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External costs of inter-capital freight in Australia

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Abstract

The Australian inter-capital freight task is growing quickly, with governments and the community being increasingly concerned with the costs associated with carrying out this task. In order to encourage socially efficient choice between modes, it is important to understand the full social costs of each transport mode. The costs include external costs not faced by freight operators, primarily associated with accidents, pollution, noise, and congestion. This paper provides indicative estimates of the external costs of moving non-bulk freight between capital cities by road and rail. The estimates are derived by adopting existing estimates for each externality based on other studies, and by applying these estimates to specific freight routes between several Australian capital city pairs, taking account of road conditions, vehicle characteristics, and population densities along the routes, to, ultimately, estimate the economic costs of these impacts.

Some parts of this paper have drawn on research undertaken in the Bureau of Infrastructure, Transport and Regional Economics by David Mitchell, Carlo Santangelo and Caroline Pratt.

Introduction

The external cost of any activity is defined as the component of the total social cost of that activity that is not borne by the individual undertaking that activity. Failure to consider external costs can result in distortions in resource allocation. Over recent decades significant research has been undertaken in developing more complete values for external costs attributed to the transport sector. This study draws on literature from both overseas and within Australia in order to estimate indicative costs of externalities associated with inter-capital non-bulk freight transport.

This paper comprises two sections. In the first, generic unit costs of externalities per kilometre, derived from other studies, are estimated for different conditions. In the second, four inter-capital case studies are considered, with the generic unit costs derived in the first section being applied to the different conditions along each route.

The focus is on intercapital freight as this is the market in which there are most possibilities for substitution between road and rail (see BITRE 2009), and so where policies encouraging freight operators to take account of external costs are likely to have the most effect on modal choice. Coastal shipping is not considered[1].

[1] Under present conditions, the only significant inter-capital sea freight is carried on international ships with spare slots available between Australian cities. As these ship journeys would take place regardless of the amount of domestic freight carried, the marginal external cost of sea freight moved in this way is negligible.

Section 1: valuing freight transport externalities

This section provides a discussion of each principal externality associated with inter-capital freight, and attempts to identify appropriate estimates of these external costs, based primarily on international studies. There are inherent difficulties in transferring estimations of valuations of externalities from other countries to Australia, and the resulting estimates come with a high level of uncertainty. This study considers five externalities associated with freight transport:

- Accidents;
- Greenhouse emissions;
- Noxious emissions (including ozone and more local pollutants);
- Noise; and
- Congestion.

Pavement deterioration is not considered an external cost, as heavy vehicle charges are explicitly set such that infrastructure managers recover direct infrastructure costs (see Treasury 2010a).

In this section, external costs from freight movement by B-doubles and trains are derived for different route characteristics, in terms of $/km or cents per net tonne-km (c/ntk). Throughout, each B-double is assumed to carry a net load of 36 tonnes, and each train a net load of 1,262 tonnes on 40 wagons, pulled by three locomotives. B-doubles are assumed to consume 51 L/100km on rural roads and 82L/100km on urban roads (the former number is taken from CRA International's (2006) Sydney-Brisbane case study). Trains are assumed to consume 9.8 litres/km (based on CRA International 2006)[2].

Accidents

External costs of road accidents

A road accident is costly both to those directly involved in the accident and to the rest of society. Costs borne by those directly involved include the costs of fatalities and injuries resulting from the accident, and the costs of damage to vehicles involved in the accident, and to their contents. Costs borne by people not directly involved in the accident may include the costs of: damage to infrastructure; emergency services attending the accident; and delay to other motorists; as well as the costs to the health system, the justice system, and the cost to the victim's family in pain and suffering.

Note that heavy vehicles can impose an external accident cost on other vehicles even where they are not at fault in accidents, because regardless of fault, they can both slightly increase the accident risk of accidents, and significantly increase the costs of accidents.

In general, it is possible for the total external component of the costs of multivehicle accidents to exceed total accident costs. When a driver enters a road, they take the average accident risk on that road into account. If they do not affect the overall accident risk themselves, this is equivalent to fully internalising the expected accident cost. However, any increase in the risk to other drivers will be external to the choice whether to drive on the road. The external cost component, then, is proportional to the marginal accident rate minus the average rate. This will,

[2] According to FRA (2009) each container (assuming one per yard truck) uses 0.094 litres for each intermodal terminal. This is roughly consistent with Canadian National () who suggest that emissions from lifting comprised around two per cent of emissions from the intermodal freight operation. Given the distances involved, the effect of this is negligible compared with the fuel consumption en-route

in general, be positive when accident rates increase with traffic volume (see, for example, Vickrey 1968).

It is unclear whether accident risk grows with traffic volume on Australian inter-capital highways. It is possible that the accident rate is more likely to be proportional to the number of vehicle interactions, rather than the traffic volume *per se*. Following this reasoning, for this study it was assumed that on divided roads the accident rate is almost constant with traffic volume (with the only external accident cost arising from overtaking), and on undivided roads the accident rate increases significantly with traffic volume, due to the number of cars passing in opposite directions.

In accidents between heavy and light vehicles, there is likely to be an additional component to the external cost, because the cost to each heavy vehicle operator is usually less than the costs to the occupants of the other vehicle involved.[3] To some extent, compulsory third party insurance internalises some of the cost of accidents. However, it does not completely internalise the cost: both because premiums do not vary with kilometres travelled, and because heavy vehicles are only found at fault in a minority of such crashes.

Estimated costs used in this study

For a given segment of road, the external accident cost of a kilometre of truck travel is estimated as $\epsilon\{r_f c_f + r_i c_i + r_a cu_a\} + (1+\epsilon)\, r_a cn_a - I$, where:

- r_f, r_i and r_a are the fatality, injury and accident rates respectively, per heavy vehicle kilometre. For each local government area a road passes through, the probability of each accident type is taken to be the average accident rate on the road in that local government area between 1997 and 2004. Accident rates have been provided by state road authorities.
- c_f = \$2.4 million; c_i = \$214,000; cu_a = \$4,441.6; cn_a = \$3,713 are, respectively the costs of fatalities, the costs of injuries, the other costs per accident to those involved in the accident, and the other costs per accident of those not involved in the accident. These costs are taken to be as in BITRE (2010) (a proper discussion of the value of life is beyond the scope of this paper, but the value of life used may be considered a lower estimate)
- ϵ is the elasticity of heavy vehicle accidents with respect to heavy vehicle traffic. This is estimated as: 0.47 for freeways and divided highways; 0.65 for undivided rural highways; and 1.62 for urban arterial roads. These estimates are based on the number of accidents of different types on Victorian highways.
- The factor of 0.8 reflects the proportion of accidents costs in accidents between heavy and light vehicles that tend to be borne by the light vehicle.
- I is the third party insurance paid per kilometre. This is assumed to be 0.5 cents per kilometre.

Using this methodology, the external accident cost of heavy vehicle use ranges from less than zero[4] to \$1.13/km (around 3.1 c/ntk).

[3] In accidents between heavy and light vehicles on inter-capital highways in Victoria between 1996 and 2005, 97 per cent of fatalities, 86 per cent of serious injuries and 85 per cent of minor injuries were incurred by occupants of the light vehicle.

[4] As insurance costs per kilometre are effectively fixed, there are some low-risk segments of road where net external costs are negative.

External accident costs of interstate rail freight

Most fatalities resulting from interstate rail freight are of railway workers, the costs of which will ultimately be internalised by the rail operators through having to pay a wage premium to compensate for the risk. In cases where external parties are killed or injured, the rail operator is typically not at fault. However, because the accident would not have taken place were it not for the presence of the rail operation, and the cost is not internalised to the rail company, the costs of such accidents are external.

For this study, it is assumed that intercapital freight contributes to vehicle/train but not pedestrian/train level crossing fatalities. ATSB (2009 and 2003b) suggests that across the Australian rail network, there was an average of 0.063 fatalities in train/road vehicle level crossing accidents per million train kilometre in 2001. According to BTRE (2002), of all people killed or injured in level crossing accidents in 1999, 59% were killed. The trend from ATSB (2001) suggests the level crossing vehicle accident rate per train kilometre fell at an average annual rate of 7.2 per cent per year between 2001-02 and 2008-09. Consistent with these facts, this study assumes a rate of 0.0038 fatalities and 0.0026 injuries per million train kilometre. Using the fatality and injury costs from BITRE (2010), this translates to $0.96 per train kilometre (around 0.09 c/ntk).

Greenhouse gas emissions

Greenhouse gases emitted in significant quantity from freight transport include CO_2 (carbon dioxide), H_2O (water vapour), CH_4 (methane), N_2O (nitrous oxide), SF_6 (sulfur hexaflouride) and O_3 (ozone). In quantifying the effects of greenhouse gases, it is appropriate to use CO2-equivalent units, defined as the quantity of any greenhouse gas that has the same global warming potential as one tonne of CO2. Burning one litre of diesel fuel emits 2.67 kilograms of CO_2-equivalent.

While estimating the volume of greenhouse emissions from transport is relatively straightforward, estimating the cost of emissions is not. There is uncertainty about the extent to which greenhouse emissions contribute to climate change, and the costs of climate change. Emissions in the present will have a continued effect on climate, the magnitude of which will itself depend on future climate (Stern 2007). However, there is an expectation that there will, in the medium term, be global action to avoid the worst costs of climate change. Under mitigation, emitting an extra tonne of greenhouse gas will force somebody else to emit a tonne less, so the cost of greenhouse emissions can be assumed to be at least equal to the anticipated world emissions price. Treasury (2010) forecast that the cost of emissions, were Australia to commence emissions trading in 2012-13, would be $26/tonne of CO2 equivalent emissions. Combining this cost estimate with the fuel consumption assumptions above, the external cost of greenhouse emissions from B-doubles assumed for this study are $0.035/km (around 0.10 c/ntk) on rural roads and $0.057/km (around 0.16 c/ntk) on urban roads. The estimated external greenhouse cost of freight trains is $0.63 /km (around 0.05 c/ntk).

Noxious emissions

According to BTRE (2005), in Australia in 2000, motor vehicle-related ambient air pollution accounted for between 900 and 4,500 morbidity cases and 900 to 2,000 early deaths. Local air pollution can also cause costly damage to eco-systems and to buildings, but these effects are likely to be negligible compared with the health associated costs[5]. Similarly, it can be assumed

[5] Watkiss assumes that there are no cases in Australia where critical ecosystem thresholds would be crossed, so the cost due to ecosystem damage is close to zero.

that the cost of property damage from emissions is negligible compared with the health cost (Watkiss 2002).

There is evidence that the concentration of pollutants inside vehicles is greatly dependent on the exhausts of other vehicles to the front, and is significantly higher than it is next to a road. Given that emissions from heavy vehicles are higher than from average road users, heavy vehicles can impose a net external cost on other road users. However, given the relatively low traffic densities on the roads considered in this study, this effect is assumed to be neglible here.

Table 2.2 lists the noxious pollutants considered in this study, and their primary consequences. Noxious pollutants caused by transport fall into two categories: those that are harmful immediately following emission, and those that are precursors to other harmful pollutants. Because the former are harmful closer to the emission source, they are termed 'conservative pollutants', while the latter are often termed 'secondary pollutants'. In most areas, these secondary pollutants will be dispersed over so large an area that the increase in concentration in any place (including near the emission source) is negligible. However, they can be an issue in large cities where, depending on meteorology, pollutants can accumulate to high levels (Watkiss 2002).

Estimating the costs of noxious emissions

The cost of emissions depends on: the average fuel intensity of the vehicle fleet; the emissions per unit of fuel use for each pollutant; the dispersion pattern for each pollutant; the health effects on an individual exposed to a given concentration of that pollutant (the ‘dose-response’ function); the cost of each health outcome; and the number of people exposed to each concentration level.

For conservative pollutants, such as particulate matter, the cost will depend primarily on the population density within a few hundred metres of the emission point. For secondary pollutants, the cost will depend more on the average population density in the entire metropolitan area. Based on European data, Watkiss (2002) estimated the relationship between emission costs and population density. The values used in this study are derived from Watkiss, adjusted for differences in valuations of health effects and assumed dose-response functions (overall, the costs per emission here are 0.86 times those presented in Watkiss), and applied to suburb-level population densities along the routes considered. For this study:

- Estimates of fuel consumption are as assumed in section two below;
- Emissions per unit fuel are based on BTRE (2003);
- Emissions patterns are based, implicitly, on Watkiss;
- Dose-response functions are based on BTRE (2005) and Watkiss (2002);
- Estimates of the population exposed to each concentration level (encapsulating the assumed dispersion pattern) are based on Watkiss (2002), and on suburb-level population densities.
- For each health outcome, the assumed cost is consistent with BTRE (2010).

Unit costs used in this study are shown in Table 1, and the overall costs are summarised in Table 2.

Table 1 Unit values used in this study for localpolllutants

Pollutant	*Primary effects*	*Local costs*	*Secondary costs*	*B-double, urban arterial roads*	*B-double, freeway and highway*	*120 NR class locomotive*
		\$/tonne per persons/km²	*\$/tonne in large urban centres*	*grams/km*	*grams/km*	*grams/km*
Carbon monoxide (CO)	Congestive heart failure	0.00	0	9.34	5.94	86.46
Sulphur dioxide (SO2)	(possibly a surrogate for particles)	3.02	1,512	0.23	0.21	3.14
Particulate matter (PM10)	Respiratory and cardiovascular problems	107.10	0	0.84	0.57	8.31
Benzene (C_6H_6)	Carcinogen	0.76	0	40.04	24.91	370.65
1,3-butedeine (C_4H_6)	Carcinogen	28.44	0	5.16	3.21	47.77
Nitrous oxides (NOx)	Respiratory problems (via ozone)	0.00	1,509	17.23	13.90	202.52
(Non-methane) volatile organic compounds (VOCS)	Respiratory problems (via ozone)	0	754	0.86	0.76	11.00

Source Watkiss (2002), BTRE (2003, 2005 and 2006) and fuel intensity assumptions in section 2

Table 2 External costs per vehicle kilometre used in this study, \$/km

	Local costs	*Secondary costs*
	\$/km per persons/km²	*\$/km in capital cities*
B-double - freeway	0.000052	0.018
B-double - urban road	0.000068	0.020
120 NR Class Locomotive	0.000899	0.315

With varying population densities, the estimates of local pollution external costs range from zero to \$0.33/km (around 0.93 c/ntk) for articulated trucks and from zero to \$2.89/km (around 0.33 c/ntk) for trains. Note that because of the rate of technological development in this area and turnover of the vehicle fleet, estimates of average emission rates are likely to become outdated relatively quickly.

Noise and vibration

Noise from freight can reduce the general amenity of areas near transport links in a number of ways. A common approach to estimating the cost of noise is the 'hedonic' pricing approach, in which noise costs are estimated based on the relationship between land value and noise exposure, controlling for other factors. The cost of noise per decibel per affected property can be quantified in a ‘noise depreciation index’: the proportional decrease in a property’s value due to an additional decibel-amp (dBA) of noise above some threshold. Calculating the total (or marginal) cost of noise in this way requires information about property values and noise levels near the noise source.

Delucchi and Hsu (1998) estimated a relationship between noise depreciation index and marginal noise costs per heavy vehicle kilometre for the United States; and ATC (2004), following Austroads (2003), suggest that a typical noise depreciation index used in Australia is 0.5 per cent per dBA, a value also recommended by OECD (1990). Combining this noise depreciation index with Delucchi and Hsu’s estimates of the relationship between noise depreciation index and noise costs per heavy vehicle kilometre suggest the noise costs of heavy vehicles are \$0.015 on principle arterial roads and \$0.022 on minor arterial roads. There has been little research undertaken into the external costs of noise generated by rail freight. BTE (1999) assumed that locomotives and wagons emitted the same amount of noise as trucks.

For this study, the external cost of noise is assumed to be $0.02 per heavy vehicle kilometre (around 0.06 c/ntk) on arterial roads adjacent to residential areas and $0.01 per heavy vehicle kilometre (around 0.03 c/ntk) on freeways within 200 metres of residential areas. This is broadly consistent with Delucchi and Hsu (1998) and ATC (2004). For rail freight, it has been assumed that in areas where there is residential development within 200 metres of a rail line, each locomotive and wagon creates an external cost of $0.01 per kilometre (around 0.03 c/ntk)

Congestion

Congestion from road freight

The marginal external cost of congestion is primarily the cost of the additional travel time imposed on all other road users by the marginal road user (congestion can also have non-time associated costs, such as through in increased fuel costs and stress levels—however these are likely to be small compared with the time-related costs). Estimating the external congestion cost on a given road requires knowledge of traffic volumes on the road, and estimates of the relationship between traffic volumes and traffic speeds, and of the value of time of those who have been delayed.

Empirical studies suggest that the average travel time on a road grows at an increasing rate as traffic volumes increase, meaning that for an additional vehicle, the marginal delay on all other vehicles exceeds the average delay, which is the expected delay faced by the incoming vehicle. The external congestion impact on other road users from road freight vehicles is equal to the marginal delay on all other vehicles times the value of those users' travel time. For this study, the marginal delay from an additional passenger car unit has been estimated using the speed-flow relationship described by Akçelik (1991).

To reflect the different contributions to congestion from different vehicle types, different vehicles can be weighted by passenger car equivalents. On a required road-space basis, the United States Department of Transportation (2004) suggests that a B-double sized truck is equivalent to between 2.6 and 3.4 passenger cars on uncongested freeways, and between 2.2 and 2.7 passenger cars on major arterial roads. This study has used a value within their ranges, assuming a B-double is equivalent to 2.6 passenger cars.

There is no generally accepted methodology to valuing the time lost due to congestion. A common assumption is that an individual's valuation of time at the margin is equal to their post-tax income at the margin, and that the appropriate cost of business travel time must be at least equal to the traveller's pre-tax income. This study assumes a value of time of $32 per hour, consistent with the value of time of private vehicle occupants assumed by BITRE (2010).

For this study, traffic volumes on roads within metropolitan areas of capital cities at different times of day have been obtained from state road agencies. Where the proportion of traffic that is heavy vehicles is unknown, it has been estimated based on similar roads. In the absence of other data, freight movements have been assumed to be evenly distributed throughout the 24 hour period. On the road segments considered in this study, the marginal external cost of congestion ranges from zero to $8.2 per kilometre (around 23 c/ntk).

Congestion from rail freight

Train movements can impose congestion both on rail passengers in metropolitan areas and on car users at level crossings.

In and around Sydney, interstate rail freight shares tracks with suburban passenger rail. However, freight trains can only enter the shared track during hours when passenger services are relatively infrequent, and passenger trains are given priority at all times. In Adelaide the interstate line crosses the passenger network in at least two places, but passenger trains are given priority. Thus in both Sydney and Adelaide it can be assumed that in the absence of unforseen incidents, interstate freight trains do not impose an external cost on the passenger network.

The only metropolitan area with level crossings between the interstate rail line and major arterial roads is Adelaide, which has six such crossings. The amount of time vehicles are restricted from level crossings is around 1.5 times the time it takes for the train to cross the road. For this study it has been assumed that all vehicles reaching the crossing while the crossing is closed are delayed until the crossing is reopened. While there are a large number of level crossings in regional areas, low traffic volumes mean the delay will be minimal. This study has assumed that delays at level crossings in Adelaide depends on traffic volumes, and in regional areas are zero.

Summary of unit cost estimates

Table 3 shows the range of unit external costs used in this study, when applied to the case studies (described below), along with the location where the maximum external cost is reached (average external costs across the routes are shown in Table 11, after discussion of the route characteristics). The external costs associated with greenhouse emissions vary only with the different fuel consumption in urban and rural area. The costs of all other externalities are more variable, being zero on some segments and significantly positive on others. The external cost with the biggest range is congestion, which is zero across most inter-capital road segments, but on busy road segments can be an order of magnitude higher than other external costs.

Table 3 Unit external costs used in this study, cents per net tonne km

	Road			*Rail*		
	Min	*Max*	*Location of maximum*	*Min*	*Max*	*Location of maximum*
Accidents	-0.0139	3.1389	Warrego Hwy, Esk LGA, Qld	0.0761	0.0761	-
Greenhouse	0.0984	0.1581	Urban areas	0.0539	0.0539	-
Noxious emissions	0.0000	0.9276	Woolloomoolloo (Syd-Bris)	0.0000	0.3313	North Strathfield , NSW
Noise	0.0000	0.0556	Areas within 200m of housing	0.0000	0.0341	Areas within 200m of housing
Congestion	0.0000	22.8148	Pacific Highway, Brisbane	0.0000	3.23	Adelaide

Section 2: Inter-capital freight externality case studies

In this section the external cost of freight transport for four case studies of inter-capital freight movements are presented: Sydney-Melbourne; Sydney-Brisbane; Melbourne-Brisbane; and Melbourne-Perth. For each corridor studied, representative origins and destinations were chosen based on statistical divisional districts which account for more than ten per cent of freight origins or destinations in a metropolitan areas, based on the ABS Freight Movement Survey. Within each of these statistical divisional districts, a representative origin or destination was chosen based on concentration of logistics activities. Road terminals were assumed to be in: Smithfield and St Peters in Sydney; Laverton, Somerton and Port Melbourne in Melbourne; Eagle Farm and Acacia Ridge in Queensland; and Kewdale in Perth.

For all modes, only the freight journeys between terminals or warehouses are considered. In reality, freight travelling by all three modes will involve additional collection or distribution by road within metropolitan areas . These activities are not considered in this paper. Because of the types of road origins and destinations chosen, it seem reasonable to suppose that the inter-city road trips considered here will also necessitate additional collection and distribution. Furthermore, because road is usually the only feasible option for such movements, there is little scope for competition between road and rail for this part of the freight movement, and policies influencing inter-capital mode choice are unlikely to have the same impact on urban collection and distribution mode choice.

Sydney–Melbourne route characteristics

The road route between Sydney and Melbourne is assumed to follow the Hume Highway for the enitre route. The only town of more than 10,000 people the route passes through is Albury (which is internally bypassed). Table 4 shows characteristics of the Sydney-Melbourne road route.

Table 4 Characteristics of the Sydney-Melbourne road routes

	Sydney		Sydney - Melbourne	Melbourne		
	Smithfield	St Peters		Somerton	Laverton	Port Melbourne
Distance	40	58	786	8	43	50
Single carriageway	11	4	20	8	3	2
Through suburbs of more than 2,000 persons/km^2	3	9	0	8	0	7
Within 200m of housing	5	23	0	0	14	22
Directly adjacent to housing	0	0	0	0	0	0

Source: ABS census data.

The rail line between Chullora in Sydney and Dynon in Melbourne passes through suburban Sydney for 26 km, suburban Melbourne for 34 km, and passes through 6 towns with population greater than 10,000: Bowral, Goulburn, Wagga Wagga, Albury-Wodonga, Wangaratta and Benalla. Altogether approximately 102 km of the route is through urban areas. Table 5 shows characteristics of the rail route between Melbourne and Sydney.

Table 5 Characteristics of the Sydney-Melbourne rail route

	Sydney	Sydney-Melbourne	Melbourne	Total
Distance	26	900	34	960
Through suburbs of more than 2,000 persons/km^2	7	0	0	7
Within 200m of housing	19	42	18	79

Source: ABS census data.

Sydney-Brisbane route characteristics

The limits of the urban areas of Sydney and Brisbane are taken to be the beginning of the Sydney-Newcastle Freeway in Wahroonga and the interchange of the Pacific Highway and Logan Motorway in Beenleigh. The route passes through three urban centres of more than 10,000: Maitland, Coffs Harbour, and Grafton. Table 6 shows characteristics of the road route.

Table 6 Characteristics of the Sydney-Brisbane road routes

	Sydney		Sydney - Brisbane	Brisbane	
	Smithfield	St Peters		Acacia Ridge	Eagle Farm
Distance	40	48	858	7	46
Single carriageway			558	0	0
Through suburbs of more than 2,000 persons/km^2	18	18	0	8	10
Within 200m of housing	9	9	37	6	0
Directly adjacent to housing	0	0	12	0	0

Source: ABS census data.

The rail line passes through nine urban centres of more than 10,000 people: Woy Woy, Gosford, Wyong, Newcastle, Maitland, Taree, Coffs Harbour, Grafton and Casino. Table 7 shows characteristics of the rail line between Acacia Ridge in Brisbane and Chullora in Sydney.

Table 7 Characteristics of the Sydney-Brisbane rail route

	Sydney	Sydney-Brisbane	Brisbane	Total
Distance	36	927	15	978
Through suburbs of more than 2,000 persons/km^2	13	0	0	13
Within 200m of housing	33	72	10	115

Source: ABS census data.

Melbourne-Brisbane route characteristics

Road freight between Melbourne and Brisbane is assumed to follow the Hume, Goulburn Valley, and Newell Highways. From Goodna, trucks are assumed to travel along the Logan Motorway and the Gateway Motorway. Between Sydney and Brisbane, the route passes through four towns of more than 10,000 people: Shepparton, Parkes, Dubbo, and Toowoomba. Between Toowoomba in Queensland and Arcadia in Victoria, the road is a single carriageway. Table 8 shows characteristics of the inter-city component of the road between Brisbane and Melbourne.

Table 8 Characteristics of the Melbourne-Brisbane road routes

	Melbourne			Melbourne-Brisbane	Brisbane	
	Somerton	Laverton	Port Melbourne		Acacia Ridge	Eagle Farm
Distance	8	43	50	1,.625	12	43
Single carriageway	0	3	2	1,370	1	0
Through suburbs of more than 2,000 persons/km^2	0	0	7		0	0
Freeway within 200m of housing	0	14	22	26	3	10
Arterial road adjacent to housing	0	0	0	18	1	0

Source: ABS census data.

The line-haul component of the Melbourne-Brisbane rail route is the concatenation of the Melbourne-Sydney and Sydney-Brisbane rail routes.

Melbourne–Perth freight route characteristics

The road route is assumed to follow the Western, Dukes, Eyre, Coolgardie-Esperance and Great Eastern highways. For the principal scenario, the route into and out of Melbourne is assumed to follow the Princes Freeway, the Western Ring Road and the Western Highway, and the route into and out of Perth is assumed to follow the Roe Highway. The route through Adelaide is assumed to follow the Adelaide-Crafers Highway, Portrush Road, Ascot Avenue, Hampstead Road, Grand Junction Road and Port Wakefield Road. The road corridor passes through a large number of small regional centres, and bypasses or skirts a small number of large centres. These include Ballarat (bypassed), Ararat, Horsham in Victoria, Bordertown (bypassed), Keith, Tailem Bend, Murray Bridge (bypassed), Port Augusta, Ceduna in South Australia and Coolgardie, Merredin, and Northam (bypassed) in Western Australia. Table 9 shows relevant characteristics of the Melbourne-Perth road routes.

Table 9 Characteristics of the Melbourne-Perth road routes

	Melbourne			Melbourne-Adelaide	Adelaide	Adelaide-Perth	Perth
	Somerton	Laverton	Port Melbourne				
Distance	31	22	36	698	33	2657	21
Single carriageway	0	0	0	509	0	2564	0
Through suburbs of more than 2,000 persons/km^2	0	0	0	8	4	0	0
Within 200m of housing		0		6	17	4	8
Arterial road adjacent to housing	0	0	0	6	17	4	1

Source: ABS census data

The rail route passes through Adelaide and through five towns of more than 10,000 people: Geelong, Horsham, Murray Bridge, Port Augusta and Kalgoorlie. Table 10 shows characteristics of the Melbourne-Perth rail route.

Table 10 Characteristics of the Melbourne-Perth rail route

	Melbourne	Melbourne-Adelaide	Adelaide	Adelaide-Perth	Perth	Total
Distance	31	761	44	2,635	21	3,513
Through suburbs of more than 2,000 persons/km^2	0	0	0	0	0	0
Within 200m of housing	14	7	27	7	7	72

Source: ABS census data.

The rail route also cross three major (Austroads class 6 or 7) roads at level in Adelaide. Based on traffic volumes on these roads, it is estimated that each train causes a total of around 5 hours of delay to road users.

Summary

Table 11 summarises the external costs of road and rail freight for each corridor considered in this study. Note that for each city pair, the costs are taken as an average across the assumed origins and destination terminal locations. (Table 3, above, shows the range of external costs of each type for road and rail).

Table 11 Summary of external costs: cents per net tonne kilometre

	Sydney-Melbourne		Sydney-Brisbane		Melbourne-Brisbane		Melbourne-Perth	
	Road	Rail	Road	Rail	Road	Rail	Road	Rail
Accidents	0.06	0.08	0.26	0.08	0.21	0.08	0.12	0.08
Greenhouse emissions	0.1040	0.0539	0.09	0.0539	0.10	0.0539	0.10	0.0539
Noxious emissions	0.0180	0.0103	0.0176	0.0052	0.0049	0.0076	0.0032	0.0031
Noise	0.0008	0.003	0.0011	0.004	0.001	0.003	0.002	0.001
Congestion	0.0221	0.0000	0.0136	0.0000	0.0113	0.0000	0.0047	0.0036

For road freight, accidents are the most significant external cost of road freight on most corridors, followed by greenhouse emissions, noxious emissions, and congestion. A significant exception is the Sydney-Melbourne corridor, where external accidents are relatively low due to the relatively safe road between the cities. The results also suggest that inter-capital road freight has much lower external costs than much other road freight would. For example, the average estimated external accident cost here is lower than would be similar estimates of average external accident costs from all road freight. This is due to the intercapital routes being relatively safe roads. Similarly, the external costs of congestion and noxious pollution—largely urban phenomena—are likely to be lower on inter-capital routes than the national average. This is due not only to the intrinsically non-urban nature of intercapital routes, but also because the urban areas along the routes are often bypassed. Indeed, as can be seen in Table 3, where these routes do pass through urban areas, the external costs of congestion can be orders of magnitude higher than the average across the route.

For rail freight, greenhouse costs are an order of magnitude higher than any other cost. The results also suggest that, on these corridors, rail freight imposes less of all types of most external costs than road freight does. An exception is noise costs, which are higher for rail than for road on all but the Melbourne-Perth corridor, despite the actual noise per unit of freight being assumed to be lower for rail than for road. This occurs because, while many inter-capital highways now bypass major towns and suburbs, railways still pass relatively close to residential areas. For a similar reason, noxious emissions costs are higher from rail than from road on one corridor, due to rail routes passing through relatively dense suburbs in Melbourne and Adelaide.

Overall, the results suggest that road freight is slightly under-priced relative to rail freight, compared to a situation where external costs were taken into account. The policy implications of this finding are not immediate. As suggested by Treasury (2010), there is not always a case for dealing with transport externalites directly through pricing. The potential mode shift impacts of internalising these externalities are also unclear, as price is only one factor determining mode choice for freight customers.

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