehicle-kilometre basis).¹³

Table 5.1 sets out our views on whether there are material differences in the external costs and benefits in peak and off-peak times.

¹¹ The updated version is available from Transport for NSW's website at <http://www.transport.nsw.gov.au/publications/economic-appraisal-transport-investments-initiatives>

¹² Rail Emission Costs in NSW, Arup, March 2015 available at www.ipart.nsw.gov.au

¹³ A vehicle kilometre is equal to one kilometre travelled by a vehicle.

Table 5.1 Externalities and peak and off-peak impacts

Externality item	Substantially different in peak and off-peak periods	If different, how can it be measured
Congestion cost – time	Yes	STM outputs
Congestion cost – vehicle op cost	Yes	STM outputs
Congestion cost – reliability	Yes	IPART assumptions based on STM outputs
Environmental externalities	No	.
Accidents	No	.
Active transport	No	.
Crowding of public transport	Yes	STM outputs (only for AM peak)

Source: IPART analysis.

Table 5.1 shows that we are proposing to measure the differences in peak and off-peak externalities using the STM. This is consistent with our approach set out in the Draft Report on external benefits of public transport¹⁴. The STM produces outputs for four distinct periods – AM, Inter-peak, PM and Evening. From previous modelling undertaken for our Draft Report for measuring external benefits, congestion impacts are substantially different across time periods. For example, the time component of the congestion cost ranges from 10 cents per additional vehicle kilometre in the Evening period to \$1.30 per additional vehicle kilometre in the AM peak period.¹⁵ These differences indicate that the advantages of subsidising public transport to remove vehicles from congested roads will be very different in the peak and off-peak periods.

The extent to which transport users switch modes in response to changes in travel costs (such as fares) may also be different between peak and off-peak periods. In peak periods, STM modelling has indicated a relatively low price responsiveness for public transport users in the peak period. The STM estimates that for a 10% increase in prices, the number of users would fall by around 1% in the AM peak period. As noted in our Draft Report on external benefits of public transport, some studies have found that public transport users are *more responsive* to price changes in off-peak periods.¹⁶ A higher price responsiveness will lead to a lower optimal fare, other factors equal.

¹⁴ IPART, *Review of external benefits of public transport - Draft Report*, December 2014.

¹⁵ IPART calculations using data in our *Transport Externality Model*, February 2014.

¹⁶ IPART, *Review of external benefits of public transport - Draft Report*, December 2014, Appendix A.

5.3 How do marginal external costs and benefits differ by journey distance?

As part of our review, we will consider how fares for journeys of different distances should vary. In order to do so, it is necessary to understand how marginal external costs vary by the distance travelled. Our approach is to identify which externalities increase with the distance travelled, and which result only from the numbers of trips being taken.

The congestion externality results from both kilometres travelled, and number of journeys. For trips through the Sydney CBD, where there is a well-defined bottleneck, the number of vehicles per hour has more impact on congestion than the distance travelled by each vehicle to reach the bottleneck. However, where peak congestion occurs over an extensive area, the longer the trip through it, the greater the time delays incurred (and caused) by a car's occupants.

The environmental externality from emissions depends on the distances travelled, rather than the number of trips. One car trip of 10 km length will consume roughly as much fuel as two car trips of 5 km each, and therefore will lead to the same emission cost.

The road user charge from the fuel excise tax also depends on the distances travelled, rather than the number of journeys. Like emission costs, the risk of accident is greater the larger the number of vehicle kilometres travelled, although there are some complexities to calculating the external component of this cost.

Conversely, the active transport benefits depend on the number of trips, rather than the distance travelled on motorised transport. Tolls and parking levies will also depend on the number of trips.

5.4 How are marginal external costs and benefits different in the long run compared to the medium run?

As with marginal financial costs, marginal externalities are different in the long run. In the long run, higher levels of usage lead to infrastructure investments, and this additional infrastructure produces benefits for non-transport users. These would include:

- ▼ Agglomeration benefits for the Sydney CBD, which is the role that public transport plays in enabling co-location in cities and freeing up movement between customers, workers, businesses and services, which leading to improvements in productivity, welfare and consumption.
- ▼ Increased land values across the Sydney metropolitan area, as a result of changes in land use and particularly greater allowable densities around new public transport infrastructure.

- ▼ Deferred investment in publicly funded road infrastructure investments to cater for growth.

A large investment such as the second harbour rail crossing and associated new underground rail stations in the CBD would also eliminate the existing capacity bottleneck in the City Circle.

As explained above, our existing framework for measuring marginal external costs and benefits does not capture some of these longer term costs and benefits. However, we need to consider how to measure these externalities in our estimate of long term socially optimal fares. Our preliminary view is to consider:

- ▼ Previous estimates of the benefits and costs from changing Sydney's spatial structure and of greater densification.¹⁷
- ▼ Using the STM to measure congestion benefits of new transport infrastructure by comparing future scenarios with and without the additional transport capacity.

We are also seeking stakeholder view on other approaches to measuring these external benefits.

While some of these benefits are private benefits (such as increasing land values), they are externalities because they accrue to people **other than passengers**. The Government could consider whether it would be appropriate to implement measures through which the beneficiaries of these externalities contributed to the cost of the infrastructure spend (for example, development levies or land tax). However, for setting maximum fares, we do not need to consider other funding arrangements - only that the externalities are captured in our optimisation model.

Box 5.3 sets out an example of how our approach might work for the Sydney Metro (including a second Sydney Harbour crossing).

¹⁷ The CIE 2013, *Reform of the NSW planning system: Better Regulation Statement – Final Report*, Prepared for NSW Planning and Infrastructure, October; The CIE and ARUP 2012, *Costs and benefits of alternative growth scenarios for Sydney focusing on existing urban areas*, prepared for NSW Planning.

Box 5.3 Approach to measuring longer-run costs and benefits

The preliminary scope of the Sydney Metro project is for a new rail line from Chatswood through to Sydney's CBD and conversion of the existing Bankstown line into a Metro line. The project would add an additional 6 stations to the network. The reported costs of the project are in the order of \$10-\$11 billion.^a

The Sydney Metro project will have benefits to users (less crowded services, more frequent services, faster services) and benefits to other transport users (less road congestion). It may also have benefits associated with changes in land use, such as allowing densification and continued expansion of Sydney's CBD.

One approach to considering longer-run costs and external benefits would be:

- ▼ measuring the costs of the expansion of capacity (\$11 billion plus operating costs)
- ▼ subtracting our estimate of the non-transport related net benefits (benefits less costs), such as arising from land use changes
- ▼ dividing the remaining costs of providing additional capacity by the passenger growth on the rail system
- ▼ use transport modelling in 2026 or 2031 to inform the calculation of *future* marginal external costs and benefits of different transport types
- ▼ generate optimal fares using the long-run marginal financial cost and future marginal external costs and benefits as the key inputs.

^a NSW Treasury, *Infrastructure Statement 2015-16*, Budget Paper No. 2, p 3-3. Available from: http://www.budget.nsw.gov.au/__data/assets/pdf_file/0003/126372/BP2_Infrastructure_Statement_2015-16_dnd.pdf, p3-3

5.5 Why are we not measuring social inclusion as a marginal external benefit?

Our Draft Report also considered the benefits of increasing social inclusion. We are not proposing to include these benefits in our estimate of socially optimal fares, whether medium run or long run. There are several reasons for this.

Many of the benefits associated with social inclusion are private. The ability of people to access resources such as education, employment, health and other services (eg, cultural, sporting activities) improves a person's well-being. These well-being benefits are not external to the user and are not appropriate to include in our estimate of external benefits.

We note that some benefits associated with improved mobility and social inclusion are external. These include lower crime and welfare payments, and a potentially lower burden on the public health system resulting from greater health and well-being. Other benefits include having access to education, which provides benefits to society as well as to the individual.

Transport for NSW's appraisal guidelines refer to an Australian valuation from Stanley et al of around \$20 per journey.¹⁸ This study was also discussed in a submission to our issues paper, which indicated that the social transit value (the value of trips that would not be undertaken if public transport services did not exist) is likely to be high compared with other external benefit components.¹⁹ However, we have some concerns with adopting the Stanley et al valuation for our purposes. This value is found by estimating a proxy for the willingness to pay for an additional trip of a representative individual, and therefore represents a private benefit. In addition, we consider that preventing social exclusion is more likely to be about having the ability to make trips rather than being related to the number of trips made.

Furthermore, we also note that the benefit of reduced social isolation is reflected in the substantial amount of funding provided for underutilised public transport, and the arrangements for concession fares. The Government currently chooses to offer many services at a level of Government subsidy that would not be justified by the external benefits that relate only to the external cost of car use they avoid. For example, services that operate in the middle of the day, in less populated outer suburbs, early morning and/or late night services are likely to have very low levels of utilisation, which means they have high costs on a per passenger basis and avoid few car trips. Consistent with our past practice, we do not intend to incorporate the cost of providing poorly utilised services with high per passenger costs into our marginal cost estimates.

Ensuring social inclusion for groups that rely on public transport is likely to be a reason for Government choosing to provide these services. Because the value of the benefits of social inclusion is already reflected in the provision of these services and the funding arrangements for concession users, we consider that no further adjustment should be made to fares to reflect this benefit.

IPART seeks comments on the following

- 8 Do you agree with our proposed approach for estimating marginal external benefits and costs? Have we identified all the relevant costs and benefits?
- 9 Do you agree with our proposed approach to estimating scale benefits in the medium run for buses, ferries and light rail? Because the train network is currently at capacity in peak times, this benefit will only be considered in our long term analysis. Do you agree with this approach?
- 10 What is your view on how we should measure crowding costs of public transport, particularly in peak times? Options include:
 - Including an estimate of the cost equal to what that displaced passenger would have been willing to pay to make the journey.

¹⁸ Transport for NSW, *Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives*, March 2013, pp 295-298.

¹⁹ Bus Industry Confederation submission to IPART's Issues Paper - Estimating the external benefits of public transport, 15 October 2014, pp 5 and 11.

5 How will we estimate the marginal external costs and benefits?

- Measuring the amount of crowding and placing a cost to users of this crowding.
- 11 Do you agree with our view on which externalities are likely to be materially different in peak and off peak times?
- 12 Is using the Bureau of Transport Statistics' Strategic Travel Model the best approach available to estimate the differences in externalities in peak and off-peak periods?
- 13 Do you agree with our proposed approach to determining how external costs and benefits vary with distance or result simply from the trip being taken?
- 14 Do you agree with our proposed approach for capturing longer term external costs and benefits?
- 15 Do you agree with our proposal not to measure social inclusion as a marginal social benefit for setting fares?

6 How will we estimate demand for public transport?

The final key inputs for our fare optimisation model are the ‘demand functions’ for each mode. The demand functions describe the relationship between the price of the service and the quantity of the service likely to be consumed at this price. To determine these functions we need to estimate, for each mode:

- ▼ the expected levels of demand for the service, and
- ▼ how this demand is likely to change in response to changes in fare levels, known as the ‘price elasticity of demand’.

The sections below outline how we propose to estimate each of these things.

6.1 Expected levels of demand

As Chapter 3 discussed, we propose to have regard to socially optimal fares – both in the medium-run period (the next three years to 2018-19), and in the long-run period (the next 10 or more years). Therefore, we will need to estimate the expected levels of demand in these periods.

We propose to obtain these demand estimates from the Bureau of Transport Statistics’ (BTS’) Strategic Travel Model (STM) for Sydney and surrounds. This model uses:

- ▼ data on the current levels of demand for each mode and current travel behaviour
- ▼ forecasts of population and employment size and distribution, and
- ▼ information on likely changes in road and public transport networks and services.

It combines this information to estimate future travel demand under different strategic land use and transport scenarios.²⁰

²⁰ Bureau of Transport Statistics, *Travel Forecasts*, Available from: <http://www.bts.nsw.gov.au/Statistics/Travel-Forecasts/Travel-Forecasts/default.aspx#top>, Accessed 20 August 2015.

We have used the Strategic Travel Model forecasts of demand to inform our previous fare determinations. In our view, this model is the best available resource for estimating future demand for public transport services in Sydney and surrounding areas.

For this fares review, we propose to estimate future demand for each mode using the outputs of the current version of the STM, STM3.

6.2 Price elasticity of demand

The price elasticity of demand measures how responsive the demand for a good or service is to changes in its price. For example, a price elasticity of -0.5 means that for a 1% increase in price there will be a 0.5% decrease in the quantity demanded.

Price elasticities for goods where there are no substitutes or complements are almost always negative, because there is an inverse relationship between price and demand.²¹ That is, when the price increases, the quantity demanded decreases, and vice versa.

If there are no close substitutes for a good or service, the price elasticity is almost always small – typically between 0 and -1. The closer the elasticity is to 0, the smaller it is (that is, the smaller the change in demand in response to changes in price). When there **are** close substitutes for a good or service, the price elasticity may be larger than -1, and will depend on a wider range of factors, such as the relative price of the substitutes and other non-price costs and benefits.

In the case of public transport services, there are a range of different substitutes or complements available in Sydney and surrounds. For example, instead of using a bus service, passengers may be able to use a private car, a rail service, a light rail service or a ferry service. In addition, instead of travelling in the peak periods, they may be able to travel in the off-peak.

Given these choices, we need to estimate three elements of the price elasticity of demand for each mode:

- ▼ **‘Own-price elasticity’**, which is the change in demand for the services when their own price changes (eg, how demand for rail services responds to changes in rail fares).
- ▼ **‘Cross-price elasticity’**, which is the change in demand for the services when the price of substitute services changes (eg, how demand for rail services responds to changes in bus fares).
- ▼ **‘Time-of-day elasticity’**, which is the change in demand for the services in different time periods when the price in one time period changes (eg, how demand for services in the weekday peak responds to changes in peak fares).

²¹ In the case of cross elasticities outlined below, elasticities can be negative or positive.

We will also need to estimate each of these elements for both the medium-run pricing period and the long-run pricing period.

6.2.1 Proposed approach for estimating own-price and cross-price elasticities

We propose to determine the own-price elasticity and the cross-price elasticity having regard to the estimates we derive from the outputs of the BTS' Strategic Travel Model (STM), and estimates from available literature.

Estimates using the outputs of the STM

The STM doesn't use estimates of price elasticities as an input, or produce them as an output.²² Instead, it uses data from the Household Travel Survey to model how people respond to changes in fares. It takes account of the transport choices that people make based on the state of the transport network as well as demographic, spatial and car ownership characteristics. However, by making incremental changes to the price of different transport modes in the model, we can estimate the own-price and cross-price elasticities.

The STM estimates the demand for a number of travel purposes, each with their own elasticities. For this fares review, we propose to estimate these elasticities for each mode using the outputs of the current version of the STM, STM3. Table 6.1 shows the own-price elasticities (for all travel purposes combined) we estimated using the previous version of the STM (STM2) as part of our concurrent review of the external benefits of public transport.

Table 6.1 STM own-price elasticities

Mode	AM peak
Rail	-0.13
Bus	-0.16
All public transport	-0.11

Source: STM 2 and IPART, Transport Externality Model, February 2014, Available from http://www.ipart.nsw.gov.au/Home/Industries/Transport/Reviews/External_Benefits_of_Public_Transport/09_Feb_2015_-_Transport_Externality_Model/Transport_Externality_Model_-_February_2014.

Available literature

Many international and Australian surveys have produced aggregate estimates of the price elasticities of demand for public transport. These studies have consistently found that:

- ▼ the average of short-run and long-run estimates of price elasticities is between -0.3 and -0.4 (with variation around the mean)

²² The STM is not an elasticity-based or direct demand model. It is instead composed of multiple logit choice models nested across different purposes and sociodemographic characteristics.

- ▼ long-run estimates of price elasticities are around two times larger than short-run estimates, and
- ▼ estimates of price elasticities can be affected by the approach used to measure elasticity.

Australian average estimates tend to be slightly lower than those noted above – between -0.2 and -0.4. For example, one recent estimate of the elasticity of public transport in Sydney is by Tsai, Mulley and Clifton. Like the STM, this study uses data from the Household Travel Survey. It found that the short-run elasticity with respect to all public transport fares is -0.22.²³ The estimates of own-price elasticities based on the outputs of the STM are slightly lower again at -0.11. (Appendix E provides a more detailed overview of the available literature.)

Our preliminary views

For the medium-run period, we propose to have regard to both the outputs of the STM and the available literature. As noted in our review of external benefits, the available literature suggests that the STM response is relatively low compared with other short and long run estimates of price elasticity. However, we note that many of the public transport journeys made in Sydney and modelled by the STM are made by passengers commuting to the CBD where we would expect relatively lower elasticities.

For the long-run period, we propose to use higher estimates of elasticity. This reflects the findings in available literature that long-run elasticities are twice as large as shorter-run elasticities. This is because in the long run, passengers have a greater range of options for responding to fare changes, such as changing the location of where they work and live or buying or selling a car. For our draft report on externalities, we adopted a range of elasticities, with the STM estimates at the lower end of the range and long-run elasticities that were around four times larger than the STM estimates at the high end of the range. We are seeking stakeholder feedback on what estimates are appropriate for this fare review.

We also propose to use a simplifying assumption that people will respond to price changes by changing mode but not by changing their journey distance. We consider this is reasonable, because people's journey distance often depends on their locational decisions (eg, where they live and work) and they don't tend to make these decisions in response to short run price changes.

We have not formed a view if and how we should adjust the long-run elasticities to take account of changes in journey distance, and are also seeking feedback on this issue.

²³ Tsai, Mulley and Clifton, *A review of Pseudo Panel Data Approach in Estimating Short-run and Long-run Public transport Demand Elasticities*, *Transport Reviews*, p 120.

6.2.2 Time-of-day elasticities

For this review, we need to examine how differences between peak and off-peak fares drive passengers' behaviour – particularly their decisions to shift their travel out of the peak periods. To do this, we need to understand the time-of-day price elasticities of demand. However, it is difficult to find published estimates of this type of cross-price elasticity and, as far as we know, none are available for the Sydney area. In addition, the STM is not designed to estimate public transport passengers switching between time periods.

We can gain some understanding of the time-of-day elasticities from observations of traveller behaviour on trains in Sydney. The crush loading phenomenon in morning and afternoon peak hours has persisted for many years, despite a significant price premium to travel by train in the peak. This suggests the cross-price elasticity between peak and off-peak rail services is relatively low.²⁴

Intuitively, the key driver of this behaviour is likely to be the need for full-time employees to start and finish their work at standardised times. The intensity of the morning peak hour also reflects the need for school students to arrive at school at nearly the same starting time as full-time employees. Charging rail passengers more to travel in the peak will not necessarily persuade them to change their time of travel if doing so conflicts with their obligation to start work or school on time.

For the same reason, the cross-price elasticity between peak and off-peak bus, ferry and light rail services is also likely to be low. However, the lack of experience with peak pricing on these modes means we have no evidence to validate this at present.

There are several possible methods we could use to estimate time-of-day elasticities, including:

- ▼ examining the effect of past changes to the difference between peak and off-peak rail fares on the height and width of the peaks in demand, and
- ▼ examining the impact of changes in peak pricing for the Sydney Harbour Bridge and Harbour Tunnel over time.

Similar studies performed for other cities may also provide some useful insight, although translating these quantitative results to Sydney conditions could be problematic.

We are seeking stakeholder comments on what methods could be used to estimate the peak/off-peak cross-price elasticities for all of the public transport modes, and what information is available on this question.

²⁴ This analysis is also complicated by lower service frequency and fewer express services.

IPART seeks comments on the following

- 16 We propose to estimate the demand and price elasticities having regard to the estimates we derive from the outputs of the Bureau of Transport Statistics' Strategic Travel Model, and estimates from available literature. Do you agree with this approach?
- 17 How should we estimate the peak/off-peak cross-price elasticities for all public transport modes? For example, this could include:
 - examining the effect of past changes to the difference between peak and off-peak rail fares on the height and width of the peaks in demand, and
 - examining the impact of changes in peak pricing for the Sydney Harbour Bridge and Harbour Tunnel over time.

7 How will we estimate the marginal excess burden of taxation?

Once we have established the marginal social cost of each mode, the next key input for our model for calculating the socially optimal fares is the marginal excess burden of taxation. In our Draft Report, *Review of external benefits of public transport*, we proposed to account for the economic efficiency losses associated with the funds used to subsidise public transport by including an estimate of the excess burden of taxation in the net external benefits calculation. However, after considering stakeholder comments on the Draft Report, we now propose to include the excess burden of taxation as a separate input to our fare optimisation model. We consider this approach applies the excess burden of taxation to subsidies for public transport and roads equally, and so addresses stakeholders' main concerns about our original proposal.

The sections below discuss what we mean by the marginal excess burden of taxation, our preliminary estimate of this excess burden, and stakeholder comments on our original proposal.

7.1 What is the marginal excess burden of taxation?

Most taxes impose a burden on society in excess of the tax itself by changing the behaviour of households and businesses. In particular, taxes distort the decisions of labour, consumers, investors and producers by changing the incentives to work or invest, and influencing consumption and production patterns. These distortions lead to a loss of consumer welfare. The excess burden of taxation is a measure of the social costs associated with these distortions. The **marginal** excess burden is a measure of the social costs resulting from a small increase in tax, not the whole tax.

In our view, it is important to include the marginal excess burden of taxation in our model for calculating the socially optimal fares. Fares recover only a small proportion of the financial costs of providing public transport, so the NSW Government funds the balance. As it raises these funds primarily through taxation, fare levels and taxation are linked. If all else remains equal, lower fares would lead to higher taxation (or lower spending on other social services), and higher fares would lead to lower taxation. Therefore, the social costs of increasing taxation are a critical consideration in determining the fare levels likely to maximise the net benefit to society (ie, the socially optimal fares).

If the marginal excess burden of taxation is high, the socially optimal fares will be higher than would otherwise be the case. This is because the marginal social benefit generated by increasing fares and (reducing the taxpayer subsidy) will be higher.

It is becoming common practice to include the excess burden of taxation in cost benefit analyses. For example, the *Independent cost-benefit analysis of broadband and review of regulation* included a measure to capture the cost of raising government revenue to fund high-speed broadband infrastructure. The report argued that “the losses associated with these excess burdens should be included where there is a substantial net government contribution.”²⁵

7.2 What is our preliminary estimate of the marginal excess burden of taxation?

Our preliminary view is that we should include an estimated marginal excess burden of taxation equal to 8% of the size of the subsidy in our fare optimisation model.

This is the same estimate of the marginal excess burden of taxation we proposed in our draft report on external benefits. We maintain our view that this is the appropriate estimate for the purpose of setting public transport fares, notwithstanding that we now propose to use the measure in a different way.

We based our estimate on the marginal excess burden of the Goods and Services Tax (GST) estimated by KPMG Econtech in its 2010 analysis of the Australian tax system.²⁶ We considered using estimates of the marginal excess burden of a range of other applicable taxes, including the weighted average of NSW state taxes. We concluded that the GST is the most appropriate because it is the most efficient tax. This is consistent with our view that only efficient costs should be taken into account in setting fares, and that the cost of inefficiencies should be borne by the Government (see Chapter 4).

7.3 What did submissions say about our original proposal for the excess burden of taxation?

As noted above, in our draft report on external benefits, we proposed to include an estimate of the marginal excess burden of taxation in calculating the net external benefits of public transport. Of the stakeholders who submitted comments on this element of the report, none supported this approach.

²⁵ Australian Government, Department of Communications, *Independent cost-benefit analysis of broadband and review of regulation, Volume II – The costs and benefits of high-speed broadband*, August 2014, p 41.

²⁶ KPMG Econtech, *CGE Analysis of Current Australian Tax System, Final Report*, 26 March 2010.

Some stakeholders argued that if the excess burden of taxation is to be included, then it should also be applied to taxpayer funding of private transport (eg, road funding). For example:

- ▼ NSW Council of Social Services (NCOSS) submitted that our “proposal to include the cost of the excess burden of funding the public transport system will distort the relative cost of public transport unless the same approach is also applied to the cost of car travel.”²⁷
- ▼ Action for Public transport (APT) stated that it is not “clear why the cost of raising funds for roads, ambulances, police etc would not then be treated as an additional external cost of car use (and conversely as an additional external benefit of public transport). The cost of government raising funds to do anything is presumably “distorting” the economy, on this view.”²⁸

In addition, Mr Baojin Wang noted that funding of public transport operations may have avoided funding additional road maintenance. He argued the cost of the taxation burden for funding public transport needs to consider how it has substituted the road maintenance funding.²⁹

After considering these submissions, our view is that for the purpose of setting fares, the marginal excess burden of taxation should apply equally to taxpayer funding of roads and public transport. The fare optimisation model that we have developed takes this approach. More information on this model, including how the marginal excess burden of taxation is included, is provided in Appendix D.

In response to Mr Wang’s comment, we note that the inputs to our fare optimisation model are **marginal** costs and benefits, rather than total costs and benefits. For roads, the marginal costs, such as pavement damage that requires maintenance, are relatively small. For some public transport services, the marginal costs may also be small.

IPART seeks comments on the following

- 18 Do you agree with our preliminary view to include an estimated marginal excess burden of taxation equal to 8% of the size of the subsidy in our fare optimisation model?

²⁷ Council of Social Service of NSW (NCOSS) submission to Draft Report on Review external benefits of Public Transport, 25 March 2015, p 4.

²⁸ Action for Public Transport submission to Draft Report on Review external benefits of Public Transport, 25 March 2015, p 6-7.

²⁹ B Wang submission to Draft Report on Review external benefits of Public Transport, 25 March 2015, p 4.

8 How will we incorporate our fare decisions into the legal determination?

Once we have decided on the fares that strike the best balance between our assessment criteria, we need to translate these decisions into a legal determination. We need to decide what form this fare determination should take. In our view, there are two broad options for this:

1. We can determine a maximum price for all individual fares. This would be similar to the fare determinations we made prior to 2013.
2. We can determine the maximum average fare increase for Opal fares. We could set a maximum average fare that applies to all journeys, or different maximum average fares for different types of journeys, for example:
 - for each mode of transport (which was how we have been setting fares since 2013)
 - for peak and off peak journeys that would be the same for each mode of public transport, or
 - for peak and off peak journeys that would be different for mode of transport.

Under both options, TfNSW can set fares lower than our maximums. However, under the second option, TfNSW can offset any reduction in one fare by increasing a different fare (so on average the fares would not exceed the maximum fare). TfNSW would not have this flexibility under the first option.

The sections below discuss each option in more detail and seek stakeholder comment.

8.1 Determine a maximum price for all individual fares

The first option is to determine the maximum price for all individual fares. Essentially, this would involve establishing a maximum fare schedule for each year of the determination that covers all Opal services. Depending on our decisions on fare structure, it could involve setting fares for journeys of different distances, and at different times of the day and week. In addition, it could involve setting the same or different fares for each mode of transport. Our preliminary view is that we would also set the level of daily and weekly caps, and the travel rewards structure, because these affect the average fare for a single journey.

Our preliminary view is that IPART should determine individual fares for our legal determination. This would be most consistent with our proposed approach for this review of identifying individual fares – including the relativities between fares for different journeys – that strike the best balance between the pricing objectives for the review. Setting all individual fares would allow IPART to clearly specify these fares in the determination. It would also benefit passengers by giving them certainty about the maximum fares they would pay for each year in the determination period.

However, TfNSW is not required to set fares in line with IPART's maximum fare schedule. It could make changes to fare structure during the determination period by setting fares lower than IPART's fares. This would result in the Government forgoing farebox revenue, and taxpayers paying a greater proportion of the financial costs of public transport (see Box 8.1). We consider that this risk is minimised for this review, because we must consider the need to ensure consistency between the fares in our final determination and NSW Government's announced fare structure policy.

If we choose this option, we would also need to take into account the current Opal card technology. For example, as our Issues Paper on fare structure discussed, if the fare structure involves more integrated fares, rail fares would need to be calculated based on the straight-line journey distance (like fares for other modes), rather than the track distance (as is currently the case). This change is likely to be able to be made before 1 July next year. However, other changes may require longer lead time. Therefore, we would need to consider setting transitional fares in the first year or two of the determination period.

Under Option 1, we would also need to consider whether to set maximum concession fares, including Gold Opal fare.

Box 8.1 An example of revenue losses from restructuring fares when setting individual fares– MyTrain

In introducing the MyZone fare structure in 2010, the Government consolidated the 20 distance-based bands for CityRail fares into 5 bands, and created a new 'MyTrain' ticket product for each band. However, because the 2009 determination specified a maximum fare for individual CityRail tickets based on the original 20 fare bands, the fares for MyTrain tickets could not exceed the lowest fare in the new consolidated distance bands.

For example, the new MyTrain4 ticket applies to journeys of 35–65 km, where previously there were 3 separate tickets for journeys of 35–45 km, 45–55 km, and 55–65 km. Under the 2009 determination, the maximum weekly fares for these journeys in 2010 were \$50, \$52 and \$56 respectively. To comply with the determination, the fares for MyTrain4 weekly tickets had to be set at or below \$50.

As the table below shows, assuming ticket sales remained constant following the fare changes, this would have resulted in CityRail **forgoing** approximately \$14 million in revenue from weekly ticket sales in 2010 (across all 5 MyTrain bands). If the determination had set maximum average fare changes instead of individual fares, the revenue forgone due to the restructuring could have been a much lower (around \$78,000).

Old distance bands (km)	Annual ticket sales	Maximum fare set in determination 2010	New fare structure	Maximum fare under determination	Possible fare if determination had set average fare change
0 - 5	322,293	\$25.00	MyTrain1	\$25.00	\$28.00
5 - 10	753,153	\$29.00			
10 - 15	1,210,542	\$31.00	MyTrain2	\$31.00	\$32.00
15 - 20	920,131	\$34.00			
20 - 25	817,284	\$38.00	MyTrain3	\$38.00	\$40.00
25 - 30	822,306	\$40.00			
30 - 35	610,373	\$43.00			
35 - 45	637,406	\$47.00	MyTrain4	\$47.00	\$49.00
45 - 55	351,084	\$49.00			
55 - 65	183,242	\$54.00			
65 - 75	163,939	\$56.00	MyTrain5	\$56.00	\$60.00
75 - 85	79,933	\$60.00			
85 - 95	62,319	\$62.00			
95 - 105	21,227	\$63.00			
105 - 115	15,416	\$66.00			
115 - 125	5,113	\$69.00			
125 - 135	3,274	\$74.00			
135 - 155	2,628	\$81.00			
155 - 175	1,894	\$84.00			
175+	208	\$92.00			
Revenue		\$267,142,622		\$253,440,256	\$267,064,460
Revenue forgone				\$13,702,366	\$78,162

Note: This analysis assumes that ticket sales remain constant.

Source: IPART, *Review of maximum fares for CityRail services from January 2013 – Final Report*, November 2012, p 55.

8.2 Determine maximum average Opal fares

The second option is to set maximum average fares for Opal services. This option could involve us setting one average fare for all modes of transport, or different average fares for each mode. In addition, we could set a different average fare for peak and off peak journeys to provide more guidance on the relativities between fares that would best meet the objectives of the review.

TfNSW would then determine the fare schedule for all Opal services, so that on average the fares do not exceed our maximums.

Compared with Option 1, determining average fares would provide TfNSW with more flexibility to change the fare structure during the determination period. This is how we set fares in our most recent determinations to give TfNSW this flexibility during the roll out of Opal. It meant TfNSW was able to reduce some fares and increase others to drive the uptake of Opal without having to forego farebox revenue.

Setting the average fare was also consistent with the approach we used for previous reviews, which aimed to ensure fares generated an overall level of revenue that reflected passengers' appropriate share of the costs of public transport. However, it is less consistent with our proposed approach for this review, which focuses more on identifying individual fares that strike the best balance between the pricing objectives for the review.

Therefore, if we set average fares for this review, our preliminary view is that we should set different average fares for different types of journeys (for example peak and off peak average fare) to signal the relativities between fares for these groups that reflect our pricing decisions. Option 2 would provide more flexibility to TfNSW to transition to our preferred fare structure, particularly if there are technological constraints to making changes to the fare structure by July 1 next year.

8.2.1 Should we set limits on the maximum increases to individual fares if we set average fares?

If we determine maximum average fares, we need to decide whether we should set limits on price changes for individual journeys to limit the impacts on customers.

Setting limits on changes to individual fares would give customers more certainty about the maximum possible increase to the fares for their journey during the determination period.

On the other hand, it would reduce TfNSW's flexibility to undertake further fare reform, for example, increasing fares:

- ▼ to manage demand during peak times
- ▼ to assist in the phasing out of products, and
- ▼ to enable particular fares to better reflect the costs and benefits of providing the service.

IPART seeks comments on the following

- 19 Once we have decided on the fares that strike the best balance between our assessment criteria, we need to translate these decisions into a legal determination. Do you agree with our preliminary view that IPART should determine individual fares for our legal determination?



Appendices

A Minister's referral



The Hon Andrew Constance MP
Minister for Transport and Infrastructure

PR15/05990

Mr Peter Boxall AO
Chairman
Independent Pricing and Regulatory Tribunal
PO Box K35
Haymarket Post Shop NSW 1240

Dear Mr Boxall

A handwritten signature in blue ink that reads "Peter".

I am writing to refer to the Independent Pricing and Regulatory Tribunal (IPART) the task of determining appropriate maximum fares for classes of Opal fares from 1 July 2016 to 30 June 2019. This referral, which is attached, has been approved by the Premier, the Hon Michael Baird MP, in accordance with the requirements of s123 of the *Passenger Transport Act 2014*.

Now that the implementation of the Opal electronic ticketing system (Opal) has been substantially completed, the NSW Government wishes to consider options for fare structure reform that would achieve greater levels of fare integration, including the benefits and costs of these options.

This referral, therefore, requires IPART to consider fare structure reform options for Opal following IPART's usual engagement with the community. It is intended that, if Government decides to make changes to the structure of Opal fares, IPART's final maximum fare determination would allow for those changes to be implemented from the middle of next year.

I look forward to the commencement of this important review, to considering IPART's advice with respect to fare structure options for the Opal system, and to receiving IPART's final report in due course.

Yours faithfully

A handwritten signature in blue ink that reads "A Constance". To the right of the signature is the date "19/6/15".

Andrew Constance MP
Minister for Transport and Infrastructure

52 Martin Place, Sydney NSW 2000

Phone: (61 2) 8574 5807 Fax: (61 2) 9339 5512 Email: office@constance.minister.nsw.gov.au



Passenger Transport Act 2014
Section 123(1)(a)

Referral

I, the Hon Andrew Constance MP, Minister for Transport and Infrastructure, with the approval of the Hon Michael Baird MP, Premier of New South Wales and Minister administering the *Independent Pricing and Regulatory Tribunal Act 1992*, under section 123(1)(a) of the *Passenger Transport Act 2014*, refer to the Independent Pricing and Regulatory Tribunal (IPART) the following matter for investigation and report:

The determination of appropriate maximum fares for Opal Services.

In addition to the matters contained in s124 of the *Passenger Transport Act 2014*, in undertaking this investigation, IPART is, under s123(2)(b) of the *Passenger Transport Act 2014*, to consider:

1. The benefits of fare structures that support network integration to increase network efficiency and reduce overall costs;
2. The benefits and costs of spreading demand for public transport to increase efficiency in service delivery and the likely impact of different fares on the travel behaviour of customers, including whether current concession arrangements for peak and off-peak travel support the optimal use of the network;
3. Whether there are strong arguments for or against full integration of fares across all Opal Services, given that some modes have significantly different costs and/or externality benefits;
4. The relative contributions that customers and taxpayers should make to the cost of delivering Opal Services, including light rail as an Opal Service;
5. The technical feasibility of making changes to the current fare structure, given the features of the Opal system and the contracts in place for its implementation and operation;
6. The most appropriate method or methodology for determining maximum fares for Opal Services, including the need for sufficient flexibility to implement any changes to the current fare structure (where relevant);
7. Where relevant, transitional arrangements from the current fare structure to a new fare structure, assuming that new fares would apply from 1 July 2016 and including any customer impacts and technical limitations; and
8. The need to ensure consistency between:
 - (i) the structure of fares in the final determination of appropriate maximum fares for Opal Services; and
 - (ii) the NSW Government's announced policy position on the structure of fares for Opal Services.

For the purposes of this referral, Opal Services means the following services:

1. Train services operated by Sydney Trains;
2. NSW Trains services operated under the business name NSW TrainLink Intercity;

3. Sydney Ferries services operated under the authority of a service contract with Transport for NSW (TfNSW);
4. The Stockton Ferry;
5. Bus services operated under the authority of a Metropolitan Bus Service Contract with TfNSW;
6. Bus services operated under the authority of a Outer-Metropolitan Bus Service Contract with TfNSW; and
7. The Sydney Light Rail service.

IPART is to publish a draft report as soon as practicable but no later than 18 December 2015. The draft report is to include appropriate mode specific maximum fares for Opal Services and any integrated fare structure options developed by IPART.

IPART is to submit its final report and determination under this referral to the Minister for Transport and Infrastructure as soon as practicable but no later than 31 March 2016, or such later date as notified in writing by the Minister for Transport and Infrastructure.

This referral ceases to have effect on 30 June 2019, unless earlier varied or withdrawn.

Signed: 

Hon Andrew Constance MP
Minister for Transport and Infrastructure

Date: 16/6/15

Signed: 

Hon Michael Baird MP
Premier

Date: 8.7.15

B | What are socially optimal fares?

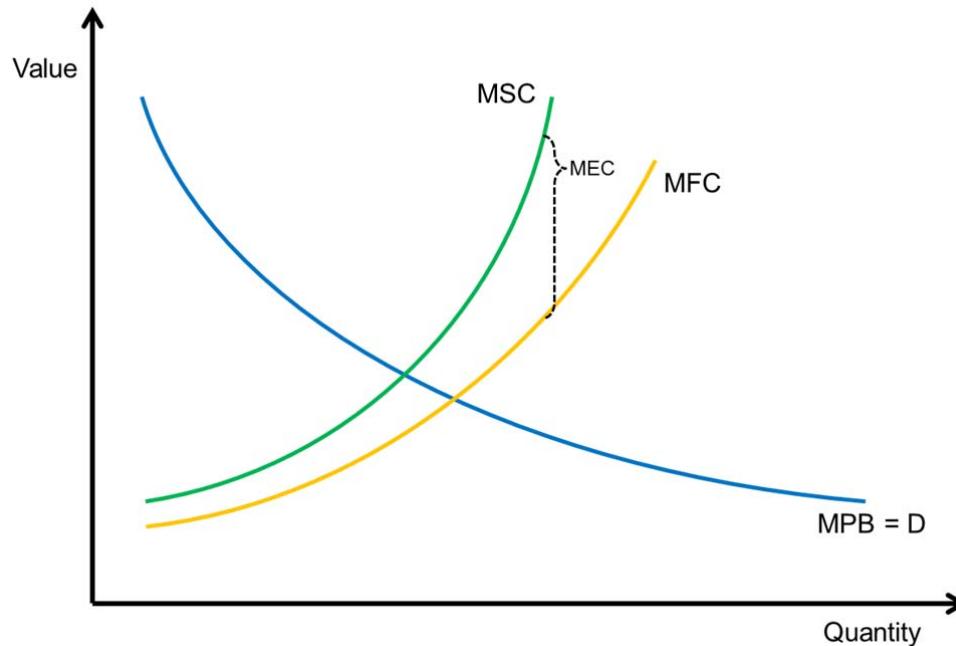
B.1 The optimal price for any good or service is equal to the marginal social cost of consumption

Whenever a good or service is consumed, there is a cost to society. The full social cost of consuming a good or service is the sum of:

- ▼ the direct financial costs of consumption (including the cost of production and delivery of the good or service, such as costs of material and labour), and
- ▼ any external costs to society that arise as a result of the consumption, such as environmental and health impacts and costs of road congestion.

When we compare the cost of a given level of consumption with that of a marginally different level of consumption (eg, one more unit consumed or 100 more units consumed), we refer to the cost difference as the “marginal cost”. The marginal social cost (MSC) of one additional unit consumed is therefore the additional cost to society that results from the production, delivery and consumption of that additional unit of good or service.

Because resources are limited, on average, the cost of consumption tends to increase with each additional unit consumed. This is because the least costly sources for the good or service tend to be used first, before moving on to the next cheapest and so on. As resources deplete and competition for the remaining resources increase, both the direct financial costs and the external social costs tend to increase. This gives rise to an increasing MSC curve as shown in green in Figure B.1.

Figure B.1 Marginal costs and benefits

At the same time, different people value goods and services differently. The marginal private benefit (MPB) refers to the highest value any of society's consumers places on each additional unit of consumption. This is the highest price that any consumer would be willing to pay for the next unit. At any price, only those that would value the good or service higher than that price would be willing to buy the good or service. The lower the price, the more consumers would be willing to buy the good or service, down to the last person that would only value the good or service at exactly the asking price. This MPB of each additional unit consumed by society is represented by the blue curve in Figure B.1, which therefore also depicts society's total demand.

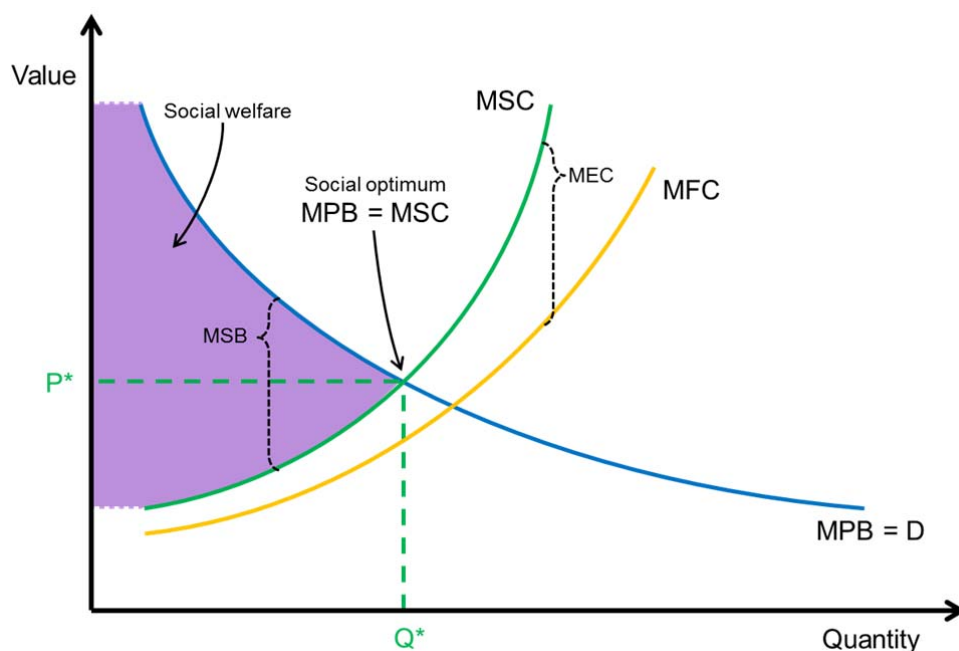
The gold curve in Figure B.1 represents the marginal financial costs (MFC) of the good or service consumed (ie, the direct cost of production and delivery), and the vertical gap between the green and the gold curves represents the marginal external costs (MEC). MEC is the additional cost that is borne by anyone in society other than the consumer of the good or service, such as the costs of environmental impacts and road congestion.

The socially optimal level of consumption of any good or service occurs where the benefit to the user of the last unit consumed (ie, the MPB) is no more and no less than the total cost borne by society when that unit is consumed (ie, the MSC). This is shown in Figure B.2 where the MPB and MSC curves intersect, at the socially optimal quantity of consumption, Q^* . At this point, if more of the good or service was consumed, the benefit enjoyed by the consumers would be smaller

than the cost to society of the additional consumption, resulting in a loss of overall welfare to society. On the other hand, at quantities below Q^* , each additional unit consumed would generate private benefits greater than the social cost of that consumption, so social welfare could be increased by consuming more. The increase in social welfare for each additional unit consumed would be equal to the gap between the MPB curve and the MSC curve. This amount represents the marginal social benefit (MSB) of consumption.

Total welfare to society is therefore maximised when consumption is at Q^* . The value of the social welfare enjoyed when consumption is at Q^* is represented in Figure B.2 as the purple area between the MPB curve and the MSC. This welfare-maximising level of consumption represents what economists refer to as the *allocatively efficient* level of consumption, where goods and services are allocated first to those consumers whose consumption would generate the largest social net benefit (ie, the largest MSB).

Figure B.2 Welfare maximising consumption



If the price per unit was the same for every consumer, ensuring the welfare maximising level of consumption (Q^*) would require a per unit price of P^* , as shown in Figure B.2.³⁰ For each unit consumed above Q^* , the private benefit of consumption would be less than P^* , and consumers would therefore rather choose to not consume these units. On the other hand, the private benefit of each unit consumed below Q^* would be higher than P^* , and therefore consumers would be willing to pay P^* to be able to consume these units.

B.2 Public transport services create large external benefits and should be subsidised

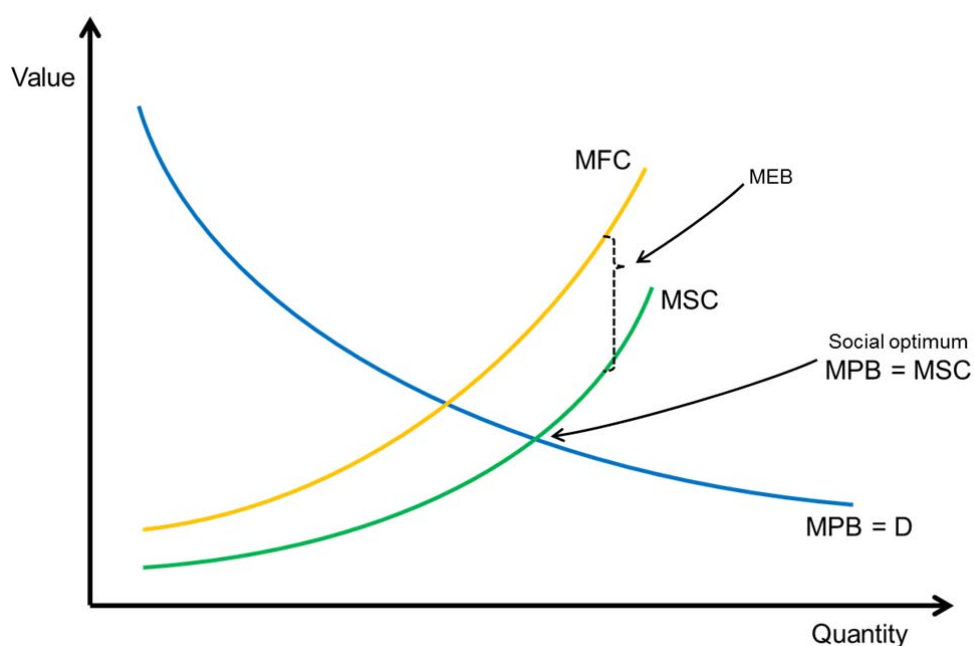
In an ideal world, all goods and services would be priced at their MSC. As explained above, this would result in the socially optimal level of consumption of all goods and services, and would therefore maximise welfare. Road users currently do not pay the full cost that their road use imposes on society as a whole, including the economic and social costs of road congestion. Motorists pay fixed costs related to motor vehicle ownership such as registration, and charges related to use such as the fuel excise and various tolls. However, most of these charges do not provide price signals that encourage drivers to modify their patterns of road use to allow scarce road space to be allocated to those who place the highest value on this space. One of the primary benefits of public transport use arises as a consequence of road user charges (eg, fuel excise, tolls and parking levies) being well below the MSC of road use. This results in over-use of private road transport, causing excess congestion and other external social costs.

In the absence of socially optimal pricing for road use, the second-best approach to minimising the excess social cost associated with road use is to lower public transport fares and encourage more people to use public transport instead of private road transport.

³⁰ There are other pricing strategies that could be used to achieve this optimal consumption level, but for simplicity we will limit our discussion here to uniform pricing.

In addition to the benefits from avoided road use, there is a range of other important external benefits associated with public transport use. These are discussed in detail in Chapter 5. Overall, the external benefits from public transport tend to outweigh the external costs, on average generating net benefits for each additional public transport journey. This is shown in Figure B.3, where the green MSC curve is below the MFC curve. The difference between MFC and the MSC curves represent the marginal (net) external benefits (MEB) of each additional public transport journey.³¹

Figure B.3 External benefits of public transport



As explained above, the allocatively efficient level of public transport use would be where the MPB is equal to the MSC, shown in Figure B.3 where the green MSC curve intersects with the blue MPB curve. But since the social cost of public transport is *less* than the financial cost, a government subsidy is necessary to allow fares to be set at the socially optimal level. Instead of fares recovering the full marginal financial costs of public transport journeys, it is better for society to cover the remaining costs through taxes. This is shown in Figure B.4, where the

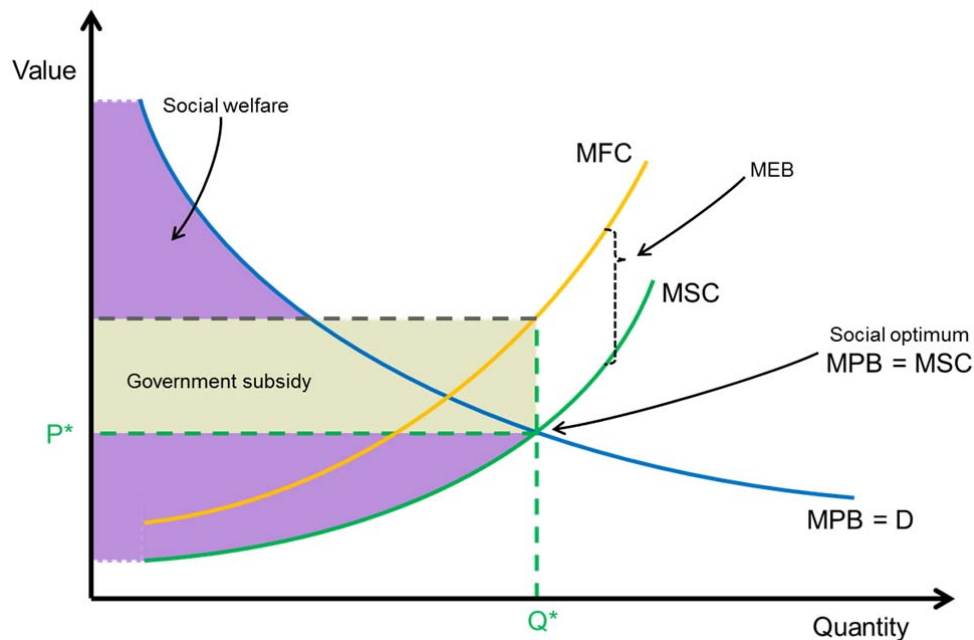
³¹ The benefits from shifting use away from private road travel to public transport would be more accurately depicted by showing how, as a result of public transport subsidy and lower public transport fares:

- demand for private road travel would shift inward away from above socially optimal level of consumption, and
- demand for public transport would shift outward towards the socially optimal level of consumption.

However, for simplicity, we have instead depicted the average net benefit per public transport journey as shifting the marginal social cost curve below the financial cost curve.

socially optimal quantity and price is again at Q^* and P^* respectively, and the light shaded box represents the required subsidy for the allocatively efficient outcome.³² The purple shaded area between the MSC and MPB curves shows the total social welfare from the optimal level of consumption of public transport services.

Figure B.4 Optimal subsidy of public transport



In the case of public transport, P^* represents the socially optimal fare level, and the purpose of the first step in our approach is to identify P^* for:

- ▼ each mode
- ▼ the medium run and the long run
- ▼ weekday peak and off-peak periods, and
- ▼ short distance and long distance journeys.

This set of socially optimal fares represents the fares that would best address our first two assessment criteria – encouraging efficient use and promoting efficient delivery of public transport.

³² For simplicity, we assume that the MSC curve incorporates the marginal excess burden of taxation associated with the required subsidy at each level of consumption. See Chapter 7 for more on the marginal burden of taxation.

C Public transport fare optimisation model

C.1 Key formulae

Optimal prices for public transport are here taken to be the prices that maximize a social welfare function that includes consumer and producer surplus in transport markets, as well as externalities relating to transport use (i.e., congestion, air and noise pollution, accidents) and taxation. This is a partial equilibrium approach in which impacts of transport on land use and the economy more broadly are ignored. This partial equilibrium approach is reasonable where the emphasis of the analysis is on transport pricing, as opposed to long-lived infrastructure investment.

Nomenclature:

- j “mode”: a particular combination of transport mode, time of day, and distance travelled
- λ marginal excess burden of taxation
- p^j price for “mode” j
- e^j own-price elasticity for “mode” j
- m^i marginal external cost of “mode” i
- c^i marginal cost of “mode” i
- X^i total usage of “mode” i . Units are passenger-journeys of the specified length.

Equation (1) below is derived from equation (17) in De Borger, et. al. (1996),³³ which sets out the derivation of the welfare relationships in detail. It expresses the necessary (but not sufficient) condition to guarantee a local maximum of a

³³ Bruno De Borger, Inge Mayeres, Stef Proost and Sandra Wouters, “Optimal Pricing of Urban Passenger Transport, A Simulation Exercise for Belgium,” *Journal of Transport Economics and Policy*, January 1996, 31-54.

welfare function. It is derived by setting the partial derivative of welfare with respect to the price of “mode” j to zero³⁴.

$$\frac{\partial W}{\partial p_j} = \lambda X_j - (\partial X_j / \partial p_j)(m_j + (1+\lambda)(c_j - p_j)) - \sum_{i < j} (\partial X_i / \partial p_j)(m_i + (1+\lambda)(c_i - p_i)) = 0 \quad (1)$$

In order to convert this equation into a form which is soluble for optimal prices it is necessary to assume a functional form for the demand schedule. Linear demand is assumed, with own-price elasticity equal to e_{jj} at the current set of transport prices and usage (ie, p_{j0} and X_{j0}). Specifically,

$$X_i = D + (\partial X_i / \partial p_i) p_i + \sum_{i < j} (\partial X_i / \partial p_i) p_i$$

Noting that $e_{jj} \equiv (\partial X_j / \partial p_j) (p_{j0} / X_{j0})$,

$$(\partial X_i / \partial p_i) = e_{ij} X_{i0} / p_{i0} \quad (2)$$

Also, $X_{i0} = (\partial X_i / \partial p_i) (p_{i0} / e_{ij})$, implying that

$$D = (\partial X_i / \partial p_i) p_{i0} (1 / e_{ij} - 1) - \sum_{i < j} (\partial X_i / \partial p_i) p_{i0}$$

By the assumption of linearity, the partial derivatives are constant and therefore so is D . Making this substitution and grouping price terms on the left,

$$\begin{aligned} & (\partial X_i / \partial p_i)(1+2\lambda) p_i + \sum_{i < j} (\lambda (\partial X_i / \partial p_i) + (\partial X_i / \partial p_i) (1+\lambda)) p_i \\ & = (\partial X_i / \partial p_i)(m_i + (1+\lambda)c_i) + \sum_{i < j} (\partial X_i / \partial p_i)(m_i + (1+\lambda)c_i) - \lambda D \end{aligned}$$

This expression can be simplified by dividing both sides by $(\partial X_i / \partial p_i)$ and adopting the new variables:

$$Z_{ij} \equiv (\partial X_i / \partial p_i) / (\partial X_j / \partial p_j) \text{ and}$$

$$V_{ij} \equiv (\partial X_i / \partial p_i) / (\partial X_i / \partial p_i)$$

Note that if $i = j$

$$Z_{ij} = V_{ij} = 1$$

With these changes, the first-order condition becomes:

$$\sum_i (\lambda V_{ij} + (1+\lambda)Z_{ij})p_i = \sum_i Z_{ij} (m_i + (1+\lambda)c_i) + \lambda[p_{j0} (1 - 1/e_{jj}) + \sum_{i < j} V_{ij} p_{i0}] \quad (3)$$

Note that in equation (3), the summation over i includes automobile as well as public transport modes. An important premise of this work is that road pricing

³⁴ I have adopted the simplifying assumption that the marginal social utility of income is the same for all individuals. Alternatively one could say that this analysis proceeds with a focus on one representative individual.

is not able to be optimized. For this reason, equation (1) is recast to treat automobile mode pricing as a constant.

To derive a more useful form of equation (3), we split the summation over i into a sum over public transport modes ($i < ax$) and a sum over automobile modes (sum over x). Here, “ ax ” represent the range of “modes” involving the automobile mode. The “ x ” part of this index refers to time of day and distance components.

The automobile components of the summation on the left hand side are moved to the right hand side. Since we assume no change to automobile prices, the components of the automobile price summation involving the factor V cancel out the corresponding components of the constant D . The resulting equation (4) is shown below. Note that the final constant term is not $-\lambda D$ because the automobile terms involving $V^{ax} p^{ax}_0$ are excluded from the final summation.

$$\sum_{i < ax} (\lambda V_j + Z_j(1+\lambda)) p^i = \sum_{i < ax} Z_j (m^i + c^i(1+\lambda)) + \sum_x Z^{ax}_j (m^{ax} + (c^{ax} - p^{ax})(1+\lambda)) + \lambda [p^j_0 (1 - 1/e^j) + \sum_{i < j, ax} V_j p^i_0] \quad (4)$$

Equation (4) will be used in the calculations. This gives a set of equations, one for each non-auto mode, j .

C.2 Data structures

Index j can take up to 40 values = $5 \times 4 \times 2$. Each value is one combination of one of five transport modes (automobile, train, bus, ferry, light rail), one of four journey distances (2, 5, 15, 25 km), and one of two times of day (peak, off-peak).

Index x can take up to 8 values = 2×4 , representing the possible combinations of one of two times of day and one of four journey distances.

Index ax can take the same number of values as index x .

The marginal excess burden of taxation is a scalar value (usually $0 < \lambda < 1$).

Public transport prices are the unknowns for which we solve. This is a 32-element ($4 \times 4 \times 2$) vector.

Other 32-element vectors needed for public transport “modes” are:

- ▼ Own-price elasticities;
- ▼ Marginal costs;
- ▼ Marginal external costs.

In performing the calculations, we assume that all marginal costs and marginal external costs are constant (that is, independent of usage). To the extent this

assumption is not valid, the projected welfare outcomes at prices very different from the status quo may be distorted.

For automobile “modes”, 8-element vectors are needed:

- ▼ The difference between marginal cost and the price the motorist pays ($cax - pax$);
- ▼ Marginal external costs.

Marginal external costs for each “mode” are the sum of the following components, which are each calculated separately:

- ▼ Marginal external congestion cost (mainly for automobiles, but also buses);
- ▼ Marginal external emission cost (for all modes, but less so for trains);
- ▼ Marginal external accident cost (mainly for automobiles, but also for buses and light rail).

A table of values Z_{ij} and V_{ij} is needed. Index i can take 40 values (public transport and automobiles). Index j can take only 32 values (public transport “modes” only). Table 1 below indicates how the Z values are assumed to depend on the indices i and j . Each of these indices actually represents a combination of values of three other indices: one each for time of day, distance, and mode type.

Table C.1 Z values

I			J			Z
TOD	Distance	Mode	TOD	Distance	Mode	
a	b	c	a	b	c	1
a	b	c	a	$v \leftrightarrow b$	c	0
a	b	c	a	b	$w \leftrightarrow c$	Z_w^c (Based on STM runs)
a	b	c	$u \leftrightarrow a$	b	c	-0.1
a	b	c	$u \leftrightarrow a$	$v \leftrightarrow b$	c	0
a	b	c	a	$v \leftrightarrow b$	$w \leftrightarrow c$	0
a	b	c	$u \leftrightarrow a$	$v \leftrightarrow b$	$w \leftrightarrow c$	0
a	b	c	$u \leftrightarrow a$	b	$w \leftrightarrow c$	0

Note: TOD = Time of day

Source:

The V values can be derived from Z values:

$$V_{ij} = Z_{ij} (\partial X_i / \partial p_i) / (\partial X_i / \partial p_i)$$

Using (2), this can be expressed as:

$$V_{ij} = Z_{ij} (e^{ii} X_{i0} p_{i0}) / (e^{ij} X_{j0} p_{j0})$$

C.3 Calculation process

Equation (4) can be expressed in vector notation as:

$$A p = \text{RHS} \quad (5)$$

The diagonal elements of matrix A are equal to $(1 + 2\lambda)$.

The off-diagonal elements of A are $(\lambda V_{ij} + (1+\lambda) Z_{ij})$.

Element j of the RHS vector is equal to

$$\sum_{i \neq j, \text{auto}} Z_{ij}(m^i + c^i(1+\lambda)) + \sum_{i=\text{auto}} Z_{ij}(m^i + (c^i - p^i)(1+\lambda)) + \lambda[p^j_0 (1 - 1/e^{ij}) + \sum_{i \neq j, \text{auto}} V_{ij} p^i_0],$$

since motoring prices are not optimized.

Equation (5) can be used to solve for the vector of optimal prices:

$$p^* = A^{-1} \text{RHS} \quad (6)$$

where A^{-1} is the inverse of matrix A.

C.4 Additional steps

Once the set of optimal prices has been determined, a series of further calculations is required.

C.4.1 Predicted patronage at optimum

Given prices, demand schedules for all transport modes and times of day are needed to estimate patronage. Some care may be required in taking account of subsidized travelers, such as pensioners and travelers taking advantage of the school student transport scheme.

C.4.2 Predicted revenue and subsidy requirement

With the knowledge of prices and patronage, farebox revenue for public transport can be estimated. A knowledge of total costs for public transport will then permit a calculation of the subsidy implications of optimal prices.

C.4.3 Are capacity constraints satisfied?

Optimal patronage levels for public transport must be compared to current capacity limits by mode and time of day to ensure that the transport task can actually be met.

C.4.4 Second-order conditions are met

In order to rule out the possibility that the optimal prices calculated by this method represent a local minimum rather than a local maximum of welfare, we calculate the second derivative of the welfare function and show that it is always negative.

We start with equation (1) for the first derivative of welfare with respect to the price for mode j :

$$\frac{\partial W}{\partial p_j} = \lambda X_j - (\partial X_j / \partial p_j)(m_j + (1+\lambda)(c_j - p_j)) - \sum_{i < j} (\partial X_i / \partial p_j)(m_i + (1+\lambda)(c_i - p_i)) \quad (1)$$

We assume that in the neighborhood of $\partial W / \partial p_j = 0$, demand for transport mode j is linear:

$$X_j = X_0 - \beta p_j + (p^i \text{ terms}), \text{ where } \beta > 0.$$

The terms in the demand function containing p_i (with $i < j$) will drop out when X_j is differentiated with respect to p_j .

The second derivative of welfare with respect to p_j is therefore:

$$\frac{\partial^2 W}{\partial p_j^2} = -\beta\lambda - \beta(1 + \lambda) = -\beta(1 + 2\lambda) < 0$$

C.4.5 Welfare implications of optimal prices

The change in welfare from moving away from optimal prices can be calculated by integrating a version of equation (1). This calculates the welfare impacts of moving a single price (for one mode, distance and time of day) away from its optimal level, while keeping other prices at their optimal levels.

$$\begin{aligned} \int dW &= \int \{ \lambda X_j - (\partial X_j / \partial p_j)(m_j + (1+\lambda)(c_j - p_j)) - \sum_{i < j} (\partial X_i / \partial p_j)(m_i + (1+\lambda)(c_i - p_i)) \} dp_j \\ &= \lambda \int (X_j dp_j + p_j dX_j) - \lambda \int c_j dX_j + \int p_j dX_j - \int (m_j + c_j) dX_j \\ &\quad - \int \sum_{i < j} Z_j^i (m_i + (1+\lambda)(c_i - p_i)) dX_j \end{aligned}$$

When this indefinite integral is evaluated between the bounds p_{j0} (initial price) and p_j^* (the calculated optimal price),

$$\begin{aligned} \Delta W_j &= \lambda [p_j^* X_j^* - p_{j0} X_{j0} - c_j \Delta X_j] \\ &\quad + \Delta X_j [(p_j^* + p_{j0})/2 - m_j - c_j] \\ &\quad - \Delta X_j \sum_{i < j} Z_j^i (m_i + (1+\lambda)(c_i - p_i^*)) \end{aligned} \quad (7)$$

The terms in equation (7) have the following natural interpretations. The first term, if negative, represents the deadweight loss arising from raising taxes to pay for the public transport subsidy. The second term represents the sum of consumer and producer surplus in the market for mode j . The third term represents the cross-modal effects. This term principally expresses the welfare benefit arising from any substitution of public transport mode j for automobiles which reduces the external costs of motoring (less any contributions made by cars through road pricing.)

C.4.6 Sensitivity testing of inputs

Range testing on inputs must be done to determine how sensitive results are to input uncertainty (which affects many of the key variables).

D Submissions to our Draft Report on the external benefits of public transport

Last year we reviewed our approach to estimating the external benefits of public transport. The purpose of that review was to develop new estimates that would feed into our next public transport fare review. In December 2014, we released a Draft Report on the external benefits of public transport.³⁵ The Draft Report included a wider set of external benefits and costs associated with using public transport than we have previously included.

We received eight submissions on the Draft Report. This appendix sets out a summary of the Draft Report, the comments made in submissions, and our response to those comments. In some cases we have changed our proposed approach in response to submissions, in other cases we have not (and this appendix explains why) and in some cases we will further consider the points raised as we proceed with the review of public transport fares.

D.1 What did our Draft Report say?

Our draft decision was that the following external costs and benefits should be included:

- ▼ **Congestion cost.** This is the external benefit associated with avoided road congestion when people use public transport. For future fare reviews, we intend to measure this benefit in three ways:
 - **Time** - the value of time saved by existing drivers when people use public transport instead of adding to road congestion.
 - **Vehicle operating cost** - the value of vehicle operating costs, such as fuel, avoided by existing drivers when people use public transport instead of adding to road congestion.
 - **Reliability** - the benefit of more predictable travel times for existing drivers when people use public transport instead of adding to road congestion.

³⁵ IPART, *Review of external benefits of public transport - Draft Report*, December 2014.

- ▼ **Environmental externalities.** This includes the external benefits of avoided air pollution and greenhouse gas pollution when people use public transport instead of driving. In estimating a total benefit from the public transport network we have netted off the external costs associated with the pollution created by the public transport services themselves.
- ▼ **Accidents.** This is the external benefit associated with avoided road accidents when people use public transport instead of driving.
- ▼ **Active transport.** This is the external health benefits that arise because public transport encourages greater levels of physical activity – primarily when people walk or cycle to and from public transport.
- ▼ **Road user charges.** This adjustment is made to recognise the fact that road user charges – such as tolls, the fuel excise and parking levy – offset some of the external costs that driving imposes on the community. Because they also form part of the cost people consider when deciding whether to drive or use public transport, not including these would overstate the external benefits of public transport.

Our model calculates very specific estimates of each of these because it is based on modelled outcomes from the Sydney Strategic Travel Model (STM), which predicts public transport and road usage under a given scenario and values from Transport for NSW's *Principles and guidelines for the economic appraisal of transport investment and initiatives*.³⁶ While it is difficult to put a range around these estimates due to the way we calculate them, we acknowledge that there is a degree of uncertainty around the values.

On a per kilometre basis, estimates are very similar across the different modes. The estimates are different on a passenger journey basis because the average trip length is different.

We considered other possible external benefits such as social inclusion and the wider economic benefits from agglomeration and increasing land values, and concluded that they would not be relevant to setting fares in the short term.

D.2 What did submissions say about our draft decisions and how are we responding?

We received eight submissions in response to our Draft Report. The main comments we received in submissions, and our responses to them, are discussed below.

³⁶ The updated version is available from Transport for NSW's website at <http://www.transport.nsw.gov.au/publications/economic-appraisal-transport-investments-initiatives>

Overall approach

We received several submissions about our approach to fare-setting more generally. For example, Action for Public Transport (APT) submitted that our approach to estimating external benefits and fares is needlessly complex and that it should be straightforward to 'set fares at a level that recovers as much as possible for operators, while remaining affordable and encouraging people to use public transport.'³⁷ Our proposed methodology for setting fares considers each of these elements.

Costs of congestion

APT agreed with the inclusion of vehicle operating costs and reliability costs in the cost of congestion estimate.³⁸

A submission (Baojin Wang) questioned the difference in methodology between our approach to estimating the costs of congestion that public transport use avoids and the approach taken by Transport for NSW to estimate total congestion. This submission also argued that we should take locational differences into account.³⁹

Another submission (Philip Norman) suggested using a higher value of time in the congestion cost estimates.⁴⁰ He suggested that 'busy Sydney women are the market segment that should drive fares policy' and that revealed preferences about the value of travel time of busy women suggested it was 1.28 times the wage rate – similar to the business travel time value in the TfNSW guidelines. (Our Draft Report used a weighted average of the private and business values in the TfNSW guidelines).

Environmental externalities

One submission (Baojin Wang) argued that the external costs of greenhouse gas emissions and air pollution should not include pollution associated with electricity generation.⁴¹ The submission notes that TfNSW's position is to treat the cost of these emissions as pollution costs of electricity generators not transport operators. In principle, we still consider that these 'upstream' pollution costs should be included. TfNSW currently has no estimate of upstream

³⁷ Submission from Action for Public Transport to IPART Draft Report on external benefits of public transport, 25 March 2015, p 2.

³⁸ Submission from Action for Public Transport to IPART Draft Report on external benefits of public transport, 25 March 2015, p 5.

³⁹ Submission from B Wang to IPART Draft Report on external benefits of public transport, 23 March 2015, p 1.

⁴⁰ Submission from P Norman to IPART Draft Report on external benefits of public transport, 21 March 2015, p 6.

⁴¹ Submission from B Wang to IPART Draft Report on external benefits of public transport, 23 March 2015, p 5.

pollution costs in its guidelines for rail or light rail services so we engaged a consultant to estimate these values.

However, as part of our draft fares report we will consider whether the air pollution estimates for emissions associated with electricity used to drive trains and trams should be reduced to take into account the location of electricity generators.⁴² Greenhouse gas emissions are unaffected by this.

External benefit from fewer road accidents

APT welcomed the inclusion of avoided external accident costs but considered that they should also include the consequent burden on the court system.⁴³ We didn't include legal costs as for the most part these costs are recouped and are not external. We did however include the costs of coronial and correctional services. Another submission (Baojin Wang) argued that 'for society, road accident costs are always external costs regardless of the internalisation through insurance.'⁴⁴ We think that people do make decisions that show they are internalising accident costs in their choices. For example, people may choose particular car models because of their safety features or may choose not to drive a motorbike because of safety concerns.

There is now a more recent dataset on crash statistics compared with the one used in our draft external benefits report.⁴⁵ We intend to update our estimates to take these into account.

Health benefits

Generally, submissions supported the inclusion of health benefits in our external benefits model – with APT calling it 'a bright spot in the evolution of IPART's methodology'.⁴⁶

However, NCOSS considered that we were too limited in our scope.⁴⁷ We included the reduction in healthcare costs borne by society, however NCOSS argued that this 'does not adequately capture or reflect the external costs associated with other types of transport' and that time spent commuting, in particular road congestion, is associated with lowered reported life satisfaction, well-being and physical inactivity. NCOSS referred to work by Mulley et al

⁴² Note that the pollution costs associated with public transport are only relevant to the extent that a change in demand for services results in a change to the number of service kilometres.

⁴³ Submission from Action for Public Transport to IPART Draft Report on external benefits of public transport, 25 March 2015, p 5.

⁴⁴ Submission from B Wang to IPART Draft Report on external benefits of public transport, 23 March 2015, p 3.

⁴⁵ See <http://roadsafety.transport.nsw.gov.au/statistics/reports.html>.

⁴⁶ Submission from Action for Public Transport to IPART Draft Report on external benefits of public transport, 25 March 2015, p 6.

⁴⁷ Submission from Council of Social Service of NSW to IPART Draft Report on external benefits of public transport, 25 March 2015, p 5.

which proposed a model capable of incorporating these factors into a comprehensive assessment of the external benefits linked to public transport in the NSW context. We intend to consider this issue further.

Another submission (Rick Banyard) commented that ‘it is wrong to assume that there is no walking involved with the use of the car’, implying that our estimates of this benefit may have been too high.⁴⁸

Road user charges

APT did not agree with deducting road user charges from the external benefit estimate submitting that ‘unless all the external costs of car use are captured in the methodology, road user charges should not be offset.’⁴⁹

Another submission (Baojin Wang) also considered that these road user charges should be excluded as they are transfers (for example, fuel excise is a transfer from road users to the Government in which no resource cost is involved). He suggested ‘that road user charges are removed from the external benefit calculation and replaced by the avoided resource costs of road provision, road maintenance and parking space provision, some of which have been estimated by TfNSW.’

We have carefully considered these submissions. Our preliminary views are that our analysis will include an estimate of the difference between the price faced by road users (their ‘fare’) and the marginal cost for the road operator. The price faced by road users would reflect road user charges and fuel excise. The marginal cost for the road operator would reflect the marginal costs of road maintenance and parking space provision.

Scale benefits and crowding

APT welcomed the idea of considering the potential costs and benefits associated with scale and crowding. However they consider there may be a perverse outcome with our proposed approach - ‘External benefits increase if extra services are provided, so that passengers are not crowded; this presumably is reflected in *lower* fares. But if government fails to provide extra services and passengers are crammed in, their fares for a worse service will *rise*.’

⁴⁸ Submission from R Banyard to IPART Draft Report on external benefits of public transport, 24 March 2015, p 1.

⁴⁹ Submission from Action for Public Transport to IPART Draft Report on external benefits of public transport, 25 March 2015, p 8.

These issues have to be considered consistently with the approach to estimating marginal costs of providing the service. In particular, if additional passengers lead to extra services then this has an additional financial cost, which may be partly offset by benefits from additional service frequency for existing passengers. If additional passengers do not lead to extra services then this has an external cost of crowding on other passengers, but there would be a smaller (or no) increase in the costs of operating the transport service.

Another submission (Baojin Wang) mentioned the methodologies in TfNSW's guidelines for calculating the costs of crowding. We have been working with the Bureau of Transport Statistics (BTS) on possible ways to model crowding costs.

Social inclusion, agglomeration and other wider economic benefits

Submissions from APT, NCOSS, and NRSDC all considered that the external benefits estimate should include social inclusion, agglomeration and other wider economic benefits. These submissions argued that not being able to measure a benefit does not mean that it should be excluded.⁵⁰

Our Draft Report indicated that we would like to consider additional external benefits associated with changes in service frequency and/or levels of crowding that would occur over the determination period. Our Draft Report also discussed other external benefits that result from capacity expansions to the network in response to higher levels of demand. These include wider economic benefits from agglomeration and increasing land values that accrue to third parties. However, we considered that these external benefits would not be relevant to setting fares for the existing network. We are now also proposing to estimate socially optimal fares over a long-run timeframe, where network capacity can be expanded. As discussed in Chapter 5, this means we would also need to include external benefits that are associated predominantly with the network expansion undertaken in response to higher demand.

APT did not agree that the benefits of social inclusion couldn't be measured and quoted work done by Stanley et al⁵¹ which assigns a value of around \$20 per journey. However, as we discussed in Chapter 5, we have some concerns with adopting the Stanley et al valuation for our purposes.

⁵⁰ Submissions from Action for Public Transport to IPART Draft Report on external benefits of public transport, 25 March 2015, p 8; R Sandell, 9 March 2015, p 1; Submission from Council of Social Service of NSW to IPART Draft Report on external benefits of public transport, 25 March 2015, p 5.

⁵¹ See Transport for NSW, *Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives*, March 2013, pp 295-298 for a discussion of this work.

Similarly, submissions did not agree that the benefits of social inclusion are either private or more closely linked with the availability of transport services than with the level of fares. For example, NRSDC argued that ‘affordability is equally important, as availability is irrelevant if people cannot afford the fare. A number of people on low incomes fall through the cracks for concession fares and suffer transport disadvantage and social exclusion as a result.’

One submission (Baojin Wang) suggested that we look at including option value in our fare-setting framework – he describes this value as ‘the value of public transport availability even if some households are currently not using it.’ There are two reasons why we do not consider that option value should be further explored in the context of fare-setting:

- ▼ Option value, where applied in economic appraisals for transport, is generally restricted to circumstances where the availability of service will substantially change.⁵² This is not the case in considering options for public transport fares.
- ▼ We would expect that people who place value on having access to a service will have some probability of future use of the service. (Similarly, existing users may have some probability of not requiring the public transport service in the future.) In this case, option value should translate into usage of the service and adding a separate option value may lead to double counting.

⁵² UK Department of Transport, WebTAG Unit 3.6.1: The Options Values Sub-objective.

E Available literature on public transport elasticities

E.1 International surveys

In a landmark study from 1968, Simpson and Curtin studied the impact to demand of 77 public transport fare changes.⁵³ This led to many American transport agencies adopting an estimate of transport elasticity based on the paper's findings. This rule equates to an elasticity of around -0.4 (though it was often misapplied by transport planners to -0.3).⁵⁴

In 1980, the Transport and Road Research Laboratory published a collaborative report on the demand for public transport, which became the seminal piece of work on demand evaluation in the UK (commonly known as the "black book" study).⁵⁵ The price elasticities in this report ranged from -0.1 to -0.6 and averaged around -0.3.⁵⁶

In 1991, the American Public Transportation Association (APTA) published updated bus fare elasticity estimates for use in transport planning, based on the short run effects of a transport fare change. APTA's estimates are outlined in Table E.1 below.

Table E.1 Bus fare elasticities (APTA)

	Large cities (more than one million population)	Small cities (less than one million population)
Off-peak	-0.39	-0.46
Peak	-0.18	-0.27
Average	-0.36	-0.43

Source: Victoria Transport Policy Institute, *Transit Price Elasticities and Cross-Elasticities*, April 2014, p 7.

⁵³ Curtin, J. F., *Effect of Fares on Transit Riding*, Highway Research Record No. 213. Highway Research Board, Washington, DC (1968).

⁵⁴ Transportation Research Board, *Transit Pricing and Fare: Traveler response to transportation system changes*, 2000, p 12-9.

⁵⁵ Balcombe et al., *The demand for public transport: a practical guide*, 2004, p 1.

⁵⁶ Webster and Bly, *The demand for public transport, part II: supply and demand factors of public transport*, *Transport Reviews: A Transnational Transdisciplinary Journal*, p 24.

In 1992, Goodwin calculated average elasticities based heavily on European estimates of bus and rail elasticities.⁵⁷ Goodwin differentiated between short and long run, and noted that short run elasticities were lower than longer run elasticities. This conclusion is consistent with other studies, which found that long-run elasticity is two to three times larger than short-run elasticity.⁵⁸ Goodwin's estimates are outlined below.

Table E.2 Public transport elasticities (Goodwin)

	Short-run	Long-run	Average
Bus elasticity	-0.28	-0.55	-0.41
Rail elasticity	-0.65	-1.08	-0.79

Source: Goodwin, *A review of new demand elasticities with special reference to short and long run effects of price changes*, Journal of Transport Economics and Policy, May 1992, pp 160-161.

In 1992, Oum et al. conducted a survey of public transport elasticity estimates.⁵⁹ (Despite being contemporaneous with Goodwin's study, few of the estimates used in the two studies overlapped).⁶⁰ Oum et al. found that most public transport elasticity estimates fell in the range from -0.1 to -0.6.⁶¹ They also demonstrated that the approach and functional form of the econometric study resulted in widely different elasticity estimates, even with the same set of data.⁶²

In 2006, a group of major English universities collaborated to produce a guidance manual on the demand for public transport for use by public transport operators and planning authorities in the UK.⁶³ This was meant as an update to the estimates of elasticities in the "black book" study, but with greater detail around the short/long run and taking advantage of more advanced econometric techniques to understand how transport demand changes over time.⁶⁴ This study found slightly higher elasticity estimates than the previous study, see Table E.3 below.

⁵⁷ Goodwin, *A review of new demand elasticities with special reference to short and long run effects of price changes*, Journal of Transport Economics and Policy, May 1992, pp 160-161.

⁵⁸ For example, see Victoria Transport Policy Institute, *Transit Price Elasticities and Cross-Elasticities*, April 2014, p 5.

⁵⁹ Oum, Waters and Yong, *Concepts of Price Elasticities of Transport Demand and Recent Empirical Estimates: An Interpretative Survey*, Journal of Transport Economics and Policy, May 1992.

⁶⁰ Goodwin, *A review of new demand elasticities with special reference to short and long run effects of price changes*, Journal of Transport Economics and Policy, May 1992, p 149.

⁶¹ Oum, Waters and Yong, *Concepts of Price Elasticities of Transport Demand and Recent Empirical Estimates: An Interpretative Survey*, Journal of Transport Economics and Policy, May 1992, p 153.

⁶² Ibid, p 153.

⁶³ Paulley, Balcombe, Mackett, Titheridge, Preston, Wardman, Shires & White, *The demand for public transport: The effects of fares, quality of service, income and car ownership*, Transport Policy 2006.

⁶⁴ Paulley, Balcombe, Mackett, Titheridge, Preston, Wardman, Shires & White, *The demand for public transport: The effects of fares, quality of service, income and car ownership*, Transport Policy 2006, p 296.

Table E.3 Public transport elasticities in the United Kingdom

	Short-run	Medium-run	Long-run	Peak short-run	Off-peak short-run
Public transport	-0.44	NA	NA	NA	NA
Bus	-0.42	-0.56	-1.01	-0.26	-0.48
Metro	-0.30	NA	-0.65	-0.26	-0.42
Suburban rail	-0.58	NA	NA	-0.34	-0.79

Source: Paulley, Balcombe, Mackett, Titheridge, Preston, Wardman, Shires and White, *The demand for public transport: The effects of fares, quality of service, income and car ownership*, Transport Policy 2006.

E.2 Local estimates of public transport elasticities

In 1993, Luk and Hepburn surveyed Australian elasticity estimates,⁶⁵ and compared them to the international estimations by Goodwin (discussed in the previous section). From five bus estimates and five urban rail estimates, Luk and Hepburn estimated the elasticities outlined in Table E.4.

Table E.4 Short run public transport elasticity (Luk and Hepburn)

Mode of transport	Luk and Hepburn (Australian review)	Goodwin (International review)
Bus	-0.29	-0.28
Rail	-0.35	-0.65

Source: Luk and Hepburn, *New review of Australian demand elasticities – research report*, Australia Road Research Board, p 19.

In 1996, we engaged the Institute of Transport Studies to estimate price elasticities of Sydney transport for all ticket types. This study is one of the few to estimate elasticities for ferries. Much of the individual ticket's elasticity derives from "within mode" transfers, ie, customers who substitute one ticket type for another but remain on the same mode. When we attempted to find aggregate estimates – by calculating a weighted average of all cross and direct elasticities – the results were unreliable and in some cases positive (a positive elasticity means that raising fares would raise demand, which is unrealistic).

In 2006, we engaged Booz Allen Hamilton to forecast patronage of ferries. Booz estimated an elasticity estimate of -0.22 by taking a weighted average of the Sydney Transport Authority's (STA's) ticket type fare elasticities (similar to the Institute of Transport Studies's report above).⁶⁶

⁶⁵ Luk and Hepburn, *New review of Australian demand elasticities – research report*, Australia Road Research Board.

⁶⁶ Booz Allen Hamilton, *Review of patronage trends and projections for Sydney Ferries*, October 2006, p 14.

In 2008, we engaged Booz&Co to estimate the elasticities of CityRail. Booz estimated that a price elasticity of CityRail of -0.29,⁶⁷ focusing on stated preference surveys. In addition, Booz performed a literature review of rail elasticity estimates. They found a median short run rail elasticity of -0.28 and a long run median of -0.36.

RailCorp also estimates elasticity of rail fares. Its estimates for 2010 are outlined in Table E.5.

Table E.5 Rail elasticity (RailCorp)

	Peak	Off-peak	Overall
Price elasticity	-0.35	-0.42	-0.38

Source: Transport for NSW, *Principles and guidelines for economic appraisal of transport initiatives*, March 2013, p 269.

Finally, in 2014, Tsai, Mulley and Clifton estimated the elasticity of public transport fares in Sydney using Household Travel Survey data.⁶⁸ They found a short run elasticity of all mode public transport with respect to the fare paid of -0.22 and a long run elasticity of -0.29.

⁶⁷ Booz&Co, *CityRail Fare Elasticities - Final report to Independent Pricing and Regulatory Tribunal*, May 2008, p ii.

⁶⁸ Tsai, Mulley and Clifton, *A Review of Pseudo Panel Data Approach in Estimating Short-run and Long-run Public Transport Demand Elasticities*, *Transport Reviews*, p 120.

