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*Paper 2:  
Social, Economic and  
Environmental  
Impacts of Transport  
Modes*

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## Table of Contents

List of Figures and Tables .....	ii
Executive Summary .....	iii
1. Transport Benefits and Costs.....	1
1.1. Benefits.....	1
1.1.1. Mobility and Access Benefits .....	1
1.1.2. Efficiency Benefits .....	1
1.2. Social Costs .....	1
1.2.1. Travel-time Costs.....	2
1.2.2. Congestion Costs .....	2
1.2.3. Accidents .....	2
1.2.4. Impacts on Non-motorized Travel .....	2
1.2.5. Land Use Impacts .....	2
1.2.6. Road Infrastructure Costs .....	3
1.2.7. Environmental Costs .....	3
2. Social and Environmental Cost Valuation.....	4
2.1. Congestion.....	4
2.2. Accidents .....	4
2.3. Environmental Costs.....	5
2.3.1. Air Pollution.....	5
2.3.2. Noise.....	5
2.4. Rural versus Urban Costs.....	5
2.4.1. Pollution and Noise Costs.....	6
3. Road Versus Rail Social Costs .....	11
4. Transport Social Costs: The Australian Setting.....	12
4.1. Relevance of European Data .....	13
4.2. Social Costs of Transportation in Australia.....	14
5. References .....	17

## List of Figures and Tables

Table 2.1:	Range of estimates for pollution costs .....	7
Table 2.2:	Range of estimates for noise costs .....	7
Table 2.1:	European air pollution values adjusted for Australia .....	8
Table 2.4:	Climate change estimates damage cost approach .....	10
Table 2.5:	Range of externality values from freight transport .....	13
Table 2.6:	Total social costs adjusted for Australia .....	14
Table 2.7:	Passenger social unit costs (A\$/1000pkm) .....	14
Table 2.8:	Passenger transport social costs: Total costs 2003-2004 (A\$ billion 2004).....	15
Table 2.9:	Freight social unit costs (A\$/1000tkm).....	15
Table 2.10:	Freight social total costs (A\$ billion, 2004 dollars) .....	15
Table 2.11:	Congestion costs (A\$ billion).....	16

## Executive Summary

Transport generates a range of social and environmental costs and benefits that are a significant component of the full impact of transport activities. The benefits to the individual and society arising from transportation are so large that it is difficult to calculate the total benefits of all transportation activities. For example, freight transportation is a vital element in the economies of nations, regions, and cities. Low-cost and reliable movement of freight helps a business to be competitive. Transportation benefits are usually divided into two major categories: Mobility and Access Benefits and Efficiency Benefits. Mobility benefits from increased travel such as more vehicle kilometres travelled, or more transit trips, further walking or cycling and increased freight transport, while access is related to mobility but is defined according to how the benefits from access to services or facilities are accrued. Efficiency benefits reflect the cost savings to individuals, businesses and society when transport becomes more efficient in the sense of using less resources to achieve the same outcome.

The social costs from transportation comprise all costs to which transport gives rise and which are borne by society. They consist of both internal and external costs. Internal costs are costs that transport users pay individually, for example, fuel, insurance, fares, etc, or bear as non-financial costs, such as travel time. External costs are social costs not borne by those responsible for them, yet are borne by other members of society. The degree of internalisation of external costs is not examined since various studies reach very different conclusions, whereas the purpose of this report is to illustrate the size of social costs and how they may be reduced with a change in modal split (as opposed to measuring to what degree they have been internalised). However, where external costs are present, the decision maker does not have an incentive to take into account these effects. As a result, activity levels may be too high. Despite this, the optimal level of external costs is unlikely to be zero owing to the beneficial effects of transport that would be lost if the activity and the cost of amelioration were all borne by the transport user.

Social costs as a result of transport include travel time costs, road infrastructure costs, congestion costs, accident costs, environmental costs such as air pollution, noise pollution, water pollution, disposal costs, impacts on non motorised travel, land use impacts, and greenhouse gases. This report only examines congestion, accident, air and noise pollution in detail, in addition to greenhouse gas costs.

The valuation of social costs as a field of study is undergoing constant development. At present, estimates in the literature vary widely on account of the diverse sources of data. The economic approach to valuing congestion argues that, to eliminate congestion to the point where traffic flows freely, would not be desirable because road infrastructure would then not be utilised efficiently and economic activity would also be constrained. An economic approach argues that there is an 'optimal' level of congestion that needs to be reached (through marginal cost pricing) where some road users either do not travel at all, postpone their trips to another day, travel at different times of the day (off-peak) or travel on other modes (public transport) or with other users (ridesharing).

Common measures of accident costs include the share of total accident costs, the difference between total accident costs and total insurance premiums, costs imposed on non-road users (system costs being the main ones), and costs arising from the disparate vulnerability of road users.

In addition to health costs imposed on society, air pollution can also contribute to a number of environmental problems. These include smog, degraded visibility, loss of biodiversity, and damage to infrastructure such as discolouration of stone, erosion and the soiling of buildings. Noise tends to have an adverse impact on residential property values. This impact has been the basis for dollar costs of truck and rail noise. Because of the generally sparse settlement patterns in rural areas, few housing units are affected by passing trains or highway traffic.

Estimating climate change unit costs is extremely difficult owing to the many assumptions required in the calculation. Two main methods are used to arrive at figures, these are the damage cost approach techniques (such as willingness to pay to estimate costs of damage in monetary terms) and the control cost approach (different types of expenditures such as mitigation, abatement, replacement, restoration or avoidance costs)

In general, the major external costs associated with rail are the same as road. While the types are similar, the magnitude of the costs appears to be approximately one third of the costs associated with road transportation. A lack of systematic externality costing for either rail or road favours road since its externalities are larger.

Within Australia there is, at present, no charging of externalities for road or rail projects. The current practice is increasingly to apply externality values within a project appraisal process. Therefore, motorists or rail passenger are not charged for the production of any externalities in their use of that transport mode. Conversely, when the viability of a project is being assessed, it is becoming common practice to include externalities and decide in favour of the project that maximises the benefits and minimises these externalities.

The report provides estimates of a range of social and environmental costs. These indicate that, for passenger transport the most significant external costs for cars, in terms of dollars per 1000 pkm, are accidents and air pollution, which comprise as much as 50% and 25% respectively of social and environmental costs. For passenger rail, air pollution accounts for about one third of the total. However, the total identified external costs for cars is more than three times, on a passenger km basis, the level for rail passengers. For freight, the social and environmental costs for road is almost five times that of rail per 1000tkm. Three additional modelling scenarios are examined with various modal shifts to rail from road. The result of these scenarios suggests significant reduction in social costs as a result of this modal shift.

## 1. Transport Benefits and Costs

### 1.1. Benefits

Transportation provides many benefits, and various techniques can be used to measure these benefits. The benefits to the individual and society are so large that it is difficult to calculate the total benefits of all transportation activities. For example, freight transportation is a vital element in the economies of nations, regions, and cities. Low-cost, reliable movement of freight helps a business to be competitive. However, in most situations, the important factor is the marginal benefits provided by a particular policy or project when compared with a Base Case. Marginal transportation benefits are usually divided into two major categories: Mobility and Access Benefits and Efficiency Benefits (VTPI 2006).

#### 1.1.1. Mobility and Access Benefits

Mobility benefits from increased travel such as more vehicle kilometres travelled, or more transit trips, further walking or cycling and increased freight transport (Schrank and Lomax 1999). Access is related to mobility but is defined according to how the benefits from access to services or facilities are accrued. Access improvements may actually reduce the need for travel (i.e., mobility), for example, if services are located nearby owing to efficient land use or delivery services. Hence mobility and access benefit individuals and society by access to schools, employment, shopping centres and recreation activities, though not in the same way. Increased ability to travel (mobility) benefits individuals and society. Despite this, improved access owing to a closer location of services and facilities resulting in less mobility also benefits individuals and society (Greene, Jones et al. 1997).

#### 1.1.2. Efficiency Benefits

Efficiency benefits reflect the cost savings to individuals, businesses and society when transport becomes more efficient in the sense of using less resources to achieve the same outcome (Greene, Jones et al. 1997).

It is difficult to measure the benefits of transport, though numerous approaches are now well documented. Mobility is usually measured in terms of the increased amount of travel. Increased mobility may have benefits to individuals and firms in some cases, such as by allowing people to access far-flung tourist sites. Conversely, efficiency benefits are often measured in the reduced need for travel to achieve a given objective. Hence, when evaluating the benefits of a policy or project, it is necessary to consider all forms of benefits since one may interact with or offset another. For example, for a road capacity expansion project, an analysis of mobility benefits might assume that more traffic at higher speeds would produce benefits. However, the same project analysed from an efficiency perspective might study the extent to which a given objective can be achieved with a lower level of traffic (VTPI 2006).

Nevertheless, the focus of this paper is not to examine the benefits of transportation but rather to analyse and review the social, environmental and economic external costs of transportation. The economic costs of various transport modes are addressed in Paper No 5. Nonetheless, it is important to keep in mind the benefits of various transportations options, while also considering the costs (Greene, Jones et al. 1997).

### 1.2. Social Costs

Social costs comprise all costs to which transport gives rise and which are borne by society. It is important to note that, as the term is used here, social costs cover both internal and external costs, and so social costs differ from externalities. Internal costs are costs that

transport users pay individually, for example, petrol, insurance, fares, etc., or bear as non-financial costs, such as travel time. External costs are social costs that are not borne by those who are responsible for them, but rather other members of society. The total external cost is the sum of the external costs within a specific area for a given time period, for example one year. The average external cost is the total external cost divided by the transport units. The average external cost provides a useful figure to compare different modes of transport (Tsolakis, Houghton et al. 2003).

The degree of internalisation of external costs is not examined since various studies reach very different conclusions and the purpose of this report is to illustrate the size of social costs and how they may be reduced with a change in modal split (as opposed to measuring to what degree they have been internalised). However, where external costs are present, the decision maker does not have an incentive to take into account these effects and, as a result, activity levels could potentially be too high. Despite this, the optimal level of external costs is unlikely to be zero owing to the beneficial effects of transport, which would be lost if the activity and the cost of amelioration were all borne by the transport user. The economically efficient level occurs where the marginal cost of reducing the external cost equals the marginal benefit of doing so (Productivity Commission 2006).

Below is a list of social costs as a result of transport that include travel time costs, road and rail infrastructure costs, congestion costs, accident costs, environmental costs such as air pollution, noise pollution, water pollution, disposal costs, impacts on non motorised travel, land use impacts and greenhouse gases. This report will only examine congestion, accident, air and noise pollution, in addition to greenhouse gas costs.

#### **1.2.1. Travel-time Costs**

Travel time is one of the largest transport costs, and travel-time savings are often highlighted as the greatest potential benefit of transport improvements. Various studies have calculated travel time values relative to wage rates based on traveller behaviour (Wardman 1998; Small, Noland et al. 1999). Many specific attributes of travel, such as comfort, safety and prestige, can be reflected in travel-time costs. Many such social costs are internalised, and so cannot be treated as external costs.

#### **1.2.2. Congestion Costs**

Marginal congestion costs consist of the incremental delay, stress, vehicle operating costs and pollution that results from each additional vehicle added to the traffic stream (VTPI 2006).

#### **1.2.3. Accidents**

Traffic crash costs include deaths, injuries, pain, disabilities, lost productivity, grief, material damage, and crash prevention or mitigation expenses (VTPI 2006).

#### **1.2.4. Impacts on Non-motorized Travel**

Changes in the design of roads and parking facilities, vehicle traffic volumes and speeds, and the quality of the pedestrian environment can affect the convenience, safety and comfort of walking and cycling. The *Barrier Effect* (also called *Severance* or *Urban Separation*) refers to the tendency of roads and traffic to create a barrier to non-motorized travel. It represents a degradation of the pedestrian and cyclist environment that reduces the viability of these modes, often leading to increased driving (Greene, Jones et al. 1997).

#### **1.2.5. Land Use Impacts**

Some researchers argue that a more balanced transportation system can increase community cohesion, reduce crime and increased employment opportunities for disadvantaged populations (Untermann and Vernez Moudon 1989).

### 1.2.6. Road Infrastructure Costs

Roads and parking are usually provided free or bundled with facility costs (for example, parking is usually included with housing purchases or rents) so most consumers have little idea of what a road or parking space costs to produce (VTPI 2006).

Highway development involves various costs, including planning and design, land acquisition, maintenance and construction costs. These costs vary significantly depending on conditions. In rural areas, planning and land costs may be modest, and construction expenses may dominate project costs. In urban areas, planning and land costs tend to be much higher. Adding capacity to existing roads can be relatively inexpensive if there is adequate right-of-way and few intersections, or very expensive if it requires land acquisition or rebuilding intersections (Bein 1997).

### 1.2.7. Environmental Costs

#### Air Pollution

Air pollution is one of the most obvious environmental costs of motor-vehicle use and the operation of diesel-electric locomotives. Motor vehicles produce several potentially harmful air pollutants, including carbon monoxide (CO), particulate matter (PM), nitrogen oxides (NO<sub>x</sub>), volatile organic compounds (VOCs), sulphur oxides (SO<sub>x</sub>), carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), road dust, and toxic gases such as benzene. Most air pollution cost studies focus on a limited number of impacts and so give an incomplete estimate of total pollution costs (Small and Kazimi 1995).

#### Noise Pollution

Motor vehicles and trains generate noise pollution. This noise tends to increase with speed, accelerations, and the proportion of heavy vehicles. Noise costs tend to be much higher on urban roads, where traffic tends to be in higher volume and closer to residences and other forms of land use, compared with rural roads where the distances between road or rail and dwellings is much larger (Vermeulen, Boon et al. 2004).

#### Water Pollution and Hydrologic Impacts

Roads and motor vehicles use also contribute to water pollution as a result of increased water run-off and the substances leached out of the road surface. Hydrologic impacts also impose a variety of costs on society (Bein 1997).

#### Waste Disposal

Motor vehicles produce a number of harmful waste products that can impose externalities, including used tyres, batteries, junked cars (for example, recently 120 cars have been found dumped in a 4 km stretch of the Maribyrnong River (Roberts 2008)), oil and other semi-hazardous materials resulting from motor vehicle production and maintenance. This also applies to rail, but to a lesser extent owing to the longevity of rail rolling stock and their fewer numbers. These wastes impose a variety of environmental, human health, aesthetic, and financial costs, through improper disposal, residual impact even when proper disposal is observed, and because some disposal efforts are subsidised by general taxes (Delucchi 2000).

## 2. Social and Environmental Cost Valuation

The valuation of social costs as a field of study is undergoing constant development. At present, estimates in the literature vary widely as a result of the diverse sources of data (Nash and Matthews 2005).

### 2.1. Congestion

Some researchers argue that congestion is not strictly an externality since an externality requires the costs to be borne by people other than those groups creating them. However, congestion primarily affects the same group of people who create it, namely the road users themselves (Infras/IWW 2004). Congestion is only an externality in the sense that it is an effect that each motorist imposes on other motorists.

The Victorian Transport Externalities Study (1994) defines congestion as the 'difference in resource costs between the road network operating under current traffic conditions, and the road network operating under ideal conditions where delays have been eliminated and traffic is able to proceed at the maximum safe speed' (EPA 1994, vol. 3, sec. 4, p. 1). However, these conditions only exist outside normal business hours, so it is argued that delays resulting from other traffic are unavoidable in an urban area. Mogridge (1990) and the Infras/IWW study (2004) therefore argue that the cost of congestion is not a classical external cost.

Nevertheless, congestion costs are rightly considered to be social costs and many projects proceed on the basis of reduced congestion and decreased travel times since this gives the project a high benefit-cost ratio (Small, Noland et al. 1999). Many studies have placed a value on congestion, for example, the Victorian Transport Externalities Study, which estimated congestion costs to be A\$2.031 billion (1994 dollars) (EPA 1994).

However, estimation of the overall social costs arising from congestion is a difficult task, partly because of the issues involved in setting the base from which the costs are measured. The economic approach to valuing congestion argues that, to eliminate congestion to the point where traffic flows freely would not be desirable because road infrastructure would then not be utilised efficiently and economic activity would also be constrained (Naude, Tsolakis et al. 2006). The economic approach argues that there is an 'optimal' level of congestion that needs to be reached (through marginal cost pricing), where some road users either do not travel at all, postpone their trips to another day, travel at different times of the day (off-peak) or travel on other modes (public transport) or with other users (ridesharing) (Naude, Tsolakis et al. 2006).

### 2.2. Accidents

Martin (2005) states that the estimation of accident costs is very complex and raises both conceptual and measurement problems. Common measures of accident costs include the share of total accident costs, the difference between total accident costs and total insurance premiums, costs imposed on non-road users (system costs being the main ones) and costs arising from the disparate vulnerability of road users (Martin 2005, p. 10).

There has been a sustained increase in the number of people killed each year throughout the 1950s until the 1970s when nearly 4000 people were killed in automobile crashes on Australian roads. This led to the introduction of compulsory seat belts in cars and helmets for motor cyclists. In addition, awareness campaigns and road improvements have seen a fall in the deaths through the 1980s to the early 21st Century. By 1999, there was a loss of 1759 lives; however, there were also over 20,000 serious injuries. In 1999, Australian vehicle operators paid motor vehicle insurance premiums of approximately A\$8 billion, yet it has been calculated that the difference between the cost of motor vehicle insurance and the cost of road crashes (including both freight and passenger) to Australia is about A\$7

billion giving a total cost of approximately A\$15 billion in 1999 (Laird, Newman et al. 2001). The estimates provided below give much higher figures for 2003-04.

### **2.3. Environmental Costs**

Major environmental externalities examined include air pollution, noise, and greenhouse gas emissions (GHGs). The OECD (1996) notes that localised noise pollution is generally perceived by society to be the first and foremost problem associated with road traffic. Another localised pollutant of concern in urban areas is air pollution. As a result of the link between health impacts and certain chemical compounds present in air pollution, urban areas experience larger adverse effects, compared to rural areas, where populations are lower (Watkiss 2002).

#### **2.3.1. Air Pollution**

According to the BTRE (2005), the total economic cost of air pollution-related mortality associated with motor vehicles is in the order of A\$1.8 billion in Australia. In addition to health costs imposed on society, air pollution can also contribute to a number of environmental problems. These include smog, degraded visibility, loss of biodiversity, and damage to infrastructure such as discolouration of stone, erosion and the soiling of buildings (WALGA 2006).

The social costs of air pollution are attributed to photochemical smog, decreased visibility, decreased biodiversity and erosion to infrastructure from the pollution. Assigning dollar values to the emissions generated per tonne kilometre of freight transportation is inherently difficult. For example, the amount of emissions associated with a unit of transportation varies with the specific type of train or truck and the conditions under which it is operating. Additionally, the value of damage to human health and other things of value—animals, crop yields, building and structures, and scenic views is bound to be subjective.

Most cost estimates of air pollution have been made for very specific circumstances, usually a particular city with an air quality problem (see, for example, (Small and Kazimi 1995) who studied Los Angeles). Studies focussing on freight movement between cities usually find the unit cost of air pollution to be relatively low since the ambient pollution levels in rural areas are lower than those in the urban areas, where higher cost estimates have been found as well as higher population densities (Forkenbrock 1999).

#### **2.3.2. Noise**

Even in rural areas where fewer people live and work, noise adversely affects people, especially when they need to concentrate, rest, or maintain tranquillity. While the psychological effects of noise are very difficult to value, noise tends to have an adverse impact on residential property values (see Hokanson, Minkoff et al. 1981). It is this impact that has been the basis for dollar costs of truck and rail noise. Because of the generally sparse settlement patterns in rural areas, few housing units are affected by passing trains or highway traffic.

In general, the literature suggests that a given level of noise produced by a freight train is usually perceived as less annoying than noise produced by vehicle traffic on a highway. As reported in Forkenbrock (2001), road traffic noise is considered to have a cost over six times greater than noise from freight rail.

### **2.4. Rural versus Urban Costs**

While the values for climate change costs are considered to be constant in all settings, this is not the case with other social costs such as accidents, air pollution and noise. As a consequence, different values have been proposed for different settings.

**2.4.1. Pollution and Noise Costs**

Pollution and noise costs also vary between rural and urban settings with more densely populated urban settings generally having higher costs. The range of values for pollution costs are shown in tables 2.1 and 2.2.

The figures quoted by Tsolakis, Houghton et al. (2003) have been adjusted to take into account the occupancy rate, population density and purchasing power parity. Therefore, it could be argued that these figures may be more appropriate than the Infrac/IWW figures. However, the Tsolakis report does not include values for rail therefore to compare the two modes is problematic. In addition, the Infrac/IWW report is particularly thorough as it takes into consideration three different types of land use (rural, suburban and urban), two time periods (day and night) and two traffic conditions (relaxed, dense). The physical and traffic parameters include target

**Table 2.1: Range of estimates for pollution costs**

Source	Cost A\$/1000vkm(tkm)		Freight Rail		Pass. road		Freight road Aggregated		LCV		Rigid		Artic	
	Pass. rail		Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Cox (Productivity Commission 2006 sub. 45)							13.8	114.2						
Laird (Submission 23 in Productivity Commission 2006)			2.2	0.4			6.5	1.3						
ATC (2004)			3	3	22	0.1			222	0.9			8.7	0.04
Tsolakis et al. (2005)					21	0.2			100	0			21	1.0
BTE (1999)				0.4				0.1						
Tsolakis & Evans(2007)					23.4	0.2			\$111.2	0			\$23.36	\$1.11

**Table 2.2: Range of estimates for noise costs**

Source	Cost A\$/1000vkm(tkm)		Freight rail		Pass. road		Freight road Aggregated		LCV		Rigid		Artic	
	Pass. rail		Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
BIC (2001)					Aggregate value: 3						Aggregate value: 18		Aggregate value: 50	
Laird (2005)													Aggregate value 80.7	
Cox (Productivity Commission 2006 sub. 45)									Aggregate value 4.2				Aggregate value: 84	
Tsolakis & Evans (2007)					7.8	0			\$25.58	0			\$2.56	\$0.26

noise levels, distance to road/rail, settlement density and inhabitants per kilometre of road/rail. From this, it can be argued the figures produced in the Infrac/IWW report are applicable to Australia despite the lower assumed affected inhabitants in Australia.

The same argument used for noise pollution costs can be made for air pollution costs with the following impacts taken into consideration: impacts on human health, impacts on buildings and materials and impacts on crops and agricultural production. Some of the figures that Tsolakis, Houghton et al. (2003) produce are higher for the Australian context.

**Table 2.1: European air pollution values adjusted for Australia**

Air pollution (human health effects)	Vehicle	A\$/1000 pkm			A\$/1000 vkt		A\$/1000 tkm	
		Car	Motorcycle	Bus	Car	Bus	LDV	HDV
	Average*	13	4	15	17	180	80	16
	Range	4-21	1-7	5-25	7-27	105-255	30-130	8-24
	Unadjusted**	22	12	29	28	345	200	41

Air pollution (building, forest and crop damage)	Vehicle	A\$/1000 pkm			A\$/1000 vkt		A\$/1000 tkm	
		Car	Motorcycle	Bus	Car	Bus	LDV	HDV
	Average <sup>#</sup>	6	2	7	4	90	20	6
	Range	1-10	0.5-3	4-10	1-7	30-150	12-28	4-8
	Unadjusted <sup>###</sup>	4	3	4	5	53	21	7

Notes: .\* Adjusted for vehicle occupancy rate, population density and purchasing power parity.

\*\*Currency and year conversion only. <sup>#</sup> Adjusted for vehicle occupancy rate. <sup>###</sup>Currency and year conversion only.

Range of values indicates one standard deviation +/- from the average (mean) values derived from full data set for EU5 countries analysed in Infrac/IWW.

The unit cost value will depend on the specific metric selected (e.g. pkm, tkm or vkt). This explains the relatively high unit cost for LDVs, which in large numbers undertake significant kilometres in urban areas, while carrying only small average loads.

Source: Tsolakis, Houghton et al. (2003, p. 10).

### Greenhouse Gas Emissions

The overall costs to society from the emissions of greenhouse gases in transport activities have been estimated by various studies. The method of calculating costs of greenhouse gas emissions consists of multiplying the amount of CO<sub>2</sub>-e emitted by a cost factor. The global nature of climate change means that the location of the emissions is irrelevant. A European average of €20 per tonne of CO<sub>2</sub> emitted was used for valuing CO<sub>2</sub> emissions. This value represents a central estimate of the range of values for meeting the Kyoto targets in 2010 in the EU based on an evaluation by Capros and Mantzos (2000). They also report a marginal cost reduction of €5 per tonne of CO<sub>2</sub> emissions avoided to reach the Kyoto targets for the EU, assuming a full trade flexibility scheme involving all regions of the world.

Estimating climate change unit costs is extremely difficult owing to the many assumptions required in the calculation. Two main methods are used to arrive at figures, these are the control cost approach and the damage cost approach. The Infrac/IWW study uses the control cost approach (i.e., different types of expenditures such as mitigation, abatement, replacement, restoration or avoidance costs), whereas another major study by ExternE (1997) uses the damage cost approach (this approach uses techniques such as willingness to pay to estimate costs of damage in monetary terms). One of the benefits of using these studies is that they provide a comprehensive and consistent set of estimates of a broad range of environmental costs. Often, other studies use diverse methodologies making it difficult to compare estimated unit costs and the shadow values vary substantially.

The shadow price in the Infrac/IWW (2004) study of €140/tonne is due to a reduction target of 50% between 1990 and 2030. This high figure is also the result of a strategy that is more inflexible than worldwide emissions trading, because the reductions should be reached within the European transport sector only. This value is used for the transport sector for long-term objectives since this sector is characterised by long-term investments. The Infrac/IWW study also includes a lower value of €20/tonne for short-term targets.

The high value used in the Infrac/IWW study differ substantially from those used in the Productivity Commission's report on Road and Rail Freight Infrastructure Pricing (2006). They quote figures from the following sources:

- Laird (2002) used a rate of A\$25 per tonne of CO<sub>2</sub>-e emissions;
- BIC (2001) assumed A\$40 per tonne;
- ATC(2004 p55) suggested A\$10 per tonne for evaluating transport infrastructure projects — recommending the lower end of previous estimates because 'there are no definitive estimates of the cost of greenhouse gas emissions'; and
- NSW Government noted that the trading price in its Greenhouse Gas Abatement Scheme in April 2006 was approximately A\$15 per tonne (Productivity Commission 2006, p. C.16).

Similar values are used in the Austroads manual on external costs by Tsolakis, Houghton et al. (2003). Despite this, Tsolakis only provides estimates for the road sector. These values are shown in Table 2.4 below. However, for the modelling in this study, the figures produced by Treasury in their 15% reduction scenario are used since this is the target recently announced by the Federal government. This scenario uses an increasing price for carbon that reaches A\$50/tonne by 2020.

**Table 2.4: Climate change estimates damage cost approach**

Climate change	Vehicle	A\$/1000 passenger km			A\$/1000 vkt		A\$/1000 tkm	
		Car	Motorcycle	Bus	Car	Bus	LDV	HDV
	Average*	13	8	8	17	100	42	4
	Range	12-15	7-9	5-11	15-19	ne	39-44	2-7
	Unadjusted**	9	9	6	911	71	87	9

Notes: \* Adjusted for vehicle occupancy rate. \*\* Currency and year conversion only. ne = not estimated.

Source Tsolakis, Houghton et al. (2003, p. 13).

### **3. Road Versus Rail Social Costs**

In general, the major social costs associated with rail are the same as road, i.e., congestion, accidents, and environmental costs. While the types are similar, the magnitude of the costs appears to be one third of the costs associated with road transportation. For example, some studies have shown that the cost of accidents is less, air pollution is less on a tonne kilometre or passenger kilometre basis, while greenhouse gas emissions are, on average, one third the amount for road transportation (Laird 2003). As a result, the lack of systematic social costing for either rail or road favours road since its social costs are larger (Productivity Commission 2006).

#### 4. Transport Social Costs: The Australian Setting

Within Australian, there is currently no charging of social costs for road or rail projects. The current practice is to apply social cost values within a project appraisal process. For example, motorists or rail passenger are not charged for the production of any social costs in their use of that mode (with the partial exception of accident costs). Conversely, when the viability of a project is being assessed, it is becoming common practice to include social costs and decide in favour of the project that maximises the benefits and minimises these social costs.

Current policy decisions take into account both the positive and negative impacts of the policy being examined. The use of unit cost factors of social cost factors, differentiated by transport mode, are the primary piece of information when deciding on policies (Tsolakis, Houghton et al. 2003).

In concurrence with international research within the Australian setting, it is generally agreed that social costs for rail are considerably lower than for road. Despite this, it is not generally accepted that these social costs should be charged to users, hence the seeming reservation of considering rail's lower social costs for project appraisal in the Australian setting. For example, while BTRE (1999) acknowledge that social costs are lower for rail freight than for road freight, they do not accept that these costs should be charged to the users. They argue that it is inappropriate to charge heavy road vehicles or freight trains but not light vehicles or passenger trains. They also argue that social costs are significantly higher in urban settings than non urban settings, whereas the primary competition between road and rail freight exists in non-urban settings and therefore the level of externalities that each mode produces are essentially the same. Hence, there is little point in charging them. However, the Infrast/IWW (2004) study takes into account such factors and, as can be seen from the calculations in this report, the costs are substantial. It is therefore difficult to argue for their omission, even if some of these costs have been internalised to some degree, as argued by the Productivity Commission (2006).

Various figures have been published and these are highly dependent on assumptions of discount rates and the extent of rational choices by adults. For example, the Productivity Commission argues that external accident costs are internalised to some degree by an informed adult understanding the costs and risks of driving a car and hence they have at least partially internalised these costs (Productivity Commission 2006). Others, however, have reached opposing conclusions (Vermeulen, Boon et al. 2004). Despite this, the lack of consistency for social cost values is evident from the summary of values listed by the Productivity Commission (2006), some of which are listed in Table 2.5.

**Table 2.5: Range of externality values from freight transport**

Externality	Estimated external costs	Unit costs (A\$/1000tkm)
<b>ACCIDENTS</b>	\$8.2b–\$17.7b (about 5% estimated due to articulated trucks)	
Road Accidents		\$20.00
Rail accidents		\$30.00
<b>AIR POLLUTION</b>	\$23.8m–\$6.4b+(about 8% due to articulated trucks, 31% to rigid trucks)	
Rail		
Urban		\$2.20
Rural		\$0.40
Road		
Urban		\$6.50
Heavy trucks		\$8.70
Light trucks		\$222.00
Passenger		\$22.00 (vkm)
Rural	\$1.30	
<b>NOISE</b>	\$730m–\$2b (urban only) (about 15.8–49% attributed to trucks).	
Urban light vehicles		\$23.00
Urban heavy vehicles		\$2.30
Rail		\$0.04

Source: Productivity Commission (2006).

#### 4.1. Relevance of European Data

The calculation of social costs for this report is based upon the Infrac/IWW (2004) study. Tsolakis, Houghton et al. (2003) for Austroads also based their results on the Infrac/IWW (2000) and ExternE (1997) studies, despite both of these studies being based on European data. Tsolakis, Houghton et al. felt that studies using American data would be more relevant since American urban and rural settings are better approximations for Australian settings than European ones. However, owing to a lack of consistent methodology among the various American studies, the Infrac/IWW and ExternE studies were chosen. As a result, Tsolakis, Houghton et al. felt that the European data had to be calibrated to Australian conditions. Indeed, a range of adjustment factors were used to reflect Australian conditions, with the adjustment involving such factors as relative wealth and urban density. The inclusion of these adjustment factors led to the range of unit costs shown in Table 2.6. However, these figures are only for the road sector and do not include accident costs. As can be seen when compared to Tables 2.6 and 2.8, these figures are broadly similar to those from the Infrac/IWW study. Since a full range of social costs is not provided by Tsolakis, Houghton et al. (2003) for both road and rail, the Infrac/IWW values have been used with the exception of climate change costs. As mentioned previously, the climate change figure is based on the 15% reduction figures from Treasury modelling since this figure is deemed most likely for an Australian setting (Treasury 2008).

**Table 2.6: Total social costs adjusted for Australia**

Item\Vehicle	A\$/1000 passenger km			A\$/1000 vkt		A\$/1000 tkm	
	Car	Motorcycle	Bus	Car	Bus	LDV	HDV
Calibrated total environmental costs	19	6	22	21	270	100	22
(Climate change costs based on 50% CO <sub>2</sub> )							
Air pollution	5	10	1	7	17	23	3
Noise	47	30	30	60	355	150	16
Climate change	7	4	3	9	31	50	4
Nature and landscape	23	12	12	29	150	140	16
Upstream/downstream cost	4	2	1	5	16	22	2
Urban separation costs	105	65	69	131	839	485	63
Average (calibrated)							
Range	75-133	47.5-81	38.5-99	98-164	ne	340-632	38-89

Item\Vehicle	Car	Motorcycle	Bus	Car	Bus	LDV	HDV
Estimated total environmental costs	19	6	22	21	270	100	22
(Climate change costs based on 8% EU CO <sub>2</sub> emissions reduction target)							
Air pollution	5	10	1	7	17	23	3
Noise	13	8	8	17	100	42	4
Climate change	7	4	3	9	31	50	4
Nature and landscape	8	4	7	10	86	33	6
Upstream/downstream cost	4	2	1	5	16	22	2
Urban separation costs	56	34	42	69	520	270	41
Average (estimated)							
Range	30-81	20-46	19-65	41-96	ne	160-382	23-61

Notes: The calibrated values are based on the Infrac/IWW climate change abatement cost €135 per tonne CO<sub>2</sub> (which is based on a 50% emissions reduction target). The estimated values are based on an EU abatement cost of €38 per tonne CO<sub>2</sub> (which is based on the Kyoto Protocol emissions reductions target of 8%). Air pollution, noise and urban separation costs are mostly relevant to urban areas. Urban separation costs are those costs arising from the fact that a road or a rail track creates a barrier separating individuals and communities in urban settings.  
ne = not estimated.

Source: Tsolakis, Houghton et al. (2003, p. 25).

#### 4.2. Social Costs of Transportation in Australia

By using the values from the Infrac/IWW (2004) study, the following social cost values have been calculated for Australia for the year 2003-2004, as shown in Tables 2.7 to 2.11.

**Table 2.7: Passenger social unit costs (A\$/1000pkm)**

	Road				Rail	Aviation	Overall
	Car	Bus	Motorcycle	Road total			
Accidents	60.26	4.68	367.77	63.18	1.56	0.78	43.49
Noise	10.14	2.54	31.20	9.95	7.61	3.51	8.19
Air pollution	24.77	40.37	7.41	25.74	13.46	4.68	19.50
Climate change high	34.32	16.19	22.82	32.18	12.09	90.09	46.22
Climate change average	19.6	9.26	13.06	18.43	6.92	51.48	26.42
Climate change low	4.88	2.34	3.32	4.68	1.76	12.87	6.63
Nature and landscape	5.66	1.37	4.10	5.07	1.17	1.56	3.90
Up/down stream effects	10.14	7.61	5.85	9.75	6.63	1.95	7.61
Urban effects	3.12	0.78	2.15	2.93	2.54	0.00	2.15
Total (climate change high)	148.40	73.52	441.29	148.79	45.05	102.57	131.04
Total (climate change low)	118.95	59.67	421.79	121.29	34.71	25.35	91.46
Total (accidents, noise, air pollution)	95.16	47.58	406.38	98.87	22.62	8.97	71.18

Note: 2008 Australian prices @ €1 = A\$1.7 and CPI = 1.147 from June 2000 to June 2004.

Source: Infrac/IWW (2004).

**Table 2.8: Passenger transport social costs: Total costs 2003-2004 (A\$ billion 2004)**

	Cars	Buses	Passenger rail total	Individual social cost total
Accidents	15.87	0.08	0.02	15.97
Noise	2.67	0.04	0.09	2.81
Air pollution	6.52	0.67	0.16	7.36
Mode total	25.06	0.79	0.28	26.13
Climate change	1.14	0.03	0.02	1.19
Mode total (including climate change)	26.21	0.82	0.29	27.32

Source: Infrac/IWW (2004) and BTRE (2008).

**Table 2.9: Freight social unit costs (A\$/1000tkm)**

	Road				Rail	Aviation	Water borne	Overall
	LDV	MDV	HDV	Road total				
Accidents	68.25	38.81	9.36	14.82	0.00	0.00	0.00	12.68
Noise	63.18	36.37	9.56	14.43	6.24	17.36	0.00	13.85
Air pollution	169.46	122.07	74.69	83.46	16.19	30.42	27.50	75.08
Climate change high	111.93	68.45	24.96	32.96	6.24	459.62	8.39	32.96
Climate change average	63.96	39.09	14.24	18.82	3.61	262.67	4.78	18.82
Climate change low	15.99	9.75	3.51	4.68	0.98	65.72	1.17	4.68
Nature and landscape	21.26	12.58	3.90	5.66	0.59	7.41	1.56	5.07
Up/down stream effects	43.68	29.06	14.43	17.16	4.68	14.43	6.44	15.60
Urban effects	10.14	6.14	2.15	2.93	0.98	0.00	0.00	2.54
Total (climate change high)	487.89	313.46	139.04	171.41	34.91	529.23	43.88	157.76
Total (climate change low)	391.95	254.77	117.59	143.13	29.64	135.33	36.66	129.48
Total (accidents, air noise, air pollution)	300.89	197.24	93.60	112.71	22.43	47.78	27.50	101.60

Costs @ €1 = A\$1.7 and CPI = 1.147 from June 2000 to June 2004.

Source: Infrac/IWW (2004).

**Table 2.10: Freight social total costs (A\$ billion, 2004 dollars)**

	Road total	Rail total	Individual social cost total
Accidents	2.78	0.00	2.78
Noise	2.70	1.18	3.88
Air pollution	6.52	3.06	17.22
Mode total	19.63	4.24	23.87
Climate change	0.64	0.06	0.70
Mode total (including climate change)	20.27	4.31	24.58

Source: Infrac/IWW (2004), BTRE (2008) and modelling by the authors).

However, these figures do not include congestion costs. From figures provided in the Australian Transport Council's National Guidelines for Transport System Management in Australia (ATC 2006), the following congestion costs have been calculated.

**Table 2.11: Congestion costs (A\$ billion)**

	European values	Aust. congestion costs
	Total cost	Total cost
Freight		
Road	3.47	4.82
Rail	6.96	n/a
Total	10.43	
Passenger		
Car	1.91	7.96
Rail	0.16	n/a
total	2.07	

Source: ATC (2006) and BTRE (2008).

For the Australian transport setting in the year 2003-2004 (the latest year with reliable data) the total social cost in 2004, including climate change costs, from passenger and freight transport was A\$51.9 billion; if congestion costs are included, this figure rises to A\$64.4 billion. These figures represent between 5% and 10% of the Gross Domestic Product (GDP) for Australia and, as a consequence, the importance of these costs cannot be overstated. How these costs would change should a significant modal shift are modelled and discussed in Paper 10.

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