Deloitte.

Queensland Department of Transport and Main Roads

Cross River Rail Economic Evaluation Final Report

28 April 2011

Contents

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1 Executive Summary

1.1 Introduction

The Queensland Department of Transport and Main Roads (DTMR) engaged Deloitte to undertake a detailed economic evaluation of the Brisbane Cross River Rail project. For this project, Deloitte has supplemented its core skills of economic appraisal of public transport projects with leading experts in the fields of wider economic impacts by engaging Steer Davies Gleave and regional economic modelling through EconSearch.

The economic evaluation includes detailed information and analysis on the expected social, economic and environmental impacts of the project. This encompasses the estimation of the transport costs and benefits of the project utilising cost benefit analysis techniques, as well as the inclusion of the wider economic impacts of the project and their effect on labour markets and productivity. The analysis also includes an assessment of the project's impact on the regional economy.

A draft economic evaluation report was submitted with the preliminary Business Case to the Queensland Government and Infrastructure Australia in December 2010. This resulted in a series of comments on the economic evaluation which have been discussed and addressed in the current report. This final economic evaluation report also reflects changes made to the analysis as a result of a peer review process undertaken by AECOM in late 2010.

1.2 Background

According to the Queensland Government's South East Queensland Regional Plan, the population of the region is planned to increase from 2.9 million currently to 4.3 million by 2026. In order to accommodate this growth, a series of activity nodes are planned, with Brisbane being the largest and the most highly concentrated. These locations will focus employment activities with higher densification of land use and which are primarily serviced by public transport modes.

A key challenge for rail is to provide the capacity to adequately serve these locations and, in particular, the Brisbane CBD which is not only the primary employment location, but is also the focus of the rail network through which most passenger services operate.

The pre-feasibility phase of the Cross River Rail project began in 2007 and was completed in October 2008, when the outcomes of the Inner City Rail Capacity Study (ICRCS) were released. The ICRCS identified and assessed a number of options to accommodate increased rail services into and through the inner city area as well as identifying a number of specific constraints which limit the ability of the rail network to handle more trains in the central area as follows:

- Line capacity on the two track Merivale Bridge section
- Line capacity generated by multiple tracks merging onto single tracks at Park Road and Milton
- Operational issues which impact on capacity such as crew changes at Bowen Hills and the need for trains terminating at Roma Street and Bowen Hills to reach Mayne Yard for stabling
- Problems at inner city stations, particularly Central, Fortitude Valley and Bowen Hills, in dealing with large volumes of passengers at peak times and the impact on train dwell times

- Congestion at locations such as Park Road, Eagle Junction and Northgate, caused by high numbers of services and exacerbated by a mixture of different service patterns (stopping, express, interurban and freight).

The current Cross River Rail study takes forward the concepts developed which target the 2016 capacity requirements. Based on detailed engineering and operational analysis a Reference Project design has been developed which includes:

- 9.8 km 2 track tunnel between Yeerongpilly train station and Victoria Park including 4 new underground stations at lower Albert Street, Roma Street, Woolloongabba and Boggo Road Urban Village
- 5 km of 2 additional surface tracks from the southern portal at Yeerongpilly to south of Salisbury (includes additional freight track) as well as a new station at Yeerongpilly
- 2.7 km of 2 additional surface tracks on the Exhibition loop from the northern portal at Victoria Park to Breakfast Creek including a new surface station at RNA/ Exhibition.

The project seeks to address the lack of rail capacity through Brisbane's CBD from 2016 by providing significant extra capacity which will benefit not only services accessing the city centre but will enable much greater utilisation of the rail network across the whole of South East Queensland. The project will also make a significant contribution to the future development of Brisbane's CBD by facilitating continued growth in employment as well as supporting higher density development along key public transport corridors. A number of additional options were also assessed including:

- An Alternative Option was assessed which is a lower cost option that seeks to improve inner city rail capacity by alleviating pressure on key network choke points including the Merivale Junction, the Roma Street to Exhibition section of the network as well the Exhibition Loop
- A Staged Option which involved the phased implementation of the project between 2015 and 2030.

1.3 Without project case

The economic evaluation includes an assessment of the Cross River Rail project against a without project scenario. The specification of the without project case is especially important in estimating project benefits, which are calculated in net terms (i.e. project case minus without project case).

The specification of the without project case was largely dictated by the assumptions utilised in the SKM – Aurecon JV demand modelling. Rail service plans have been developed to reflect increasing demand for rail over time. The rail service plan in the without project case shows peak period capacity is reached by 2016 after which growth is limited and additional demand has to be met by other modes.

The future without project case bus service assumptions are based on advice from TransLink. Future bus services are consistent with the bus strategy described in the Connecting SEQ 2031, consisting of high frequency priority trunk network services with suburban feeder services to major bus and rail interchange facilities.

The future without project case road network assumptions are based on advice from the DTMR and is consistent with the assumptions used in the draft Connecting SEQ 2031 as well as the SEQ Infrastructure Plan and Program.

1.4 Project costs

The direct costs of the project have been provided by the project team cost estimator, Turner & Townsend. The total infrastructure cost is estimated to be $5.2 billion (excluding risk) in 2010 prices. An allowance for project risk and escalation has been also been included which gives a total capital cost of $8.4 billion. The construction period is assumed to be incurred between 2014 and 2019.

In addition to the direct project costs, the indirect costs of additional rolling stock purchase is included as the Cross River Rail project enables increased utilisation of the wider rail network facilitating additional project benefits. Turner & Townsend has estimated that the estimated cost of new rolling stock is $1.2 billion based on estimates of fleet requirements from Systemwide. Including escalation the cost of purchasing new rolling stock is $1.9 billion. These costs are incurred between 2018 and 2033 as the increase in patronage requires additional rail services.

A number of adjustments have been made to the project costs in order to convert outturn estimates to economic costs for application in the economic evaluation. These adjustments include:

- Adjustment of escalation estimates to remove the general increase in prices and reflect only real escalation increases over time
- Inclusion of surplus land resale receipts upon completion of the construction phase
- Removal of contractor profit, as this is considered a transfer payment between the government and the private sector and does not reflect a resource cost
- Exclusion of nominal escalation for additional rolling stock
- Inclusion of capital costs for the North West Transit Corridor Rail Tunnel by 2031 as this project was assumed to be in the rail network from 2031 in the demand modelling analysis and therefore contributes to project benefits.

Based on the above adjustments, the economic capital cost for the project is estimated to be $8.9 billion (undiscounted) and $4.9 billion (discounted).

The whole of life costs of Cross River Rail have been estimated by Turner & Townsend for the 30 year evaluation period. This includes operation and maintenance costs for infrastructure (track, signalling, power supply and communications systems), stations, rolling stock, periodic asset replacement and fixed overheads. Based on the Turner & Townsend estimates the total undiscounted whole of life costs for the 30 year evaluation period is estimated to be $4.2 billion. The equivalent discounted present value is $705 million.

1.5 Project benefits

The impacts of Cross River Rail can be divided into four broad categories including:

- Transport system impacts – these include changes in the cost of travel for public transport users and private vehicle users as a result of the project
- Freight market impacts – these incorporate the effect of transferring more freight from road to rail as a result of increased rail capacity
- Wider economic impacts – these incorporate additional macro economic impacts as a result of changes in the labour and capital markets which cause changes in productivity which is not captured in the transport system benefits
- City shaping/ urban development benefits – these benefits include savings in urban infrastructure provision as a result of higher density development rather than green field low density development.

1.6 Economic evaluation results

The Cross River Rail project option was compared with the without project case using a discounted cash flow technique on the basis of a real discount rate of 7% in accordance with ATC and Infrastructure Australia investment appraisal guidelines. Project capital expenditure is assumed to take effect from 2012 and all values are expressed in 2010 dollars. The benefits of the project were assessed over a 30 year evaluation period beginning in 2021 and ending in 2050.

Table 1-1 summarises the results of the economic evaluation for the Reference Project. The economic evaluation results show that Cross River Rail Reference Project produces a positive economic return with a NPV of $2.3 billion and a BCR of 1.42. The largest component of benefit is perceived benefits to public transport users (time savings and improved amenity from reduced train and bus crowding) which accounts for 39% of benefits. The next largest component is travel time and cost savings to private transport users who gain from the reduction in road congestion leading to higher vehicle speeds and reduced operating costs.

In addition to passenger related travel benefits, Cross River Rail also results in benefits to rail freight as a result of providing dedicated rail freight paths to the port as well as to Acacia Ridge. This allows more intermodal freight to be transported by rail rather than by road in the with project case which results in operating cost, externality, crash cost and road decongestion benefits.

Table 1-1: Economic Evaluation Results ($ million) – Reference Project

Incremental to base case	$2010 million	Percentage
Project Costs (present value)		
Infrastructure capital costs	4,463	79%
Rolling stock	450	8%
Whole of life costs	705	13%
Total Project Costs	**5,617**	**100%**
Project Benefits (present value)		
Perceived public transport benefits	3,094	39%
Perceived highway benefits	1,942	24%
Rail reliability benefits	688	9%
Perceived road freight benefits	363	5%
Incremental fare revenue	355	4%
Change in toll revenue	-10	0%
Vehicle operating resource cost correction	172	2%
Externality cost reductions	172	2%
Crash cost reductions	89	1%
Rail freight benefits	962	12%
Residual value	135	2%
Total Benefits	**7,962**	**100%**
Summary excluding wider economic impacts:		
NPV ($million)	2,345	
NPV/I	0.53	
BCR (ratio)	1.42	
IRR (%)	10%	

Source: study estimates.

Note: Figures may not sum exactly due to rounding.

The economic evaluation of the Alternative Alignment produces a lower result with a negative NPV (-$2.1 billion) and a BCR of 0.65 which indicates that this option is not economically justifiable.

The economic evaluation of the Staged Option produces a NPV of $1.5 billion and a BCR of 1.29 (excluding wider economic impacts) or 1.50 (including wider economic impacts). This result is lower than the Reference Project as a result of marginally lower capital costs (as a result of higher discounting), being offset by the significant reduction in project benefits between 2021 and 2031.

1.7 Wider economic impacts

The construction of Cross River Rail will result in additional wider economic impacts that will increase the benefits quantified in the economic evaluation. The quantification of wider economic impacts has been used in a number of places internationally to identify additional benefits of some transport projects. Notably, mass transit projects in large urban areas have seen the highest wider economic impacts, driven by the impact of mass transit systems on the size and density of labour markets and the business to business interactions within employment zones like city CBDs and specialist business parks.

The quantification of wider economic impacts for Cross River Rail has been undertaken using the latest guidance for the UK Department of Transport methodology. Similar methods have been or are being developed for a number of other countries including New Zealand and the United States.

Wider economic impacts occur because the orthodox cost benefit analysis does not account for 'market failure' in the transport sector of the economy. There are three main types of market failure which have been assessed in the current analysis:

- Agglomeration benefits – these derive from clustering as a result of a transport project and the increased employment densities would lead to higher productivity
- Imperfect competition – since cost benefit assessments are essentially constructed on assumptions of perfect competition, there are additional benefits of a transport project which are not necessarily passed on to customers because of lack of competition. If transport costs are lowered, firms may lower their prices and increase output to satisfy demand. The additional benefit is the product of the difference between marginal cost and price and the increase in output due to reduced transport costs
- Labour supply – People may choose to enter the labour market or move to more productive jobs as a result of a reduction in transport costs. These decisions are based on after tax income received, which is covered by the conventional cost benefit analysis. However, the full benefit is measured by the gross income paid by their employer including additional tax revenue received by government.

The results of the wider economic impacts assessment are summarised in Table 1-2 and indicate that the wider economic impacts of Cross River Rail increase from $69 million in 2021 to $265 million in 2031. The total present value of the wider economic impacts is $1.2 billion. Agglomeration is the main contributor to the wider economic impacts, accounting for three quarters of the total impacts, with the remainder largely accounted for by labour supply effects.

Table 1-2: User Benefits and Wider Economic Impacts Summary ($ million)

Year	User Benefits	Agglomeration	Labour supply	Imperfect competition	Total WEI's	Uprate %
2021	362	52	17	0.4	69	19%
2031	1,197	209	53	2.3	265	22%

Source: Study team

The uplift to conventional benefits from the inclusion of the wider economic impacts on Cross River Rail was compared to other major infrastructure projects where similar analysis has been undertaken. This assessment indicated that the uplift factor of approximately 19% for Cross River Rail was in line with the average of benefits estimated elsewhere, and are similar to those estimated on two recent projects in Victoria.

The effect of including wider economic impacts on the economic evaluation is to increase the BCR from 1.42 to 1.63 and increase the NPV from $2.3 billion to $3.5 billion.

1.8 Sensitivity testing

The economic evaluation involves making estimates of a number of factors which are subject to uncertainty. These include assumptions which impact on both the project costs and benefits. The sensitivity test analysis indicates that the results are most sensitive to the assumptions regarding discount rate, capital costs and benefit assumptions. The economic evaluation results under different discount rates are broad ranging from 0.96 under the 10% discount rate, to 2.14 for the 4% discount rate. The exclusion of public transport passenger crowding benefits gives a BCR of 1.20, and the exclusion of rail freight benefits reduces the BCR to 1.25.

Under the high cost scenario, the BCR drops to 1.17 but given the already included 25% cost contingency in the core analysis, this represent an extreme scenario with, in effect, a 50% cost contingency. This level of contingency represents a project at a pre-feasibility stage where limited design work has been undertaken. However, in the case of Cross River Rail, the current project design is far more advanced and therefore a significantly lower cost contingency is warranted as per the core scenario.

1.9 Regional economic modelling

The regional economic modelling undertaken by EconSearch highlights the economic impacts of Cross River Rail on the Queensland economy. These have been quantified using a derivative of the Monash University Computable General Equilibrium (CGE model). It is important to note that the results of the CGE analysis should be considered independently from the main economic evaluation results (conventional benefits plus wider economic impacts) as there is a high risk of double counting if all benefits are considered together, especially CGE estimated impacts on Gross State Product (GSP) and agglomeration benefits from the wider economic impacts analysis. This approach is consistent with the Infrastructure Australia guidelines which state that these different measures of project impact are not additive.

The CGE modelling estimates that during a typical year of the construction phase (2016), additional real GSP for Queensland is estimated to be approximately $650 million higher as a result of Cross River Rail. Similarly, the project is estimated to contribute significantly to employment generation in the Queensland economy with an additional 5,900 jobs created during the construction phase.

In the operating phase, Queensland real GSP is projected to be $262 million higher by 2021, rising to $937 million by 2031 and $1,047 million by 2041 as a result of Cross River Rail. The employment impact during the operational phase is estimated to be approximately 5,000 additional jobs in Queensland by 2031, although some of these jobs will be displaced from elsewhere in Australia. Taking this displacement factor into account, the net increase in employment across Australia, due to Cross River Rail, is estimated to be approximately 650 jobs by 2031 compared to the without project scenario.

2 Introduction

2.1 Introduction

The Queensland Department of Transport and Main Roads (DTMR) engaged Deloitte to undertake a detailed economic evaluation of the Brisbane Cross River Rail project. For this project, Deloitte has supplemented its core skills of economic appraisal of public transport projects with leading experts in the fields of wider economic benefits (WEBS) by engaging Steer Davies Gleave and regional economic modelling through EconSearch.

The economic evaluation includes detailed information and analysis on the expected social, economic and environmental impacts of the project. This encompasses the estimation of the transport costs and benefits of the project utilising cost benefit analysis techniques, as well as the inclusion of the wider economic impacts of the project and their effect on labour markets and productivity. The analysis also includes input-output analysis (or general equilibrium modelling) which is used to assess the impacts of the project on the regional economy.

A draft economic evaluation report was submitted with the preliminary Business Case to the Queensland Government and Infrastructure Australia in December 2010. This resulted in a series of comments on the economic evaluation which have been discussed and addressed in the current report. This final economic evaluation report also reflects changes made to the analysis as a result of a peer review process undertaken by AECOM in late 2010.

2.2 Project background

According to the Queensland Government's South East Queensland Regional Plan (SEQRP)[1], the population of the region is planned to increase from 2.9 million currently to 4.3 million by 2026. In order to accommodate this growth, the SEQRP promotes a series of activity nodes, with Brisbane being the largest and the most highly concentrated. The Plan aims to focus employment activities at these locations with higher densification of land use plus infill in adjacent areas which are primarily serviced by public transport modes.

A key challenge for rail is to provide the capacity to adequately serve these locations and, in particular, the Brisbane CBD which is not only the primary employment location, but is also the focus of the rail network through which most passenger services operate. If additional rail capacity is provided in the CBD area, it would not only provide for increase passenger usage in the central area, but it would also have operational benefits across the wider rail network for both passenger and freight operations.

The pre-feasibility phase of the Cross River Rail project began in 2007 and was completed in October 2008, when the outcomes of the Inner City Rail Capacity Study (ICRCS)[2] were released. The key challenges this aimed at addressing were:

- How the rail network will accommodate the anticipated growth in passenger demand driven by population growth in South East Queensland, whilst also supporting growth in freight traffic
- How expanding rail capacity may be used to facilitate the desired land use strategies outlined in the SEQRP.

The focus of the ICRCS was on the inner city area within the triangle between Bowen Hills, Park Road and Milton rail stations.

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[1] South East Queensland Regional Plan 2009 – 2031, Queensland Government, Department of Infrastructure and Planning.

[2] Inner City Rail Capacity Study, Pre-Feasibility Report, October 2008, MPB Consortium for Queensland Transport.

The ICRCS identified and assessed a number of options to accommodate increased rail services into and through the inner city area. The study considered a number of underground rail line options as the existing high density land use in the inner city provides limited scope for additional surface level rail infrastructure. In addition the ICRCS identified a number of specific constraints which limit the ability of the rail network to handle more trains in the central area as follows[3]:

- Line capacity on the two track Merivale Bridge section
- Line capacity generated by multiple tracks merging onto single tracks at Park Road and Milton
- Operational issues which impact on capacity such as crew changes at Bowen Hills and the need for trains terminating at Roma Street and Bowen Hills to reach Mayne Yard for stabling
- Problems at inner city stations, particularly Central, Fortitude Valley and Bowen Hills, in dealing with large volumes of passengers at peak times and the impact on train dwell times
- Congestion at locations such as Park Road, Eagle Junction and Northgate, caused by high numbers of services and exacerbated by a mixture of different service patterns (stopping, express, interurban and freight).

In determining the technical feasibility of options, a range of multidisciplinary criteria were established. The ICRCS found:

- Passenger demand in peak periods to the inner city is forecast to increase from more than 44,000 in 2006 (currently 53,000) to between 70,000 – 80,000 by 2016 and 105,000 – 130,000 by 2026
- The expansion of the inner city rail network is restricted by the limited number of rail crossings over the Brisbane River and the difficulty in widening existing inner city rail tunnels
- By 2016 there will not be enough rail tracks to accommodate the required number of trains into the inner city during peak hour
- Two new rail links were proposed to cater for growth in demand, the first by 2016 and the second by 2026.

The current Cross River Rail study takes forward the concepts developed which target the 2016 capacity requirements.

[3] MPB Consortium, ICRCS Pre-feasibility Report, October 2008, page 5.

2.3 Report structure

This report provides a description of the detailed economic evaluation undertaken to assess the Cross River Rail project. This report includes the following sections:

- Section 3 - Approach to evaluation
- Section 4 – Project description
- Section 5 – Project costs
- Section 6 – Transport demand
- Section 7 - Transport system impacts
- Section 8 – Wider economic impacts
- Section 9 – Other benefits
- Section 10 – Regional economic modelling
- Section 11 – Economic evaluation results
- Section 12 – Summary and conclusions.

Supporting information is contained within the Appendices.

3 Approach to Evaluation

3.1 Introduction

This section provides an overview of the approach to be undertaken in the economic evaluation and the key assumptions that underpin it. It is proposed that the evaluation will follow standard methodologies for assessing projects of this nature. These include:

- Australian Transport Council's (ATC) National Guidelines for Transport System Management in Australia, 2006
- Queensland Government Project Assurance Framework
- Queensland Government Cost Benefit Analysis Guidelines
- Infrastructure Australia's Prioritisation Methodology
- DOTARS (2009), AusLink Investment Program: National Projects - Notes on Administration, Canberra.

The methodology also draws on international best practice for economic evaluation and, in particular, refers to guidance from the UK Department for Transport.

3.2 Steps in the methodology

A Benefit-Cost Analysis (BCA) approach is used to estimate the economic worth of the project. The methodology involves the following steps:

- Defining the project objectives and scope
- Defining the project options which form the basis of the economic evaluation
- Defining the without project case against which the project options are compared
- Identifying the costs and benefits that might be expected in moving from the without project case to each of the options
- Identifying and agreeing the core parameters of the evaluation (e.g. time scale, base year for prices to calculate present dollar values, discount rate)
- Where possible, quantifying the costs and benefits over the expected lifecycle and discounting future values to express them in current equivalent values
- Generating performance measures including the Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR) using discounted cash flow techniques over the evaluation period
- Testing the sensitivity of these performance measures to changes in the underlying assumptions utilised
- Ranking the options according to Net Present Value per unit of capital Invested (NPVI) to determine which option represents the best performing in value for money terms.

The performance measures described above are defined as follows:

- Net Present Value (NPV) – the difference between the present value of the total incremental benefits and the present value of the total incremental costs
- Net Present Value : Investment Ratio (NPVI) – the NPV divided by the present value of the investment costs
- Economic Internal Rate of Return (EIRR) – the discount rate at which the present value of benefits equals the present value of costs

- Benefit Cost Ratio – ratio of the present value of total incremental benefits to the present value of total incremental costs.

Projects which yield a positive NPV indicate that the incremental benefits of the project exceed the incremental costs over the evaluation period. The NPVI measures the overall economic return in relation to the required capital expenditure.

An EIRR greater than the specified discount rate (7% central case) also indicates that a project is economically justifiable, although the EIRR can yield ambiguous results if the time stream of costs and benefits is not uniform over time. Given this potential issue, it is only recommended that the EIRR is used in conjunction with other measures of economic viability.

The BCR measures the ratio of discounted benefits to discounted costs. A BCR greater than 1 indicates that project benefits exceed project costs. However, a higher BCR is usually required to ensure some level of built-in contingency against unforeseen increases in capital costs, program delays or scope expansion.

3.3 Key methodological issues

Key evaluation parameters used in the evaluation are summarised in Table 3-1.

Table 3-1: Key Economic Evaluation Assumptions

Item	Assumption
Discount rate	A 7% per annum real discount rate is applied in the evaluation to calculate present values. The evaluation also undertakes sensitivity tests at the discount rates of 4% and 10%. These values are in accordance with IA guidelines.
Price Year	All costs and benefits in the evaluation are presented in 2010 constant prices.
Evaluation period	An evaluation period of 30 years from the end of the capital investment is adopted for this study, i.e. 2021 to 2050 as per the Queensland State Treasury and Infrastructure Australia guidelines. Sensitivity analysis is also undertaken to assess the impact of a 50 year evaluation period as suggested in the Federal Government Nation Building guidelines[4].
Economic evaluation	The economic evaluation considers the project from a community perspective and considers the costs and benefits which are both internal and external to the rail operator including government organisations, private sector enterprises, individuals and the environment. Some of these effects, (such as time savings, noise and air quality effects) are not directly quantified in market based monetary terms. An economic evaluation differs from a financial evaluation because the latter focuses on revenue flows, capital and operating costs for key stakeholders and it does not include externalities or private benefits such as time savings.

[4] Notes on Administration for the Nation Building Program, Australian Government, The Department of Infrastructure, Transport, Regional Development and Local Government, July 2009.

4 Project Description

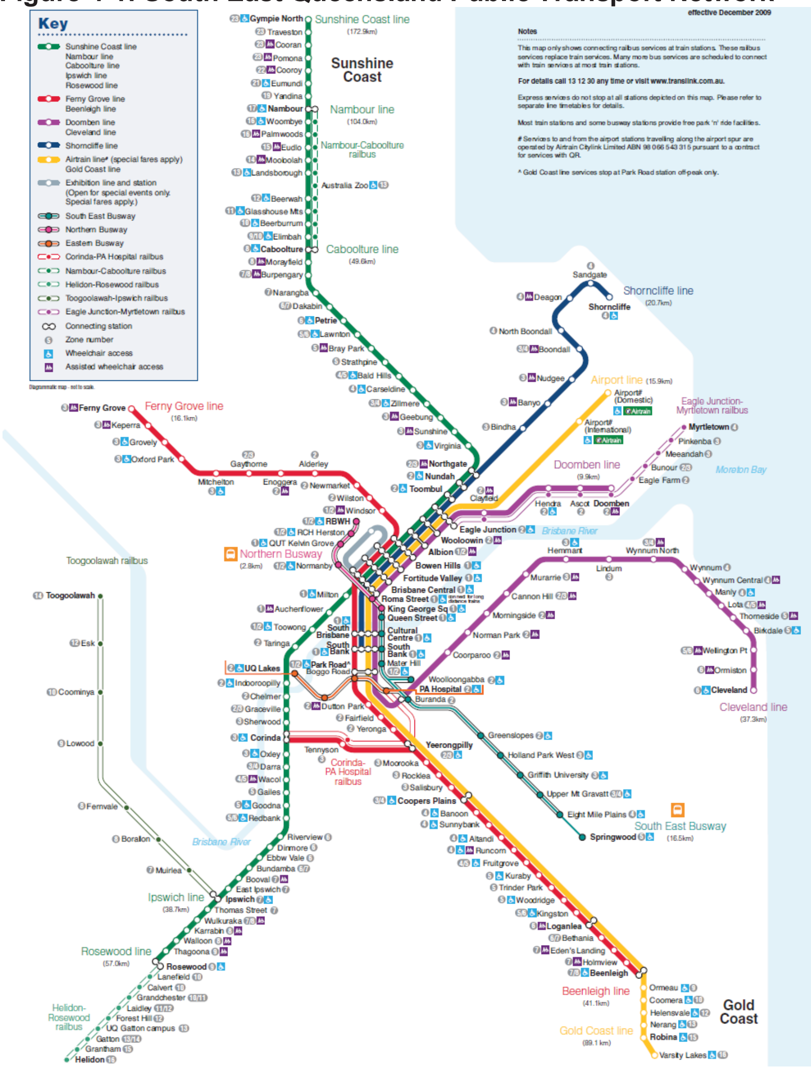
4.1 Introduction

This section provides an overview of the South East Queensland transport network, as well as a detailed description of the Cross River Rail project case and the without project case which are assessed in the economic evaluation.

4.2 South East Queensland transport network

The South East Queensland region already has an extensive heavy rail network, a dedicated bus network is being introduced in stages in the greater Brisbane area, and TransLink is delivering an integrated public transport system to increase bus, ferry and train use across the region. The existing rail and bus network is shown in Figure 4-1.

Figure 4-1: South East Queensland Public Transport Network



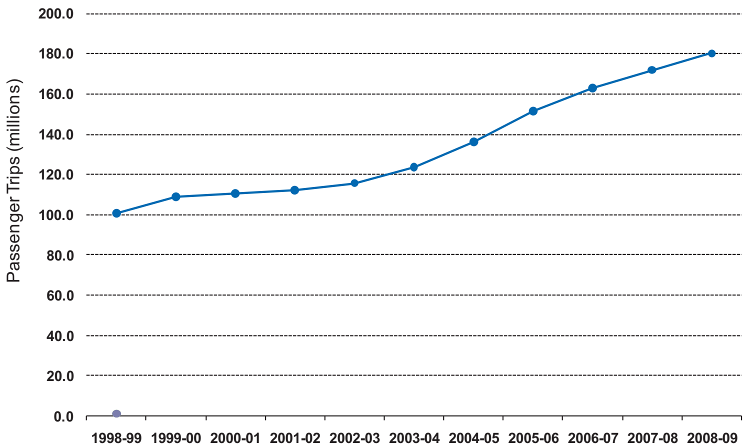
Source: TransLink

The QR Citytrain suburban network extends from the centre of Brisbane, south to Beenleigh and Robina on the Gold Coast; north to Ferny Grove, Shorncliffe, Caboolture and Gympie;

east to Cleveland; and west to Ipswich and Rosewood. The rail network includes 143 stations, with suburban and inter-urban Citytrain services. Generally, passenger services in Brisbane are medium to long distance suburban/ commuter services, with heavy use during the morning and afternoon peaks.

Citytrain shares its network with other services including regional and interstate freight and passenger services. Typically, 54 freight services and around 10 regional and interstate passenger services operate each day. The QR Citytrain system has seen steady growth in patronage over the past decade, with growth accelerating in the past five years. This growth is summarised in Figure 4-2.

Figure 4-2: TransLink Patronage Growth



Source: TransLink

At the same time, new roads, better orbital road networks and improvements to existing roads are being planned to address the most congested parts of the road network and ensure efficient regional connections. The aim is to create a balanced and integrated transport network, with the right mix of good roads and fast, frequent and reliable public transport.

4.3 The project

4.3.1 Cross River Rail option

The Cross River Rail project has three high-level objectives as follows:

- Increase the capacity of existing public transport networks right across South East Queensland (addressing the service challenge)
- Improve access to the inner city and provide more public transport choices (addressing the access challenge)
- Promote a sustainable South East Queensland by reducing traffic congestion and pollution, supporting economic growth and helping the region develop in a way that maintains the lifestyles of the resident population (addressing the sustainability challenge).

The Project's service requirements have been identified to address these high level objectives. The Reference Project includes the tunnel design, surface track design, station design, proposed construction methodology and property requirements. The Reference Project consists of:

- 9.8 km 2 track tunnel between Yeerongpilly train station and Victoria Park:

    - 4 new underground stations at lower Albert Street (with entrances on the corner of Albert/Mary Street and Albert/Alice Street), Roma Street (underneath existing rail station with entrances at the current concourse and on the northern side towards King George Square), Woolloongabba (ULDA site with one entrance at the Western side of the site near Leopard Street) and Boggo Road Urban Village (northern entrance integrating with existing busway/rail station and southern serving the growing precinct)
    - Ventilation outlet and emergency egress at Fairfield adjacent to Fairfield Road and Railway Road
    - flood control facility incorporated in the tunnel southern portal.
- 5 km of additional corridor surface tracks from the southern portal at Yeerongpilly to south of Salisbury (includes 4 km of additional freight track, 3 km of two additional Cross River Rail tracks and various track realignments and access tracks):
    - 1 new surface station at Yeerongpilly
    - elevated structure from Moorooka Station to north of Muriel Avenue
    - stabling facility at Clapham Yards
    - minor station upgrades at Moorooka and Rocklea.
- 2.7 km of 2 additional surface tracks on the Exhibition loop from the northern portal at Victoria Park to Breakfast Creek plus additional track construction and realignment to maintain capacity and functionality through Mayne Yard:
    - 1 new surface station at RNA/Exhibition
    - elevated structure near the Inner City Bypass to bypass Mayne Yards.

This system consists of two single track tunnels throughout with connecting cross passages to meet fire and life safety requirements. Particular allowance has been made for airspace developments directly above the stations at Albert Street and Woolloongabba and the potential exists for airspace developments adjacent to Roma Street and Boggo Road.

A new signalling system for the underground will enable 24 trains an hour to operate in the peak period on each new line. The new signalling system will interlock the train operation with automated platform screen doors at the stations enabling high passenger throughput through more effective train operations and control.

The project requires extensive ventilation systems to cope with the fire and life safety requirements in the underground operating environment. This has necessitated a separate ventilation and emergency shaft located at Fairfield. The southern ventilation building (adjacent to Fairfield Road) will be constructed in a shaft approximately 30m deep and will accommodate tunnel ventilation, emergency egress stairs and a tunnel sump.

4.3.2 Alternative alignment

In addition to the Cross River Rail Reference Project case, an Alternative Alignment option was assessed which is a lower cost option that seeks to improve inner city rail capacity by alleviating pressure on key network choke points as follows:

- Merivale Bridge – all services from the south currently merge together between Park Road and South Brisbane to operate as one corridor across the Merivale Bridge, restricting peak growth in the corridor
- Merivale Junction – all western corridor services currently merge together at this junction to operate on a single corridor through the inner city, restricting peak growth in the corridor
- Existing inner city stations – the capacity of existing inner city stations is limited and is expected to start impacting on service growth by the time service levels reach 23 trains per hour in either direction on the suburban lines, or 19 trains per hour in either direction on the main lines.

Based on the above constraints, a number of options were considered and the following components were considered appropriate to provide additional capacity as required:

- Grade separation to reduce crossing conflict between contra peak Gold Coast services and inbound Gold Coast/Ipswich corridor services at Merivale Junction
- Two additional surface tracks alongside the existing Tennyson Loop
- Grade separation at Corinda to Sherwood from both southern tracks on Ipswich line to a new pair of tracks on the northern side of the Tennyson Loop
- Grade separation at Yeerongpilly from the new pair of tracks on the northern side of the Tennyson Loop. To allow separation and remove conflicts with existing tracks (passenger and freight) and southern access to Clapham Yards
- Merivale Junction – two additional tracks on north side, with no change to existing tracks, requiring a widened rail corridor into the Barracks site
- Roma Street to Exhibition – double track tunnelling with a 160m long island platform at 'Central North' station. Near Bowen Bridge Road, the new outbound track rises up and ties in on the northern side of the existing outbound main line (beside Inner City Bypass), while the new inbound track turns out and dives down off the southern side of the existing mainline
- Exhibition Loop – single track turns out and dives down off the northern side of the existing rail corridor, then these pass under the existing rail corridor, over the top of the new connection to Exhibition Station, and then ties into the new inbound track on the southern side before new 'Central North' station platform.

An indicative assessment of the economic performance of the Alternative Alignment is summarised in section 11.

4.4 Evaluation scenarios

4.4.1 Without project case

The appraisal compares the proposed upgrade options against a without project case. The specification of the without project case is especially important in estimating project benefits, which in most cases, are calculated in net terms (i.e. project case minus the without project case).

It is important to determine a realistic without project case to accurately assess the merits of the project options. If the without project case is over specified it will involve additional costs of infrastructure provision but will reduce the relative merit of the project options and reduce the benefits that would otherwise contribute to a positive outcome in the evaluation. Conversely, if the without project case is under specified it could make the without project case overly pessimistic in terms of congestion and capacity constraints which would result in an overly optimistic estimation of benefits of the project case in the evaluation. This would lead to an inefficient use of capital in that project implementation would occur before its optimal timing.

The specification of the without project case was largely dictated by the assumptions included in the SKM – Aurecon JV demand model and are summarised below.

Rail

Rail service plans have been developed to reflect the increasing demand for rail travel over time. The rail service plan shows capacity is reached in peak periods by 2016 after which growth is limited. However, in the with project case the additional capacity afforded by Cross River Rail allows further train services to be run. By 2031 this equates to a 35% increase in train services compared to the without project case. This is summarised in Table 4-1.

Table 4-1: Summary of Train Operating Assumptions through CBD Station (AM peak hour)

	Trains from the south/ west	Trains from the north
2009	30	27
2016 without Cross River Rail	41	38
2016 with Cross River Rail	43	38
2031 without Cross River Rail	42	42
2031 with Cross River Rail	57	55

Source: SKM – Aurecon JV Demand Modelling Team

The without project case and with project also include the North West Transit Corridor in the future rail network (2031), and, in particular, a new rail tunnel between Cross River Rail and Alderley. This project, which is part of the Draft Connecting SEQ 2031, would provide an alternative path for inter city and suburban services into Brisbane negating the need for capacity enhancements on the North Coast Line as well as providing rail access to the under serviced area of north-west Brisbane. In the without project case, the rail tunnel does not connect to the existing rail network since the Cross River Rail project is not implemented. However, in the with project case, the connection to the Cross River Rail project facilitates additional trains services to be run and therefore generates project benefits compared to the without project scenario. In order to ensure consistency in the evaluation, a corresponding capital cost has also been included. This is discussed in section 5.

Bus

The future without project case bus service assumptions are based on advice from TransLink and the DTMR. The future bus services are consistent with the bus strategy described in the draft Connecting SEQ 2031, consisting of high frequency priority trunk network services with suburban feeder services to major bus and rail interchange facilities. No bus service changes were introduced to the planned services for the with project assumptions compared to the without project assumptions.

Road

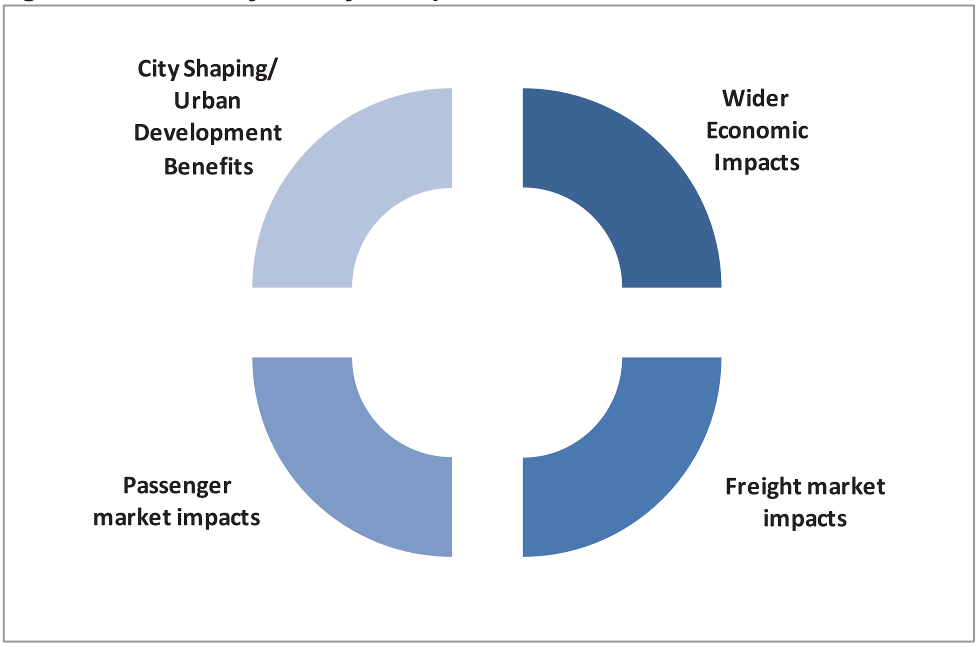
The future without project case road network assumptions are based on advice from the DTMR and is consistent with the assumptions used for the draft Connecting SEQ 2031 as well as the South East Queensland Infrastructure Plan and Program.

4.5 Project impacts

The impacts of Cross River Rail can be divided into four broad categories and these are summarised in Figure 4-3. These include:

- Passenger market impacts – these include changes in the cost of travel for public transport users and private vehicle users as a result of the project. The approach to quantifying these benefits is described in more detail in section 7;
- Freight market impacts – these incorporate the effect of transferring more freight from road to rail as a result of increased rail freight capacity. These impacts are also quantified in section 7;
- Wider economic impacts – these incorporate additional macro economic impacts as a result of changes in the labour and capital markets which cause changes in productivity which is not captured in the transport system benefits. The approach to quantifying these benefits is described in section 8; and
- City shaping/ urban development benefits – these benefits include savings in urban infrastructure provision as a result of higher density development rather than green field low density development. These are reported in section 9.

Figure 4-3: Summary of Project Impacts



5 Capital Costs

5.1 Introduction

This section provides a summary of the capital and whole of life costs of implementing the project. This includes the direct costs of constructing the new rail line through the centre of Brisbane and includes land purchase, tunnelling, track, station works, electrical and mechanical systems, design, project management, escalation and risk contingency. In addition, there are indirect costs associated with the project which include the cost of purchasing additional rolling stock which is required to run the additional train services to maximise the increased capacity provided by the project.

The section also provides an overview of the whole of life cost estimates for the project including recurrent operating and maintenance costs as well as periodic asset renewal and upgrade costs. Finally, a description of the residual value of assets is described given that a number of assets have economic lives beyond the 30 year evaluation period.

5.2 Capital Cost Estimate

The direct costs of the project have been provided by the project team cost estimator, Turner & Townsend. The total infrastructure cost is estimated to be $5.2 billion (excluding risk) in 2010 prices. An allowance for project risk and escalation has been also been included which gives a total capital cost of $8.4 billion. The construction period is assumed to be incurred between 2014 and 2019.

In addition to the direct project costs, the indirect costs of additional rolling stock purchase is included as the Cross River Rail project enables increased utilisation of the wider rail network facilitating additional project benefits. Turner & Townsend has estimated that the estimated cost of new rolling stock is $1.2 billion based on estimates of fleet requirements from Systemwide. Including escalation the cost of purchasing new rolling stock is $1.9 billion. These costs are incurred between 2018 and 2033 as the increase in patronage requires additional rail services.

A number of adjustments have been made to the project costs in order to convert outturn estimates to economic costs for application in the economic evaluation. These adjustments include:

- Adjustment of escalation estimates to remove the general increase in prices and reflect only real escalation increases over time
- Inclusion of surplus land resale receipts upon completion of the construction phase
- Removal of contractor profit, as this is considered a transfer payment between the government and the private sector and does not reflect a resource cost
- Exclusion of nominal escalation for additional rolling stock
- Inclusion of capital costs for the North West Transit Corridor Rail Tunnel by 2031 as this project was assumed to be in the rail network from 2031 in the demand modelling analysis and therefore contributes to project benefits.

Based on the above adjustments, the economic capital cost for the project is estimated to be $8.9 billion (undiscounted) and $4.9 billion (discounted).

5.3 Operating and maintenance costs

The operating and maintenance costs for the project were developed by Turner & Townsend who developed a bottom up estimation of incremental costs as a result of the scheme. The analysis was discussed with both Queensland Rail (QR) and TransLink (TTA) to ensure that the analysis was robust and used similar operating assumptions from these agencies currently being incurred on the rail network. The analysis assessed the following items:

- Infrastructure operations and maintenance costs – costs associated with track, signalling, power supply and communications systems
- Station operations – costs associated with station staff, utilities, security, cleaning, planned and unplanned maintenance for underground and surface stations
- Rolling stock – costs associated with train drivers, crew, direct vehicle operating costs and major vehicle overhaul
- Station and infrastructure asset replacement – costs associated with the replacement and / or overhaul of the stations and infrastructure
- Overhead (operating costs) – costs associated with operations overheads (scheduling, rostering, driver supervision, depot-related costs); vehicle maintenance overheads (engineering technology services); head office costs (higher management functions) and general labour and non labour overheads (information technology, human resources, insurance).

Based on the Turner & Townsend estimates the total undiscounted whole of life costs for the 30 year evaluation period is estimated to be $4.2 billion. The equivalent discounted present value is $705 million.

5.4 Residual life

The project infrastructure has been assigned a residual life to the key components of fixed infrastructure with economic lives that extend beyond the evaluation period. For the purposes of the analysis it is assumed that rail capital assets are considered to have the following economic lives[5]:

- Structures – 100 years
- Track – 40 years
- Signalling – 30 years
- Electrical and mechanical 30 years
- Property – infinite
- Rolling stock 30 years
- Management and procurement – 0 years.

The residual value is derived from the application of the following formula:

$$\text{Residual value} = \text{Capital Cost} * \left(\frac{Ec_{life} - Ev_{period}}{Ec_{life}} \right)$$

[5] Assumptions based on similar projects and ATC guidelines.

Where:

- Ec_{life} = economic life of the asset; and
- Ev_{period} = evaluation period.

Based on a 30 year evaluation period, the above asset life assumptions, the residual value is summarised in Table 5-1 and is estimated to be $2.0 billion (undiscounted) or $135 million (discounted).

Table 5-1: Summary of Residual Value

Item	Capital Cost
Economic cost ($ million)	8,881
Residual value ($ million) – undiscounted	2,018
Year incurred	2050
Residual value ($ million) – discounted	135

Source: Study estimate

6 Transport Demand

6.1 Introduction

This chapter details the forecast passenger and freight demand and its role in the economic appraisal. The forecast passenger demand was derived from the project demand model developed by SKM – Aurecon JV as part of their work for the project team.

6.2 Passenger demand

6.2.1 Land use forecasts

The detailed evaluation is based on the demand modelling outputs generated using the SKM – Aurecon JV demand forecasting suite of models. The model was based on the existing Brisbane Strategic Transport Model, Multi Modal Version which was updated and enhanced specifically for the Cross River Rail project. The model includes all modes of transport and encompasses the entire South East Queensland region including the Sunshine Coast in the north and the Gold Coast in the south[6].

The model enhancements included for the Cross River Rail project include the inclusion of a new set of sub modes specifically designed to improve the accuracy of the forecasts of public transport passenger demands and to improve the capability of the model to address the impacts and benefits of the provision of increased rail capacity. The model comprises a comprehensive description of current public transport travel patterns derived from an origin destination survey in 2006 combined with count data for 2009. In addition, a more detailed zone system for the CBD was defined to improve the model's ability to address the impacts of new stations.

The demand model uses a data base of road and rail links and public transport services running along these links for the entire model area. Given a forecast of public transport travel patterns (passenger trips between every pair of zones), the model assigns passengers to the best route through the network based on factors such as journey time, service headways and the need to interchange. The demand model also forecasts changes in car mode shares and the consequent incremental effects on future car demands are fed back through the road network model to determine the potential road decongestion benefits resulting from increased public transport capacity.

The models utilise a range of assumptions including future land uses (including population and employment forecasts), transport networks and transport pricing to predict travel movements by mode across the network. In the project case, with the introduction of Cross River Rail, it is possible using the demand model to determine the relative change in public and private transport demand and trip cost which provides the basis for the detailed economic evaluation.

The land use assumptions used in the demand modelling are summarised in Table 6-1 and Table 6-2[7]. It should be noted that all land use estimates are consistent with those included in the South East Queensland Regional Plan. Table 6-2 shows the expected growth in

[6] The transport model was primarily based on the Brisbane SD only, with trips to and from the remainder of South East Queensland treated as external demand.

[7] These forecasts are based on Queensland Department of Transport and Main Roads, Regional Plan Consistent V3.

population and employment by statistical local area, the Inner Brisbane area and the Brisbane Statistical Division (SD)[8] respectively assumed for both the base and Project case.

Table 6-1: Population Growth Assumptions (Persons)

	2009	2016	2031	Ave. Growth2009-2016 (p.a.)
Inner Brisbane SLA				
City - Inner	3,000	4,000	5,000	2.3%
City - Remainder	5,000	5,000	6,000	0.8%
Fortitude Valley	6,000	8,000	11,000	2.8%
Spring Hill	5,000	6,000	6,000	0.8%
Bowen Hills	2,000	5,000	8,000	6.5%
Milton	2,000	2,000	3,000	1.9%
South Brisbane	4,000	5,000	6,000	1.9%
Kangaroo Point	6,000	7,000	9,000	1.9%
Woolloongabba	4,000	6,000	13,000	5.5%
Inner Brisbane total	38,000	48,000	66,000	2.5%
Brisbane SD total	**1,892,000**	**2,160,000**	**2,657,000**	**1.6%**

Source: SKM – Aurecon JV demand modelling team. Note: estimates rounded for presentation purposes.

The table shows that there is forecast to be an additional 765,000 people living in Brisbane SD by 2031. However, this growth is not forecast to be uniform and it is expected that there will be significant variation in population growth by area with higher than average growth expected at key points along the project corridor. Areas with particularly high population growth are predicted to include City – Inner, Fortitude Valley, Bowen Hills and Woolloongabba. In the case of the latter two areas, population at Bowen Hills is expected to quadruple between 2009 and 2031 and triple at Woolloongabba over the same period.

8 The Brisbane SD area is based on the 2001 Census definition.

Table 6-2: Population Growth Assumptions (Persons)

	2009	2016	2031	Ave. Growth2009-2016 (p.a.)
Inner Brisbane SLA				
City - Inner	87,000	104,000	114,000	1.2%
City - Remainder	58,000	75,000	97,000	2.4%
Fortitude Valley	20,000	23,000	31,000	2.0%
Spring Hill	19,000	21,000	22,000	0.7%
Bowen Hills	9,000	16,000	21,000	3.9%
Milton	14,000	16,000	19,000	1.4%
South Brisbane	21,000	29,000	44,000	3.4%
Kangaroo Point	2,000	3,000	3,000	1.9%
Woolloongabba	15,000	18,000	35,000	3.9%
Inner Brisbane total	245,000	304,000	387,000	2.1%
Brisbane SD total	**1,042,000**	**1,236,000**	**1,514,000**	**1.7%**

Source: SKM – Aurecon JV demand modelling team. Note: estimates rounded for presentation purposes.

For employment, it is expected that there will be an additional 0.5 million jobs in Brisbane SD by 2031. High growth is also expected in the areas directly affected by the project including City – Remainder, Fortitude Valley, Bowen Hills, South Brisbane and Woolloongabba.

For the purposes of the economic evaluation, it is assumed that the land use assumptions are constant between the without and with project scenarios.

6.2.2 Other assumptions

The demand model applies parameter values for unit travel costs (time, operating costs, fares, tolls, parking etc) to determine the relative cost of travel by mode in both the with and without project scenarios. The analysis assumes all prices are expressed in real terms, i.e. inflation is excluded. However, for a number of parameters, real increases are modelled as follows:

- Fares – growth included to account for the TransLink policy of fare increases above inflation over the period 2010 to 2014. This policy is in place to improve cost recovery in public transport operations. The total fare increase over this four year period will be 75%
- Parking charges – growth is based on the modelling assumptions used for assessing the Connecting SEQ 2031 integrated regional transport plan for South East Queensland. Additionally for 2031, with large increases in employment density, parking charges in the inner city suburbs of Woolloongabba and Fortitude Valley have been increased to CBD levels
- Road tolls – growth in road tolls are assumed to increase in line with general inflation (i.e. no real increase)

- Value of time – Real earnings are forecast to increase in real terms by 1.5% per annum based on assumptions contained in the modelling for the draft Connecting SEQ 2031 integrated regional transport plan for South East Queensland[9].

6.3 Demand model outputs

Demand for inner city transport increases significantly as the city continues to grow and develop. Demand for motorised trips are forecast to increase to 7.7 million on an average week day by 2031, and public transport mode share increases to 12.1%. Table 6-3 provides an overview of the change in transport outcomes including growth in demand for public transport from 2009 to 2031.

Table 6-3: Transport Outcomes

	2009	2021	2031
Average week day transport demand (trips by private car travel mode)	5,533,200	6,988,400	7,736,500
Average week day public transport demand (trips)	546,100	841,800	1,120,800
Public transport mode share	8.1%	10.16%	12.1%
Rail AM 2hr peak trips (trips)	67,000	122,600	174,000
Rail daily trips (trips)	243,200	454,200	595,400

Source: SKM – Aurecon JV Demand Model.

The forecast rail patronage with Cross River Rail in the morning two hour peak period is presented in Table 6-4. This illustrates that with Cross River Rail there will be 13% more rail patronage than without the Project in 2021. By 2031, the rail patronage with the project is over 23% higher in the morning peak than without the project.

Furthermore, there is a decrease in average rail trip lengths and average rail trip times with the project compared to without the project in both 2021 and 2031. This correlates to higher average rail trip speeds with the project compared to without the project in 2021 (over 4% faster) and 2031 (over 10% faster).

[9] ABS data was assessed to verify this assumption. Based on ABS dataset 6302, A2795832K, average weekly earnings (AWE) in Queensland increased by an average of 5.2% per annum between 2000 and 2010. Over the same period, ABS dataset 6401, A2325816R, the consumer price index (CPI) increased by 3.5% per annum.

Table 6-4: Morning Peak Rail Patronage Data

AM peak	2021			2031		
	No CRR	With CRR	% change	No CRR	With CRR	% change
Total rail patronage	108,300	122,600	13.2%	141,900	174,000	22.6%
Average rail trip length (km)	21.2	20.7	-2.0%	24.0	22.5	- 6.3%
Average rail trip time (min)	31.7	29.8	-6.0%	34.8	29.4	- 15.4%
Average rail trip speed (km/h)	40.0	41.7	4.3%	41.4	45.8	10.8%

Source: SKM – Aurecon JV Demand Model.

Cross River Rail also provides significant transport system improvements including more trains at higher frequencies, higher CBD and key destination accessibility, public transport and vehicle travel time savings, reduced crowding, improved system reliability, reduced CBD station interchange delays. Table 6-5 provides an indicative summary of transport network benefits provided by Cross River Rail.

Table 6-5: Transport Network Impacts

	2009	2021			2031		
		Without project	With project	Benefit	Without project	With project	Benefit
Public Transport average trip time (minutes)	29.1	27.9	26.5	-1.3	28.9	26.6	-2.4
Rail average trip time (minutes)	30.7	32.2	30.1	-2.1	33.0	29.5	-3.5
Bus average trip time (minutes)	28.5	24.1	23.1	-1.0	25.8	24.1	-1.7
Average private vehicle travel time (minutes)	16.5	19.2	19.0	-0.1	23.2	22.7	-0.6
Average commercial vehicle travel time (minutes)	21.1	21.6	21.5	-0.1	30.9	30.0	-0.8
Weight network average on time reliability (i.e. within 4 minutes, in bound peak trains)					64.6%	82.8%	28.2%
CBD rail accessibility (walking distance, metres)	660	760	660	-13.2%	820	640	-22.0%
Rail accessibility - All PT average access time (minutes)	18.6	19.2	18.5	-0.6	18.3	17.7	-0.6
All PT additional crowded time (daily hours)	13,200	48,400	22,100	-54%	67,900	34,700	-49%
All PT average waiting time (minutes)	8.0	6.2	5.9	-0.3	5.2	4.7	-0.5

Source: SKM – Aurecon JV Demand Model.

6.4 Freight demand

Freight services currently pass through the Brisbane rail network to destinations including Fisherman Islands (Port of Brisbane), Acacia Ridge Freight Terminal, and to regions serviced by the North Coast line. Currently, there is no dedicated rail freight network in South East Queensland and as a result, passenger and freight rail services share network capacity with passenger services prioritised over freight (passenger services share freight lines in the passenger peak and freight traffic use train paths on the passenger network in the off-peak[10]). Efficiency and performance of non-peak operations are often affected by the need to schedule freight trains in the times available between higher priority passenger train services.

Rail freight movements through Brisbane and South East Queensland are grouped into the following market segments:

- **North Coast Line**, consisting mainly of non-bulk freight transported between Acacia Ridge (and to a lesser extent Brisbane Multi-modal Terminal) and various destinations in North Queensland
- **Western Line**, consisting mainly of coal and grain transported west of Toowoomba to the Port of Brisbane for export
- **Interstate freight**, consisting of intermodal freight transported between South East Queensland and other Australian states via Acacia Ridge and Brisbane Multi-modal Terminal
- **'Intra-urban freight'**, which currently represents a small market segment, but may become more important in the future as additional IMTs are developed in South East Queensland.

According to the Inner City Rail Capacity Study analysis, the current freight peak periods are between 4.00 am and 7.00 am arriving at terminal and 6.00 pm and 9.00 pm departure to match current logistics trends. There is more flexibility for afternoon and evening departures depending on the length of journey but freight arrivals typically must arrive at the beginning of the day to meet distribution needs[11].

There are around 344 freight services per week travelling through the Brisbane rail network along the narrow gauge lines, including:

- 120 coal services travelling along the Western Corridor, between Rosewood and Port of Brisbane (Fisherman Islands) via Corinda and Yeerongpilly
- 16 grain services travelling along the Western Corridor, between Rosewood and Port of Brisbane (Fisherman Islands) via Corinda and Yeerongpilly
- 146 intermodal freight services travelling along the North Coast Line, between Nambour and intermodal freight terminals, such as Acacia Ridge and Port of Brisbane
- 62 intermodal freight services travelling along the Western Corridor, between Rosewood and Port of Brisbane or Acacia Ridge Terminal.

In addition, there are also 59 train services per week travelling between Melbourne/ Sydney and Brisbane with a destination at Acacia Ridge intermodal terminal as well as 118 trains per week travelling between Acacia Ridge and the Port of Brisbane.

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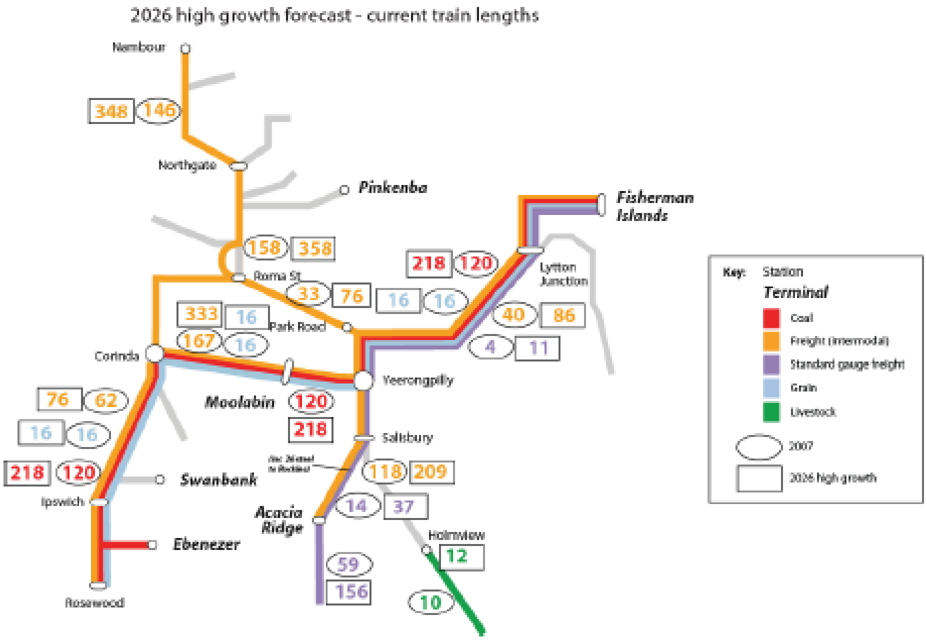
[10] Currently, freight trains do not operate during peak periods within the Brisbane metropolitan rail network.

[11] This constraint is less applicable to bulk freight (coal and grain) as these cargoes are less time sensitive and often run during non-peak times.

Figure 6-1 shows estimates of weekly freight train movements based on the work undertaken by the Inner City Rail Capacity Study (ICRCS) in 2008. These estimates were developed using baseline train movement data provided by QR Network. The estimates indicate significant growth in freight demand, subject to rail freight capacity, in the next 15-20 years. In particular, the growth in intermodal traffic and standard gauge freight is expected to be significant. If this growth is to be realised, it will require increased rail freight capacity through the CBD as well as to access the port.

As part of an independent analysis, a due diligence exercise was undertaken by the project team to validate these rail freight forecasts to ascertain whether they were appropriate for use in the current analysis. The findings of this due diligence exercise confirmed that the freight demand forecasts derived in the ICRCS were appropriate for use in the Cross River Rail evaluation.

Figure 6-1: Estimates of Existing and Future Freight Demand Flows SEQ Rail Network (weekly train movements two way flows)



Source: ICRCS, 2009

Freight services through the inner city have traditionally approached the city on the passenger network before taking an alternative route via the Exhibition loop. This is partially because the inner city stations were not designed to accommodate freight services, and largely because the freight services would cause operational difficulties in the heavily used inner city corridor. In the with project scenario, freight would have dedicated access to the Port of Brisbane from the south as well as having more capacity via the Exhibition Loop for North Coast Line services due to the diversion of some passenger services through the Cross River Rail tunnel. The benefits of this increased freight capacity are quantified in section 7.

7 Transport System Impacts

7.1 Introduction

This section also provides a description of the concepts applied in the economic evaluation as well as the approach used to quantify both the passenger and the freight benefits.

7.2 Theoretical underpinnings

7.2.1 Introduction

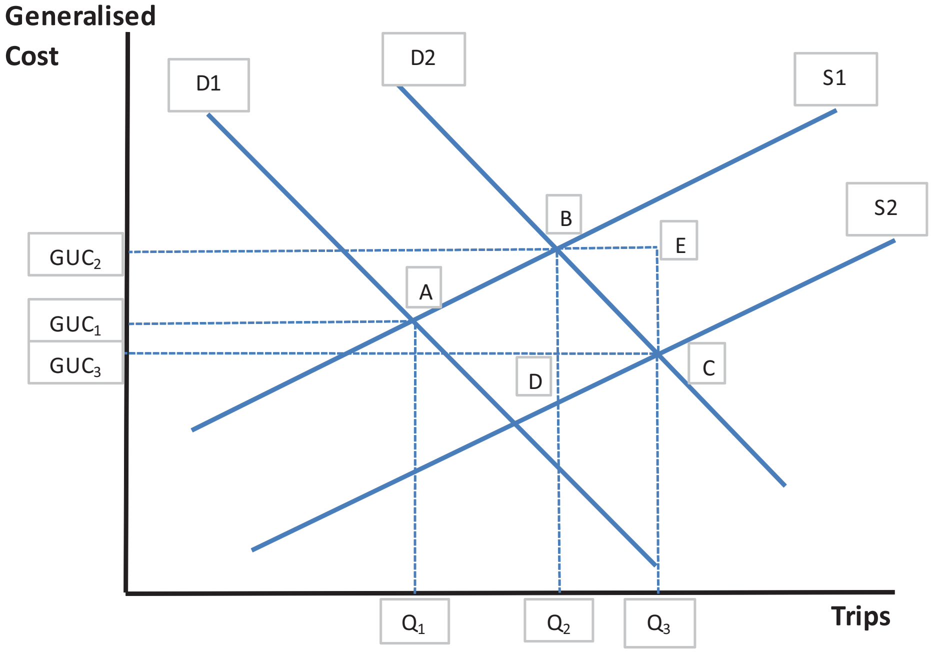
In order to fully understand where benefits will accrue it is useful to consider the theory which underpins the analysis. In determining these impacts, it is important to differentiate between the different markets upon which the project will impact. Cross River Rail will have impacts in both the rail and road markets.

7.2.2 Rail market

The assessment of impacts for the rail market is illustrated in Figure 7-1. The figure shows the two demand forecasts with two capacity provisions for the with project and the without project case. With the current capacity (S1) and demand (D1), the equilibrium number of rail journeys is Q_1 and the equilibrium generalised cost is GUC_1 (Point A). Over time, growth in demand as a result of economic and population growth leads to a shift in the demand curve from D1 to D2. This growth in demand increases the number of trips from Q_1 to Q_2. With existing levels of rail infrastructure, the average generalised cost increases (due to increased congestion) to GUC_2.

Implementation of Cross River Rail reduces the average generalised cost since it provides benefits compared to the without project case by providing a significant increase in capacity, savings in journey time, increased reliability etc. This leads to the supply curve moving down and to the right to reach a new equilibrium position at C. At this point, the number of journeys has increased to Q_3. The shift in the demand curve could be significant as a result of a substantial increase in rail passenger or freight capacity in the peak period compared to the existing situation. This step change in supply is likely to result in a further increase in demand as passengers and freight will be attracted to rail transport from road.

Figure 7-1: Rail Market Impacts



Existing future rail users (Q_2) have a consumer surplus benefit of ($GUC_2 – GUC_3$) * Q_2. However, the reduction in average generalised cost stimulates more rail trips which are either diverted from other public transport modes, from road or are entirely new rail journeys. The quantum of these new trips is (Q_3-Q_2). The total consumer surplus benefit to these new users is therefore ($GUC_2 – GUC_3$) * ($Q_3 – Q_2$) * ½ (also known as rule-of-a-half). This benefit is shown by the triangle BCD.

In addition, there is the producer surplus benefit to take account of which relates to the change in net revenue to the system operator. This is calculated by the incremental passenger fare revenue as a result of a mode shift to public transport minus the additional operating cost to the operator from running additional train services. The value of the incremental fare revenue is the number of additional trips ((Q_3-Q_2) multiplied by the fare. The additional operating cost for the system operator is net public transport resource cost.

7.2.3 Road market

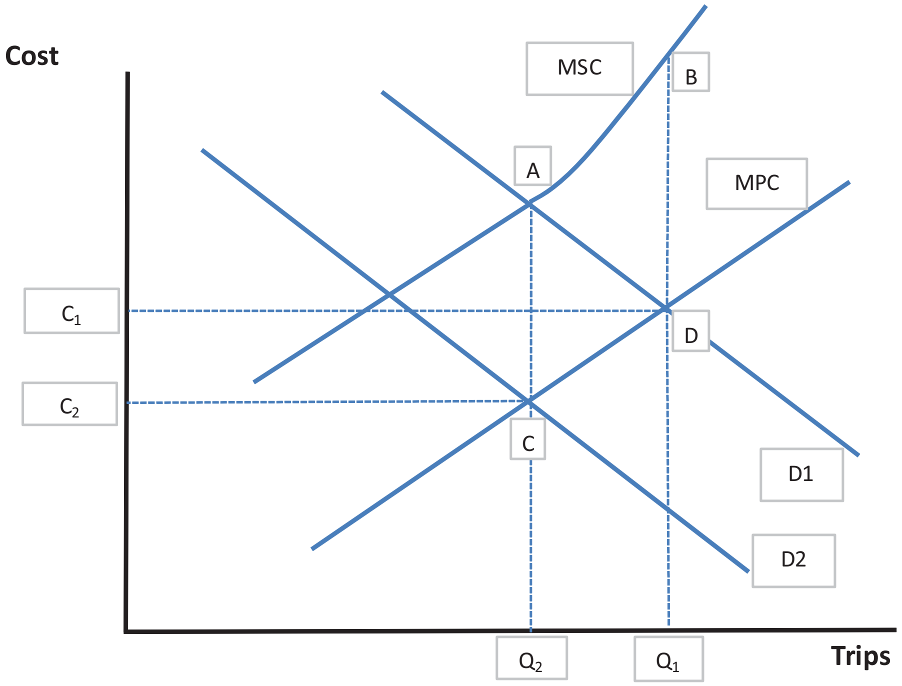
Without Cross River Rail, due to capacity constraints on rail the growth in passenger and freight traffic will largely be accommodated by additional road transport. The private and social cost of travel increases as travel speeds decrease adding to the generalised costs of the trip. The private cost of car and commercial vehicle travel takes into account user costs such as fuel, tolls, maintenance, insurance etc. whereas the social cost of travel includes the costs of negative externalities which are not included in private costs. These externalities include:

- Accidents
- Noise pollution
- Air pollution
- Greenhouse gas emissions.

As discussed above, the increase in rail capacity as a result of Cross River Rail will also have an impact on the road market, and this is summarised in Figure 7-2. In the without project situation, the number of private vehicle trips is determined by the intersection of the demand curve (D1) and the marginal private cost of travel (MPC) which gives the number of trips as Q_1. Given that drivers do not perceive the full cost of car and commercial vehicle use on the environment, this leads to the level of private transport use being higher than the social optimum. If drivers did perceive the full cost of their travel, then private vehicle demand would be to the left of Q_1 where the demand curve D1 intersects the marginal social cost (MSC) of travel curve, i.e. Q_2.

The increase in rail capacity reduces rail user costs which means that travellers will transfer from road to rail trip making. This leads to a reduction in road travel demand which is represented by a shift in the demand curve left and downwards from D1 to D2. Under these circumstances the number of trips becomes Q_2 and the average cost of travel reduces from C_1 to C_2. Consequently, those private vehicle trips remaining benefit by the amount of $(C_1 - C_2) * Q_2$. This decongestion benefit represents a consumer surplus benefit for this travel market.

Figure 7-2: Road Market Impacts



In addition, there are a number of resource cost corrections to be undertaken for the reduction in private vehicle trips $(Q_1 – Q_2)$. These include a reduction in resource vehicle operating costs and externality cost reductions. These benefits are calculated as $(Q_1 – Q_2) *$ (MSC – MPC) which is shown by the area ABCD. It is evident that there is an increasing divergence between the MPC and the MSC curves as congestion increases. This divergence is evident in increasing congestion, environmental impacts and vehicle operating cost increases.

The approach to quantifying these benefits is described in the following sections.

7.3 Economic evaluation concepts

7.3.1 Introduction

The incremental transport system costs and benefits resulting from Cross River Rail have been estimated using the evaluation framework outlined by the ATC guidelines[12]. These guidelines outline a series of impacts which can result from the consequences of changes in travel conditions (including the time and quality of travel) that, in turn, affect travel demand. For the project, the estimation of transport system impacts are derived from the combination of changes in travel demand, travel conditions and unit resource values for travel in those conditions.

The costs and benefits of the project compared to the without project case has been assessed according to changes in consumer surplus[13], producer surplus and resource costs corrections. The approach to quantifying these benefits is described below.

7.3.2 Perceived versus resource costs

Individuals and firms make their decisions of travel based on their perception of the generalised cost. Consequently the consumer and producer benefits quantified in the economic evaluation are expressed in terms of savings in perceived costs. However, there are instances where the perceived cost of travel does not relate to the level of resources consumed. To account for the difference between perceived and resource costs, it is necessary to apply a resource cost correction which largely applies to private vehicle (car and commercial vehicle) travel which under-estimate the cost of travel for the following reasons:

- Drivers base their behaviour on imperfect perceptions of cost. For example, there is evidence to suggest that people under estimate the costs of running cars and only take account of the short run variable costs (fuel, tolls etc) whilst ignoring the unperceived fixed costs (vehicle depreciation, insurance etc). Consequently, some of the reduction in the resource or unperceived cost of the private vehicle operating cost can be measured as a project benefit following a mode shift from private transport to public transport as a result of the project
- The financial costs that motorists pay includes taxes which are transfer payments and do not represent the consumption of resources
- Private vehicle use imposes costs on others that are not explicitly charged for in the form of externalities including air pollution, noise, congestion, greenhouse gas emissions etc.

In terms of estimating project benefits for the Cross River Rail, each of these factors is taken into account.

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[12] National Guidelines for Transport System Management in Australia, Australian Transport Council, 2006.
[13] Consumer surplus is defined as the benefit which a consumer enjoys in excess of the costs which he or she perceives. For example, if a journey would be undertaken by a traveller provided that it takes no more than 60 minutes, then the ‘‘cost’’ of the journey is one hour of travel time. Put a different way, the traveller is willing to pay an equivalent of 60 minutes travel time to make the journey. If the actual travel time for the journey takes 45 minutes, then the traveller enjoys a consumer surplus of 15 minutes. If an improvement in travel time occurs, as a result of a new investment, which reduces travel time to 30 minutes then there is an increase in consumer surplus of 15 minutes compared to the situation without the new investment. Across all travellers, the change in consumer surplus is the difference between the change in total benefit enjoyed and the change in the cost perceived.

7.3.3 Generalised cost

Travellers make their travel decisions based on their perception of the total cost of their travel. This includes monetary amounts paid as well as journey quality issues such as congestion, in-vehicle time, comfort, access time, wait time, reliability etc. The combination of these factors is known as the generalised cost of travel.

Generalised cost is expressed in monetary terms by valuing each attribute of travel which makes up the total journey time. The generalised time in the without project case or the with project case usually consist of the following components for public transport trips:

- In-vehicle time defined as the time taken by train/ bus to the passenger's destination
- Access time which is defined as the time taken to access the station i.e. time taken to walk, bus or drive to access the rail network
- Wait time which includes the time taken to wait for the mode of transport to arrive i.e. bus or train
- Interchange penalty and time to reflect the inconvenience and added time taken for transfer between public transport modes
- Unexpected passenger delay as a result of a loss of service reliability.

It is normal practice in public transport scheme appraisals to apply different weights to these different trip components to reflect the disutility of that activity with respect to in-vehicle time for public transport usage. The journey time weights to be used in the analysis are summarised in Table 7-1 which are based on ATC guidance and reflect the level of congestion in the future public transport network.

Table 7-1: Summary of Generalised Cost Weightings

Item	Unit of measurement	Value
Wait time	Weighting of in-vehicle time	2.0
Access time	Weighting of in-vehicle time	1.7
Interchange	Number	10
Rail reliability costs[14]	Weighting of in-vehicle time	2.0

Source: ATC guidelines, Volume 4, Table 1.6.1, Study assumptions.

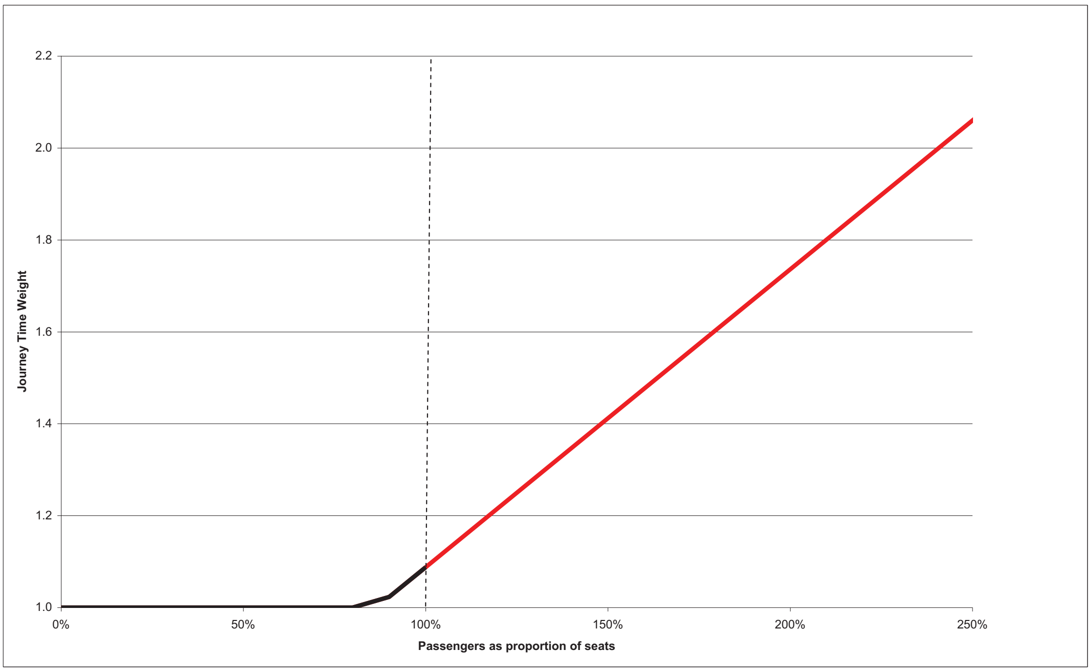
The estimated actual time taken to access the rail network by each activity is multiplied by the weight of each activity and the sum of all the weighted activities generates the generalised journey cost. This is summarised below:

*Generalised cost = (Access time * Access time $_{Weight}$) + (Wait time * Wait time $_{Weight}$) + (In-vehicle time (IVT) * IVT $_{Weight}$) + (Interchange number and time * Interchange penalty and time $_{Weight}$)*

[14] RailCorp economic evaluation guidance assigns a weighting of 3.7 to the in-vehicle value of travel time for unexpected passenger delays whereas the ATC guidelines assign a weighting value of 3.0. However, in the case of ongoing rail system unreliability, passengers would become accustomed to probable train service delays if sustained over a period of time. The likely passenger response to ongoing service unreliability would be to arrive earlier to catch a train thereby increasing their platform wait time. Consequently, the disbenefit incurred due to service unreliability would be akin to an increased wait time. Therefore in the evaluation, a weighting of 2.0 has been applied which is in accordance with the wait weighting penalty.

In addition to the above, passenger crowding, and its reduction as a result of the project, is also assessed in the evaluation. In representing crowding the demand model adopts a philosophy that the experience of using crowded trains is disliked by passengers and that this can be represented by increasing the generalised cost weight on in-vehicle journey time above the normal value of 1.0. The crowding weights incorporated in the demand model are based on a review of international practice and are illustrated in Figure 7-3. A crowding curve for the most common current rolling stock on the Brisbane network is shown. The portion of the curve below seated capacity (the dotted line) is shaded black, with the coloured portion indicating the increasing multipliers to in-vehicle time with increased load. The crowding weights were applied in the demand model to each train service throughout the day to determine the increased passenger in-vehicle time equivalent based on the loading of each train.

Figure 7-3: Crowding Weighting Assumptions



Source: SKM – Aurecon JV Demand Model.

While international research on the impact of crowding on buses is less well established, for consistency, the weighting attributable to rail travel was also adopted for bus crowding.

Sensitivity analysis has been undertaken to assess the impact of alternative assumptions relating to the generalised cost assumptions on the economic evaluation results in section 11.

7.4 Approach to quantifying passenger benefits

7.4.1 Introduction

The transport model is used to generate a number of outputs for use in the benefit computation. These outputs represent changes to both public transport and private transport trip making, with and without Cross River Rail. These model outputs include daily estimates of the following (for the with project case and the without project case) measures:

- Public transport trips
- Public transport passenger hours (expressed in generalised cost weighted hours)[15]
- Public transport passenger revenue
- Private vehicle (car and commercial vehicles) trips per day
- Private vehicle kilometres per day
- Private vehicle driver and passenger hours per day.

The transport model generated output each of the above statistics for a number of model years including 2021 and 2031. The values between these model years are derived through interpolation and the values post 2031 are derived by an estimation of the future growth rate in transport demand subject to any potential capacity constraints. The growth rate in benefits post 2031 is assumed to be 1.3% per annum which is the long run growth in population for South East Queensland.

As discussed previously, the ATC guidelines specify transport system user benefits should be categorised into perceived consumer surplus benefits, producer surplus benefits and unperceived vehicle operating and externality resource cost correction benefits. In summary, the total project benefits are estimated as follows:

Total Project Benefits *= Consumer surplus benefits + producer surplus benefits + resource cost correction benefits – deadweight loss of taxation + Other benefits*

For the purposes of the evaluation the different benefits resulting from the project are summarised in Table 7-2.

[15] Note: this combines the various components of a public transport trip including access time, wait time, in-vehicle time and interchange time.

Table 7-2: Summary of Project Benefits

ATC Benefit Categorisation	Benefit sub-components
Perceived consumer surplus benefits	Existing rail users.
	Rail users who are diverted from other public transport sub modes.
	Generated public transport users.
	Rail users who are former car drivers and car passengers.
	Remaining road users who benefit from reduced congestion and reduced vehicle operating costs.
Producer surplus	Additional resource operating cost from running additional train services.
Resource cost corrections	Incremental fare revenue from increased public transport usage.
	Loss in toll road revenues.
	Resource cost correction of private vehicle operating costs.
	Resource cost correction of externality cost reductions (accidents, noise, air quality, GHG etc).

Source: Study assumptions based on ATC guidance

The quantification of perceived consumer surplus benefits relies on the SKM – Aurecon JV demand model to directly estimate some of the main benefits arising from the project in terms of consumer surplus based on a willingness to pay approach to benefit quantification. This includes the journey time and cost benefits for existing passengers as well as application of the rule-of-a-half for diverted passengers. The estimation of the transport system benefits are described in more detail in Appendix C.

7.4.2 Expansion factors

The demand model outputs are expressed in terms of a 24 hour weekday period. In order to expand the daily demand and benefit outputs to annual equivalents, an expansion factor of 280 is applied to public transport trips and 318 for private vehicle trips.

The difference in factors between public transport and highway is due to the different usage patterns at weekends and public holidays. On non-work days, car usage remains relatively higher compared to a work day than public transport since people use cars for other trip purposes including retail and leisure based trips. These trips are not so frequently undertaken by public transport, so during non work periods, public transport usage is much lower than compared to working days where it is used for commuting and other work related purposes. Hence over a year car has a higher annualisation factor than public transport. A summary of the annualisation factors to be used in the analysis is provided in Table 7-3. A detailed description of the derivation of these factors is contained in Appendix B.

Table 7-3: Day to Year Expansion Factors

Type of day	Annual number	Public transport share of working week day	Public transport weighted week days per year	Private transport share of working week day	Private transport weighted week days per year
Working weekday	251	100%	251	100%	251.0
Saturday	52	33%	17	70%	36.4
Sunday	52	18%	9	50%	26.0
Public holiday	10	18%	2	50%	5.0
Total			**280**		**318**

Source: ATC Guidelines (2006), Tables 1.6.14 and 1.6.16 for public transport. Figures may not sum due to rounding.

7.4.3 Perceived user benefit calculations summary

7.4.3.1 Demand modelling benefit summary

The outputs from the demand model concerning the perceived benefit calculations are shown in Table 7-4. The model results are shown for two forecast years – 2021 and 2031, and disaggregates the outputs between work and non-work trips[16]. The table also shows the resultant benefit estimates derived through the application of unit parameter values (value of time) and annualisation factors. Further details of the individual benefit calculations are contained in Appendix E.

[16] Work based trips are those undertaken in the course of business hours for work purposes, whereas non-work trips include all other activities including access to/ from work (commuting), retail and leisure activities.

Table 7-4: Perceived User Benefit Calculations Summary

	2021 work	2021 non-work	2021 total	2031 work	2031 non-work	2031 total
Perceived Benefit (million minutes per day) – source: demand model						
Public transport user	0.002	3.693	3.695	0.004	6.934	6.938
Private car user	0.010	0.511	0.521	0.060	2.730	2.790
Freight vehicle	0.030	-	0.030	0.440	-	0.440
Perceived benefit ($ million per annum) – derived in economic evaluation						
Public transport user	1	249	250	1	543	544
Private car user	3	39	42	13	242	255
Freight vehicle	5	-	5	55	-	55
Vehicle operating cost benefit ($ million per day) – source: demand model						
Private car operating cost	0.002	0.084	0.086	0.011	0.490	0.501
Freight vehicle operating cost	0.006	-	0.006	0.084	-	0.084
Vehicle operating cost benefit ($ million per annum) – derived in economic evaluation						
Private car operating cost	-	28	28	3	161	164
Freight vehicle operating cost	2	-	2	27	-	27

Source: SKM – Aurecon JV Demand Model, Deloitte assumptions. Note figures may not sum due to rounding.

In the full evaluation, values between 2021 and 2031 are derived through interpolation.

7.4.3.2 Travel time benefits

The benefit perceived by public and private transport users is represented by the change in their consumer surplus. This is measured by the change in consumer surplus between each origin and destination for each mode. In the consumer surplus calculation, a unit value of travel time is required for both private vehicle transport as well as public transport users. There are a number of sources for obtaining appropriate values of time for different traveller classes. These include Austroads, the Australian Transport Council, NSW Roads and Traffic Authority (RTA) and NSW RailCorp. All sources provide similar values of time when expressed in 2010 values. The proposed value of time parameters per trip user to be used in the economic evaluation is shown in Table 7-5.

Table 7-5: Value of time (VOT) Assumptions (2010 dollars)

User	VOT ($/hour)
Public transport user – non work	12.3
Public transport user – work[17]	29.0
Car – non work	12.3
Car – work	29.0
Commercial vehicle[18]	22.8

Source: Deloitte, estimates are shown for all day average values.

The value of time is also assumed to increase over time in line with real income growth. This is calculated from the net difference between average weekly earnings (AWE) and consumer price inflation (CPI) which equates to 1.5% per annum in real terms[19].

The above values of time are applied to the estimates of travel time saved disaggregated by mode (public transport and private transport – car and commercial vehicle) and trip purpose (non-work and work). The benefit calculations are detailed in Table E.1, Table E.2 and Table E.4 in Appendix E.

7.4.3.3 Vehicle operating cost benefits

The project will facilitate a mode shift from car to public transport. As a result for those car and commercial vehicle users who remain on the highway network in the project case, there will be an improvement in vehicle speeds as a result of the decongestion due to less road vehicle in total. This increase in vehicle speeds will result in more efficient motoring (less stop starts, idling etc) and as a result there will be a reduction in unit vehicle operating costs.

The method for calculating the vehicle operating cost is prescribed by Austroads[20] and is given in the following formula:

$$\text{Vehicle operating cost} = A + (B/V) + (C * V) + (D * V^2)$$

Where V = Average speed (km/h) and A, B, C and D are Austroads developed coefficients which are summarised in Table 7-6. The coefficients shown have been derived based on data provided for different road classes as applied in the Brisbane Strategic Multi Modal Model. The derivation of these parameters is discussed in more detail in Appendix D.

[17] Derived by using the same relationship between the car work and non-work ratio and applied to the public transport user non-work estimate.

[18] Based on an average heavy vehicle split of 50% light truck (2 axle, 4 tyre) and 50% 5 axle articulated truck.

[19] ABS data was assessed to verify this assumption. Based on ABS dataset 6302, A2795832K, average weekly earnings (AWE) in Queensland increased by an average of 5.0% per annum between 2000 and 2010. Over the same period, ABS dataset 6401, A2325816R, the consumer price index (CPI) increased by 3.5% per annum.

[20] Austroads, Guide to Project Evaluation Part 4: Project Evaluation Data (2008).

Table 7-6: Vehicle Operating Cost Coefficients (2009 dollars) – cents per km

Vehicle	A	B	C	D
Car	6.722	1,358.492	0.1509	0.000375
LCV	-16.708	2,944.657	0.2453	0.000966
MCV	-11.279	7,532.889	0.3635	0.003113

Source: Deloitte estimates based on Austroads data.

The change in vehicle speed as a result of the project is measured on a link by link basis in the demand model. This allows the change in vehicle operating cost for each origin – destination trip to be measured. The total benefit is subsequently derived through the aggregation of all of these calculations for the without project and the project case.

The above values are input into the demand model to estimate the operating savings as a result of Cross River Rail. The benefit calculations, disaggregated by mode (car and commercial vehicle) and trip purpose (non-work and work), are detailed in Table E.3 and Table E.5 in Appendix E. Given the values in Table 7-6 are given in 2009 values all VOC benefits were uplifted by a factor of 3.2% to convert to 2010 equivalent values. Daily estimates were converted to annual equivalents using the private vehicle annualisation factor of 318.

7.4.3.4 Passenger rail reliability benefits

In the without project case, against a background of increasing passenger demand, the rail network is likely to become increasingly unreliable in future years. This will occur due to a number of reasons including increased train services on existing infrastructure running closer together and therefore increasing the chance of incidents as well as due to increased passengers using the network. In the case of the latter, in peak periods, trains are likely to experience increased station dwell times as crowding will mean that trains will take longer to load and unload. As a result of this unreliability, the incidences of train services not running to the scheduled timetable, is likely to increase.

There is a range of advice and guidance as to how to measure public transport reliability including assessing changes in service lateness and the variability of lateness. This approach is recommended by the UK Department for Transport in its appraisal guidance but relies on time series reliability data to support a robust analysis.

In the current evaluation, Systemwide operations analysis has been used to assess the reliability of the train service plans with and without the project based on the level of demand across the network in the AM peak period. On-time reliability was forecast for the both the with and without project scenarios for 2016 and 2031. These forecasts were derived using dynamic simulation of the detailed timetables developed to match proposed service plans in the RailSys software package. On-time reliability was forecast for services operating in both directions from the start of operations until 10am.

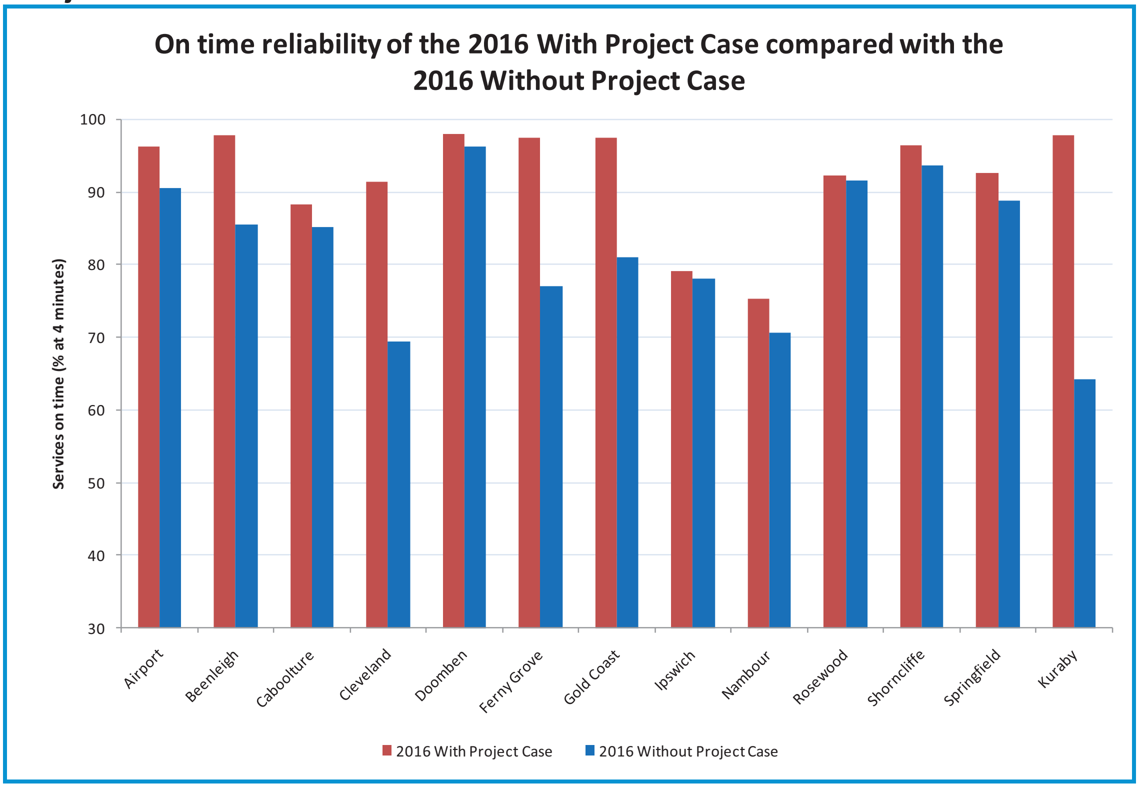
The proposed 2016 and 2031 with and without project forecast on-time reliabilities are shown below in Figure 7-4 and Figure 7-5. In both 2016 and 2031, the without project scenario was less reliable than the with project scenario. For the 2016 scenario, this is because:

- There are a similar number of passengers travelling in the AM peak 2 hours, but on fewer services
- There is less inner city capacity, requiring services to operate on corridors that are closer to their operational capacity, increasing the impact of flow-on delays.

For the 2031 scenario, the with project scenario is much more reliable than the without project scenario because:

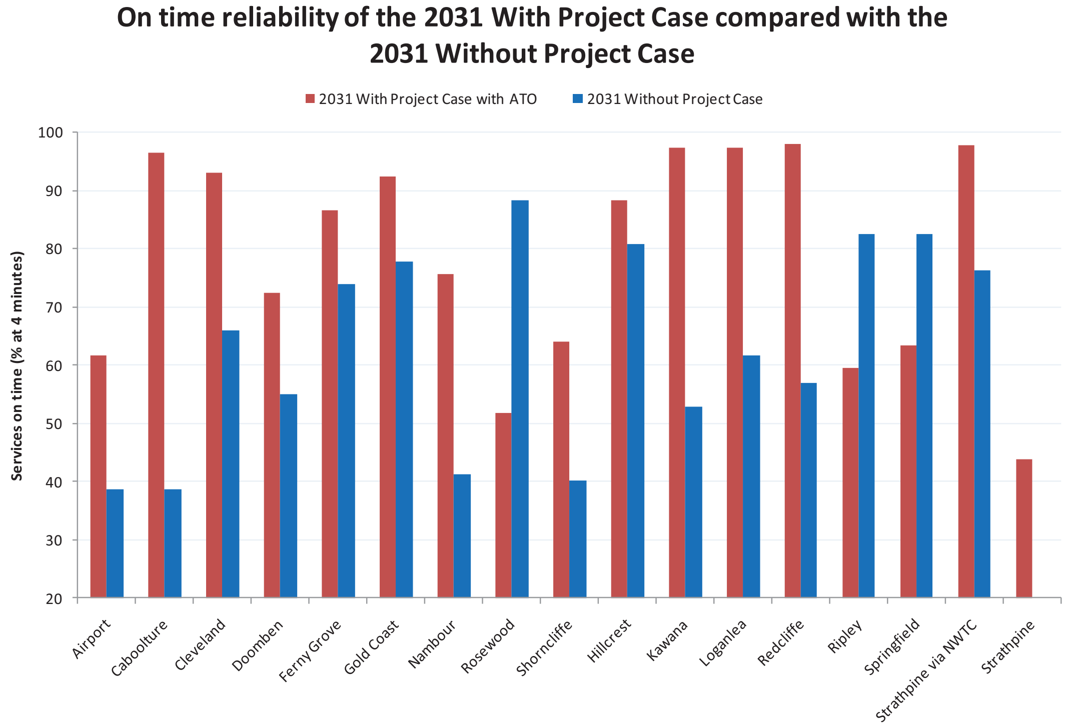
- Many more passengers travelling in the AM peak 2 hours, but on 28 fewer services, increasing crowding and dwell times
- 9-car services not being operable in the without project scenario, reducing carrying capacity and increasing crowding and dwell times
- All corridors in the without project scenario operating at capacity, increasing the impact of flow-on delays.

Figure 7-4: On-time Reliability of 2016 With Project Case Compared to the Without Project Case



Source: Study team

Figure 7-5: On-time Reliability of 2031 With Project Case Compared to the Without Project Case



Source: Study team

The predicted reliability levels are a useful guide to expected performance and the prediction of around 65% of trains on-time in 2031 for the without project case is particularly poor. These types of reliability levels would normally be associated with a very poor perception of the railway. The on-time reliability forecasts are summarised in Table 7-7.

Table 7-7: Comparison of On-time Reliability Forecasts Between 2016 and 2031

Scenario	Weighted network average on-time reliability[1]
2016 with project	92.9%
2016 without project	82.4%
Difference	**10.5%**
2031 with project	82.8%
2031 without project	64.6%
Difference	**18.2%**

Source: Study team

1. Percentage of inbound trains on-time within 4 minutes in the 2 hour AM peak

Rail reliability passenger weighted minutes (PWMs) are a useful indicator of how reliability actually affects the travelling public as it estimates the total delay on a passenger by passenger basis not on a train by train basis. PWMs are obtained by multiplying the average delay of a service at a particular station by the number of people alighting at that station (but not transferring to another service). Table 7-8 summarises the PWMs for the 2016 and 2031 with project without project scenarios for inbound and outbound passenger services during the AM peak 2 hours.

Table 7-8: Passenger Delay Minutes – AM peak Period (per day)

Year	Without project	With project	Difference
2016	247,434	169,320	78,114
2031	932,182	399,169	533,013

Source: Systemwide

In the discussion on generalised costs in section 7.2.3, a weighting to passenger delay minutes is assumed. This factor is equivalent to the passenger wait time of 2.0 which implies that 1 minute of passenger delay time is equivalent to 2 minutes of passenger in-vehicle time. This weighting was applied to the passenger delay minutes summarised in Table 7-8 above. In addition, it is assumed that an equal level of service unreliability occurred in the PM peak period.

The daily estimates of passenger delay were converted to annual equivalents by multiplying by an annualisation factor of 250 (5 days per week * 50 weeks per year). The resulting passenger rail reliability benefits are estimated to be $36 million in 2021, increasing to $149 million in 2031. Values between 2021 and 2031 were derived through interpolation; whilst post 2031 the reliability benefits were assumed to be constant. The detailed estimation of the passenger rail reliability benefits are contained in Table E.6 in Appendix E.

7.4.4 Resource cost correction benefits

7.4.4.1 Toll revenue impacts

As a result of the predicted mode shift from private transport to public transport, there will be a reduction in road usage. This reduction includes a reduced number of VKT on toll roads within the Brisbane road network. The demand model includes this impact through a reduction in the perceived cost of travellers who switch from road to rail, which represents an increase in consumer surplus for those travellers. However, at the same time, the reduction in toll revenue will represent a reduction in producer surplus to the toll road operator. Consequently, in the economic evaluation, in order to ensure that the effect is fully accounted for, the gain in consumer surplus needs to be offset by the loss in producer surplus. Given that the increase in consumer surplus is already accounted for in the demand modelling, the loss in producer surplus also needs to be included to ensure consistency.

The change in toll revenue has been determined by the demand model by establishing the reduction in VKT undertaken on toll roads and applying the toll to establish the reduction in revenue. This calculation is summarised in Table 7-9. In order to convert daily estimates to annual equivalents an annualisation factor of 318 is applied. Further details of the toll road revenue impacts are provided in Table E.7 in Appendix E.

Table 7-9: Toll Revenue Impact Estimates

Year	Daily ($)	Annual ($ million)
2021	-2,236	-0.7
2031	-6,288	-2.1

Source: SKM – Aurecon JV Demand Model

7.4.4.2 Incremental fare revenue

The inclusion of fare revenue in the economic evaluation is supported by the ATC guidelines since additional public transport users have to pay a fare, which is part of their perceived costs in making their mode choice decision. However, since the resource cost of providing public transport (both capital and operating) is already included elsewhere in the evaluation, it is necessary to add fares back in as a component of benefits to derive the net resource cost.

Incremental fare revenue estimates as a result of the mode shift from car to public transport as a result of the project are obtained from the demand model. In the demand model, unit fares are based on the existing TransLink fare schedule expressed in 2010 prices. In future years, the fare schedule will include the real increase in fares as proposed by TransLink in late 2009 which increase fares in real terms up to 2014. The estimates of incremental fare revenue are summarised in Table 7-10. Further details of the incremental fare estimation benefits are provided in Table E.8 in Appendix E.

Table 7-10: Incremental Passenger Fare Revenue

Year	Without project	With project	Difference
2021	919.5	942.2	22.7
2031	1,229.8	1,302.6	72.8

Source: SKM – Aurecon JV Demand Model, Deloitte assumptions.

7.4.4.3 Unperceived vehicle operating resource cost correction

As discussed and quantified in section 7.4.3.3, the diversion in passenger trips from road to rail will lead to a reduction in car vehicle operating costs. However, some aspects of VOC will already be captured in the decongestion benefit and it is likely that the perceived operating costs (fuel, tolls etc) which affect the decision to make a trip will already be accounted for in this measure. Additional resource or unperceived operating cost (vehicle depreciation, servicing costs, insurance etc) of a car trip would not be factored into a trip decision making process. Consequently, the reduction in the resource cost component of operating costs is assumed to be a benefit in the case of a switch to rail.

The resource cost correction is based on the RTA estimate[21] and is $0.14 per car kilometre. This value has been updated to a 2010 equivalent price base by applying the change in the general inflation level in the intervening time period. Consequently, the VOC resource cost used in the analysis is $0.143 per car kilometre. This value is applied to reduction in private transport vehicle kilometres travelled (VKT) as a result of the project in each year to determine the reduction in externality costs as a result of the project. The benefits by forecast year are summarised in Table 7-11.

[21] RTA Economic Appraisal Manual, Economic Parameters for 2009, page 2 Table 1

Table 7-11: Unperceived VOC Resource Cost Correction Benefits

Year	Annual ($ million)
2021	14.0
2031	33.6

Source: SKM – Aurecon JV Demand Model, Deloitte assumptions.

7.4.4.4 Externality cost resource correction

As a result of the project there will a mode shift from private transport to public transport. The resultant reduction in car usage in the project case will mean that there will be a reduction in externality costs compared to the without project case. The unit externality cost assumptions to be used in the analysis are based on RailCorp guidance and are summarised in Table 7-12.

Table 7-12: Externality Parameter Values (cents/vkt – 2010 values)

	Passenger cars
Accidents	5.00
Air pollution	2.26
Greenhouse	2.21
Noise	0.73
Water	0.35
Nature and landscape	0.15
Urban separation	0.52
Upstream/ downstream costs	3.79
Total	**15.00**

Source: RailCorp, updated to 2010 values.

Note: assumes an 80%/20% urban/rural split as per the assumptions in the Queensland Integrated Regional Transport Plan (IRTP) economic evaluation.

The above values are applied to reduction in private transport vehicle kilometres travelled as a result of the project in each year to determine the reduction in externality costs as a result of the project. In addition, the increase in externalities caused by increased rail service kilometres was also factored into the benefit estimation. A unit externality cost of $0.0725 per rail car kilometre (based on RailCorp guidance) was applied in the analysis and was multiplied by the increase in rail service kilometres as a result of the project.

The benefits by forecast year are summarised in Table 7-13. The detailed benefit calculations are shown in Table E.10 in Appendix E.

Table 7-13: Externality Cost Reduction Benefits

Year	Annual ($ million)
2021	13
2031	34

Source: SKM – Aurecon JV Demand Model, Deloitte assumptions.

7.4.4.5 Accident cost resource correction

As a result of the project there will a mode shift from private transport to public transport. The resultant reduction in car usage in the project case will mean that there will be a reduction in accident costs compared to the without project case. The unit road crash externality cost assumptions to be used in the analysis are based on Austroads guidance and recent work to assess the economic viability of the Integrated Regional Transport Plan for South East Queensland[22]. The crash rates and crash costs are summarised in Table 7-14.

Table 7-14: Crash Rates and Crash Costs (Road)

Accident type	Crashes per million VKT	Crash cost ($2010 values)
Fatal	0.007166	2,352,371
Hospitalised	0.086946	565,005
Minor Injury	0.193080	24,296
Property damage only	0.212011	8,880

Source: IRTP Economic Analysis, Austroads

Note: assumes an 80%/20% urban/rural split as per the assumptions in the IRTP economic evaluation.

The above values are applied to reduction in private transport vehicle kilometres travelled as a result of the project in each year to determine the reduction in accident costs as a result of the project. The benefits by forecast year are summarised in Table 7-15[23].

Table 7-15: Crash Cost Reduction Benefits

Year	Annual ($ million)
2021	7
2031	17

Source: SKM – Aurecon JV Demand Model, Deloitte assumptions.

7.4.4.6 Reduced car ownership benefits

The extent to which a new public transport investment differentially leads to a reduction in car usage and a reduction in car ownership is difficult to determine. Little empirical evidence is available and generally it is only asserted. It depends on pre-existing car ownership levels, location and characteristics of households, the nature of car usage for discretionary and non-discretionary travel. No clear empirical evidence as to whether such an outcome would occur as a result of Cross River Rail is available. It appears that only if there were clear indications as to whether such an outcome were to eventuate should the provision described in the ATC guidelines be taken up. In this event, if such an outcome were to occur, a resource cost correction would be appropriate.

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[22] AECOM, Connecting SEQ 2031: An Integrated Regional Transport Plan for South East Queensland, Economic Appraisal of Investment Scenarios, Economic Analysis Paper, November 2009.

[23] It should be noted that this assessment does not include any quantification of the potential reduction in benefit due to the increase in rail crash costs as a result of increased rail patronage. Rail crash incident data was not available to support the inclusion of such potential costs in the current analysis. Based on the low probability of rail crash incidents occurring, this omission is not expected to influence the overall evaluation to any significant extent.

The economic evaluation already incorporates a vehicle resource cost correction, representing the difference between the perceived costs, taken into account in the transport model, and the full resource costs. This correction excludes fuel costs, which are considered perceived costs, but includes all other costs including depreciation. By including fixed vehicle costs, irrespective of car usage, this correction could be considered already to reflect reductions both for car usage and car ownership and we believe that any additional cost savings runs the risk of double counting of benefits. Therefore, any further benefit of reduced car ownership has not been included in the evaluation.

7.4.4.7 Reduced car parking spaces benefit

The transport model has provided estimates of the amount of car parking revenue which is forgone as a result of car users diverting to public transport. This revenue represents a reduction in the producer surplus enjoyed by car park owners.

However, this matches the corresponding gain in consumer surplus for the car diverters. As the payments constitute a transfer payment, they cancel out and they need to be treated in the inverse way in which the incremental public transport fare revenue is handled, i.e. they should be netted out of the total benefit stream.

Some economic evaluations explicitly incorporate as a benefit the costs of avoided car parking. This issue is most relevant when the price of parking is not perceived in the car users' generalised costs and when car parking spaces are provided free or at a subsidised rate. In the current evaluation, the transport modelled outcomes incorporate pricing charges in the generalised costs. Furthermore, where market rates apply for car parking and where multiple car park locations are provided in a competitive market environment, revenues and costs would generally match. If the car park payments reflect the market value of the car parking spaces provided (a situation which would reflect conditions in the CBD), it is reasonable to assume that, in the long run, changes in demand for car parking spaces would lead to changes in car parking supply provision. Thus, the loss of car parking revenue could be expected to lead to a reduction in car parking spaces and therefore to a reduction in car parking costs. Consequently it is assumed that there would be no sustainable change in the producer surplus for car park owners in a competitive, market-based environment.

As a result, any loss in car park revenue, taken as a modest loss in the transport model, would be matched by a corresponding reduction in car parking costs. In short, there would be no change in the producer surplus.

7.5 Freight market benefits

7.5.1 Introduction

Cross River Rail will create significant additional capacity on the Brisbane rail network. As well as allowing for increased passenger train frequencies, there would be beneficial impacts for freight train activities. The current predominant rail freight movements through the Brisbane rail network are:

- From the west to Fisherman Islands (export coal and grain)
- North to south for domestic containerised freight
- Interstate domestic freight to and from Acacia Ridge.

Section 6.4 indicates that significant growth in rail freight is forecast to occur in the next 20 years in all freight categories. All rail freight currently operates on the Brisbane suburban passenger network and traffic accessing the port passes over the rail lines through the CBD. In addition, intermodal container rail freight activities which largely have either an origin or destination at the Acacia Ridge container terminal share track with passenger services to the south of the city between Salisbury and Dutton Park.

Although rail freight services operate out of peak periods, increasing off peak passenger services could restrict rail freight activities, leaving it rail paths at times of day which are not attractive to freight forwarders. This is particularly true for intermodal container traffic where arrival and departure times are more critical in mode choice decision making.

With the increased capacity provided by Cross River Rail, additional rail freight paths become available which are likely to attract more freight to rail. In the without project case, it is possible that additional growth in freight might not be able to be accommodated by rail and would instead be forced to use road transport.

7.5.2 Rail freight capacity and demand

Operational modelling undertaken by Systemwide for 2016 and 2031 which has identified the current and future rail freight capacity for the with and without project cases. Economic benefits as a result of Cross River Rail were derived for these two years. Benefits in the intervening years (including 2021, the first year of benefits in the economic evaluation) were derived by interpolation. Beyond 2031, economic benefits were assumed to be constant.

The analysis is based on a number of assumptions regarding future network operations including the following:

- Peak freight curfew – freight operational hours are currently restricted by a passenger peak freight curfew, not allowing freight services access to the passenger network during the AM or PM peak hours, with restricted access during the shoulder period. It is assumed that this restriction will continue to be in place in 2016 and 2031, preventing freight operations for approximately 4 hours per day on shared track
- Hours of passenger and freight operation – Passenger services are assumed to operate between 4am and 2am on weekdays and 5am and 2am on Saturdays, and between 6am and midnight on Sundays
- Freight time sensitivity – The peak freight periods are 4 – 7am and 6 – 9pm. The future demand for freight services is assumed to be distributed through the day and the week as is current with intermodal services being the most time sensitive[24]
- Adjustments to the off-peak timetable – An intermediate 15 minute off-peak service strategy is proposed to be operated in 2016 and 2031.

In the with project situation, a Yeerongpilly tunnel portal location on the east of the existing network ensures that the dual gauge track between Yeerongpilly and Dutton Park is dedicated to freight services 24 hours per day, rather than being constrained in the without project case. The Systemwide analysis indicates that over time with the growth in the off-peak timetable, the number of available freight paths is reduced within the study area. This is summarised in Table 7-16 which shows the capacity for the North Coast Line as well as local intermodal container movements from the south and the west for both the without and with project scenarios.

It is evident that the level of available freight capacity as a result of Cross River Rail remains constant on the freight line to the Port and also that freight capacity declines in the without project situation on the North Coast Line as a result of the growth in off-peak passenger services which utilise the available capacity resulting in freight services being crowded of the network. The increase in freight capacity as a result of Cross River Rail is largely due to dedicated freight track between Yeerongpilly and Dutton Park as well as reduced passenger usage of the Exhibition Loop for North Coast Line services.

[24] With the provision of dedicated freight track between Acacia Ridge and the Port of Brisbane in the project case, there would be freight access during the peak which is currently limited due to the passenger curfew. In the analysis this benefit is included through a longer period of operation through the day.

The freight capacity was then compared to the unconstrained rail freight demand forecasts developed as part of the ICRCS analysis[25], which is also shown in Table 7-16. It is evident unconstrained rail freight demand is less than capacity in 2016 in both the without and with project scenarios (with the exception of access to the port which is estimated to be over-capacity). However, by 2031 the reverse is true, indicating that not all of the potential freight demand would be able to be accommodated by rail in the without project case.

Table 7-16: Freight Demand and Capacity Analysis – intermodal container traffic (trains/ paths per week – both directions)

Network area	2016 unconstrained demand (trains)	2016 Without project capacity (paths)	2016 Without project capacity (paths)	2031 unconstrained demand (trains)	2031 Without project capacity (paths)	2031 Without project capacity (paths)
North Coast Line	266	360	360	332	16	704
Salisbury - Port	81	3	137	101	3	137

Source: Systemwide

The Systemwide analysis also assessed coal export traffic demand and capacity. This indicated a similar situation to intermodal container traffic with demand greater than capacity by 2016. However, the ability to run additional coal trains from the mines to the west of Brisbane to the port is not only constrained by capacity limitations in the Brisbane metropolitan network but is also likely to require additional investment in other sections of the coal supply chain as well as additional rolling stock. Furthermore, given that coal is less time sensitive than intermodal traffic, it is feasible that coal train services could operate at other times of the day where there is spare infrastructure capacity. For this reason coal has been excluded from the analysis of freight benefits resulting from Cross River Rail.

The derivation of the economic benefits resulting from the changing balance between freight path capacity and demand is discussed in the following sections.

7.5.3 Freight task estimation

The data shown in Table 7-16 indicates that there is a shortfall in rail freight capacity with respect to unconstrained rail freight demand. Intermodal container traffic transport is undertaken in a highly contestable market between road and rail. Road transport offers flexibility, convenience and door-to-door delivery whereas rail offers economies of scale for some movements over certain distances. Generally, road is more competitive for short distance movements whereas rail becomes more competitive for longer distance movements. However, the shippers' mode choice decision is determined by a number of other factors including distance, required pick-up and delivery times, price and service reliability.

The current analysis does not seek to undertake detailed logit modelling to determine future mode shares for road and rail freight based on a range of market criteria. Instead, a simplified analysis is undertaken which takes the ICRCS demand freight forecasts and assumes that these are transported by rail subject to the capacity constraint. Freight volumes over and above the rail freight capacity constraint are assumed to be transported by

[25] As part of the Cross River Rail freight analysis, a demand validation exercise was undertaken by the project team. This process involved a review of primary data sources to assess the veracity of the ICRCS freight forecasts. The conclusion of this work was to concur with ICRCS freight demand analysis and consequently these forecasts have been used in the current Cross River Rail assessment.

road. Based on the data provided in Table 7-16, the rail/ road mode split is summarised in Table 7-17. The analysis shows the number of freight trains (or excess freight trains which are assumed to be transported by road) per direction per year[26].

Table 7-17: Rail Freight Demand Mode Split –intermodal container traffic (trains per year)

	Constrained rail demand (trains per year – both directions)				Excess rail demand (transported by road) – train equivalents per year – both directions)			
	2016	2016	2031	2031	2016	2016	2031	2031
	Without project	With Project	Without project	With Project	Without project	With Project	Without project	With Project
North Coast Line	13,300	13,300	800	16,600	-	-	15,800	-
Salisbury - Port	150	4,050	150	5,050	3,900	-	4,900	-

Source: Study analysis

In order to calculate the tonnages of freight which are transported by road and rail in the analysis, the operating assumptions shown in Table 7-18 are applied. The payload assumption is based on previous freight forecasting work undertaken by Deloitte on similar recent projects, and the utilisation rates are study assumptions based on the likely availability of back-haul cargoes for each product. Both assumptions also take into account the current imbalance in directional flows, particularly on the North Coast Line[27].

Table 7-18: Train Operating Assumptions

Item	Intermodal
Payload (tonnes)	1,000
Utilisation (per cent)	55%

Source – Study assumptions

The total net tonne-kilometres for without and with project scenarios are derived by multiplying the total number of tonnes of each freight type by the average trip length. For intermodal traffic, the benefits from mode switching were assumed to occur from the point of origin to destination. In order to calculate the appropriate haul distances a weighted average (based on North Coast Line origin destination data) is applied[28]. The resulting freight task calculations are summarised in Table 7-19. It is evident that in the with project case, more volume can be transported by rail than by road as a result of the increased capacity by Cross River Rail.

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[26] The annualisation factor to convert weekly to annual data is 50 which allows for limited maintenance, possessions and public holidays.

[27] North Coast Line cargo origin – destination data indicates that the largest flows are in the South to North direction which accounts for approximately two-thirds of the total corridor demand.

[28] The average trip length on the North Coast Line was estimated to be 867km, whereas the average trip length for metro intermodal traffic was assumed to be 10km. Based on an 80%/20% split of volume for these markets, the weighted average trip length was 696km.

Table 7-19: Rail and Road Freight Task Summary (net tonne-kilometres per annum – million)

Year	Rail without project	Rail with project	Road without project	Road with project
2016	5,149	6,642	1,493	-
2031	364	8,288	7,924	-

Source – Study assumptions

In the analysis, no generated demand is assumed, consequently, the estimates of total freight tonnes are assumed to be equal in the two scenarios with only the modal distributions being different. The data in Table 7-19 forms the basis for calculating the freight benefits in the following section.

7.5.4 Freight benefit estimates

7.5.4.1 Introduction

The benefits can be split into a number of areas. Some of the benefits are consumer and producer surplus benefits since rail freight operators will be offering its customers a superior service. There will also be benefits accruing to non-rail users and the community in general, such as decongestion for remaining road users and from reduced externality cost reductions as a result of a mode shift from truck/ car to rail which will reduce air and noise pollution and road crashes. The quantification of these benefits is described below.

7.5.4.2 Operating cost savings

In commercial freight markets compared with passenger services, prices charged for transport services are assumed to be related to the costs of provision. Thus reductions in transport costs are likely to be shared between transport users (by way of lower prices) and transport providers (by way of higher profits). From an economic efficiency viewpoint, it does not matter as to where the benefit falls and it is likely that in practice it will be shared depending on the level of contestability in the different markets.

For the purposes of this evaluation, we have identified this benefit as operating cost reductions, thereby occurring as increases in operator producer surplus. As a result of a switch of freight from road to rail there will be cost impacts on road and rail operators. To determine the impact of this effect, unit parameter values from the ARTC Inland Rail Study[29] have been applied. This study estimates that rail operating costs are 2.2 cents per net-tonne kilometre. To account for the pick-up and delivery component of the end-to-end trip, this estimate was increased by 50% (based on North Coast Line operating characteristics) giving a rail operating cost of 3.3 cents per net tonne kilometre. A weighted truck operating cost was estimated to be 4.8 cents per net tonne kilometre[30].

The net impact of the change in truck/ rail operating costs was calculated by multiplying the number of road to rail diverted net tonne kilometre by the difference in the operating costs.

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[29] Melbourne to Brisbane Inland Rail Alignment Study, Final Report, ARTC, July 2010.

[30] A composite vehicle operating cost was estimated based on the average load carried by a 6-axle trailer and a B-Double. The assumed carrying capacity of these vehicles is 25 tonnes and 40 tonnes and the vehicle split 40% (6-axle) and 60% (B-Double) respectively. Source - Melbourne to Brisbane Inland Rail Alignment Study, ARTC, July 2010.

7.5.4.3 Externality cost savings

Externality impacts of transport use were quantified following changes in the road and rail mode splits for freight traffic between the with and without project scenarios. Following the introduction of Cross River Rail, there is a forecast shift of freight from road to rail. In order to measure these impacts unit parameter values for a range of impacts were applied to the change in road and rail net-tonne kilometres. These values are based on the ATC National Guidelines[31] and are summarised in Table 7-20.

Table 7-20: Unit Externality Parameter Values - 2031

Externality	Road freight (c/net tonne-kilometre)			Rail freight (c/net tonne-kilometre)		
	Urban	**Rural**	**Wtd. Ave.**	**Urban**	**Rural**	**Wtd. Ave.**
Air pollution	0.97	0.01	0.32	0.33	0.00	0.11
Greenhouse gas	0.07	0.07	0.07	0.03	0.03	0.03
Noise	0.26	0.026	0.10	0.14	0.01	0.06
Water	0.10	0.06	0.07	0.01	0.01	0.01
Nature and landscape	0.26	0.11	0.16	0.08	0.03	0.05
Urban separation	0.22	0.00	0.07	0.08	0.00	0.03
Total			**0.79**			**0.28**

Notes:

1. All values are in 2005 Australian dollars
2. Freight vehicle values are based on heavy vehicle category
3. Rural rail values are derived from the urban rail estimates based on the same proportionate difference between road rural and urban. Average values assume a 32% urban travel and 68% rural travel. In 2016, the average split was 70% urban and 30% rural given the different mix between port IMEX and interstate traffic.

Source: Australian Transport Council Guidelines, Volume 3, Appendix Tables C.2 and C.3.

The analysis derives a weighted average externality value for both road and rail freight. These values (updated to 2010 dollars) were applied to the change in net tonne-kilometres to determine the overall reduction in externality costs as a result of Cross River Rail.

7.5.4.4 Road crash cost savings

The reduction in road freight will reduce the number of vehicle kilometres travelled by trucks and one consequence of this will be a reduction in the road crashes. Booz Allen and Hamilton[32] estimated crash costs for road and rail freight. These values inflated from 2001 to 2010 dollars are 0.40 cents per net tonne-kilometre for road and 0.038 cents per net tonne kilometre for rail. In the economic analysis, the difference between these values was multiplied by the reduction in road net-tonne kilometres with the project compared to the without project case to determine the overall level of benefit[33].

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[31] Australian Transport Council, National Guidelines for Transport System Management in Australia, Volume 3 Appraisal of Initiatives, Appendix C.

[32] Booz Allen Hamilton 2001, cited in Freight Australia 2003, The Future of Rail Freight Services in Victoria: a proposal to the Government of Victoria from Freight Australia, 21 March 2003.

[33] As with rail passenger benefits, the analysis does not include any quantification of the potential reduction in benefit due to the increase in rail crash costs as a result of increased rail freight as a result of the project. Rail crash

7.5.4.5 Road decongestion cost savings

The diversion of freight from road to rail as a result of Cross River Rail will lead to a reduction in truck kilometres. This reduction will lead to a benefit to the remaining road users by relieving congestion in peak times and speeding up traffic. In the analysis it was assumed that the decongestion effect would apply only in peak periods. In addition, this impact would only be realised in the urban areas of the road trip.

The average freight trip length is assumed to be 657km across the different freight markets. The majority of this trip is likely to occur in rural areas where road congestion is minimal. However, a certain proportion of the road freight trip would be undertaken on congested urban roads. In the analysis, the length of an average road freight trip undertaken on congested urban roads is assumed to be 10% of the total road freight trip length). In addition, based on RTA[34] literature the proportion of the business peak hours compared to the whole day is approximately 20%. Consequently, the decongestion benefits are applied only to this portion of traffic and time of day.

Therefore, applying a weighted average payload of 22 tonnes to the reduction in truck net tonne-kilometres gives the total reduction in VKT. The unit decongestion value was based on advice from RailCorp[35], which recommends a value for ‘decongested car trips’ of 41 cents per kilometre. The ATC and the New Zealand Transport Agency also provide estimates for decongestion values which are higher than the RailCorp estimate but also vary by congestion severity and time of day. However, the RailCorp value was utilised so as to take a conservative to estimating decongestion benefits in the current analysis.

The RailCorp decongestion value is based on an appropriate value for a passenger car. An appropriate value for commercial vehicles would be higher given the larger dimensions of these vehicles. In the evaluation, a unit congestion value for commercial vehicles was derived from the ratio of the commercial vehicle value of time and the non-work value of passenger time. Subsequently the road freight ‘decongestion value’ was derived at 78 cents per vehicle kilometre saved.

7.5.4.6 Freight benefits summary

The freight benefits are summarised in Table 7-21 and shows a breakdown of benefits by sub category. Further details of the freight benefit calculations are contained in Appendix E, Tables E.12 to E.15. Within the benefit components, the largest contributor to the freight benefit stream is the reduction in freight transport operating costs resulting from a switch in freight transportation from road to rail being passed on by freight operators through lower prices. This result is consistent with the findings of the other recent rail freight projects including the ARTC Melbourne to Brisbane Inland Rail Alignment Study where freight operating cost benefits also represent the largest component of project benefits. These benefits would occur to either freight transport operators (producer surplus) which would result in lower costs and increased profits or to freight consignees (consumer surplus) as a result of lower shipment costs. The distribution of these benefits to these different parties would be dependent on the competitive structure of the freight logistics industry. In all likelihood, these benefits would be shared between these two groupings.

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incident data was not available to support the inclusion of such potential costs in the current analysis. Based on the low probability of rail crash incidents occurring, this omission is not expected to influence the overall evaluation to any significant extent.

[34] Annual business peak hours =1,800 compared to a total annual number of hours of 8,790. This equates to approximately 20%. Source: RTA Economic Analysis Manual, Appendix B, Table 10.

[35] CityRail Compendium of Travel Statistics, RailCorp 2008.

Table 7-21: Rail Freight Benefit Summary ($ million)

Freight benefit category	2021	2031
Operating costs	39.1	118.9
Externality costs	22.5	47.5
Accident costs	9.8	29.6
Decongestion costs	1.9	5.6
Total	**73.2**	**201.6**

Source – Study estimates

8 Wider Economic Impacts

8.1 Introduction

This section provides a summary of the wider economic impacts analysis relating to Cross River Rail. This analysis was undertaken by Steer Davies Gleave who are internationally recognised experts in the area of assessing the wider economic impacts of major transport projects. The section includes a description of the components contributing to wider economic impacts, as well as their quantification for the current analysis. The methodology used in the quantification together with supporting information for the key assumptions are contained in Appendix F.

As with the conventional benefits, model outputs were provided for the without project case and project case for 2021 and 2031. Post 2031 wider economic impacts are assumed to remain constant as there is no supporting transport demand or land use information to support analysis beyond this year. Given the ongoing growth in population and employment beyond this date, this assumption is conservative.

8.2 Background

Transport improvements have the potential of impacting on the economy through a myriad of mechanisms. This could include changes in prices, economic output, labour supply, imports and exports to identify just a few. The impacts initially accruing to a firm or an individual will be passed on to other agents in the economy through changes in demand, prices, wages, investment, output, employment etc. In order to make sense of all these changes, it is necessary to identify metrics that encapsulate the impacts that are relevant to transport projects. The preferred metric in cost benefit analysis (CBA) of transport projects is economic welfare – or the society's aggregate willingness to pay for a project based on the perceived benefits it generates.

However, CBA makes a crucial simplifying assumption which relates to perfect competition. If the economy outside the transport sector is fully competitive, and there are no positive or negative externalities that distort markets, the sum of the direct gains to transport users of a project will be identical to the sum of the benefits after they have rippled through the economy, wherever they may end up. If the perfect competition assumption holds, it is legitimate to concentrate on measuring time and cost savings and this will ensure that all impacts are fully accounted for.

Over the last few years, it has been established that the CBA assumption of perfect competition is often unrealistic and that there may therefore be additional economic welfare gains, or losses, that conventional CBA fails to accurately measure. Crucially, a number of features of an urban economy may result in wider economic impacts as the direct gains are magnified as they pass through the broader economy.

8.3 WEI components

Consensus over the existence of wider economic impacts has been increasing over time and is now well accepted in the UK, both in academic circles and amongst practitioners. Research undertaken by a wide range of academics and consultancies has shown that there are external additional benefits for the wider economy that arise from transport investment but that are not included in a standard appraisal. Based on the findings of this research the UK Department for Transport (DfT) published in 2009 formal draft appraisal guidance on wider impacts (formerly called wider economic benefits) of transport. The guidance sets out in detail what these additional impacts are and how they can be estimated for individual schemes. The impacts include:

- **Agglomeration economies**. Transport brings activities and people closer together and effectively raising density of economic activity. In this way, labour markets can operate more efficiently, interactions in the economy are made easier or less costly, and the overall scale of activity accessible to local economies increases. Consequently, there are advantages that accrue to the economy. Agglomeration effects tend to be significant for schemes that improve transport within cities or links between them – especially when the links are heavily used by business, freight and commuters.
- **Imperfect competition effects**. Firms that benefit from transport improvements will experience lower costs, which in turn can be converted to increased turnover. Evidence shows that firms, on average, are able to charge more for additional sales than what it costs them to produce/ provide. Appraisal, however, values the benefits to firms based on cost savings which, for these additional sales, underestimates their value. Imperfect competition effects tend to be more important for improvements that deliver significant time and cost savings to travellers in the course of work.
- **Additional labour supply**. Many individuals are faced with difficult decisions about whether to or how much to work. The time and cost of getting to a place of work is clearly a disincentive to working and it is likely that, if transport costs were lower, more people would decide to participate in the labour market, subject to overall labour market conditions. Where a transport scheme does encourage additional labour supply, output will increase. Importantly, the additional taxation associated with the increased labour supply is additional to the welfare benefits estimated in conventional appraisal, albeit it is usually small in magnitude.
- **More productive jobs.** Much as transport costs are a barrier to joining the labour market, they also limit the physical space over which individuals are willing to work. Typically, access to jobs in city centres tend to be limited by congestion on radial links. Jobs in city centres also tend to be more productive than comparable jobs elsewhere (partly because of agglomeration effects). Relieving transport costs as a constraint to commuting longer distances can therefore enable further productivity gains by allowing employment to grow in highly productive locations. However, the assessment of this wider economic impact requires modelling of the land use changes of the projects. As is the case for Cross River Rail, land use assessments are often not undertaken and this impact cannot be quantified reliably.

8.4 Wider economic impacts of Cross River Rail

8.4.1 Introduction

In assessing the contribution of Cross River Rail to the economy through wider economic impacts, the methodological approach developed by the UK Department for Transport[36] has been applied. Similar methods have been or are being developed for other countries, including New Zealand and the US. The theoretical and practical underpinnings of these effects, as well as the methodology we have used to assess them, are set out in more detail in Appendix F.

Whilst these economic relationships will be in effect in any urban environment, their importance will depend on a range of local factors. It is therefore paramount for a robust assessment of wider economic impacts that it is based as far as possible on local evidence and datasets. The current analysis has included considerable effort in deriving appropriate evidence for Brisbane for the assessment for Cross River Rail. Further details of this evidence can be found in Appendix F.

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[36] The Wider Economic Impacts Sub-Objective, UK Department for Transport, 2009 (http://www.dft.gov.uk/webtag/documents/expert/unit3.5.8.php).

8.4.2 Agglomeration benefits

Agglomeration economies are enjoyed by firms located in area where economic activity is dense. The measure of density used in the assessment of agglomeration benefits is '*Effective Density'*, which is an estimate of a location's access to employment in all other locations, where the contribution of employment elsewhere is deflated by the perceived cost of access.

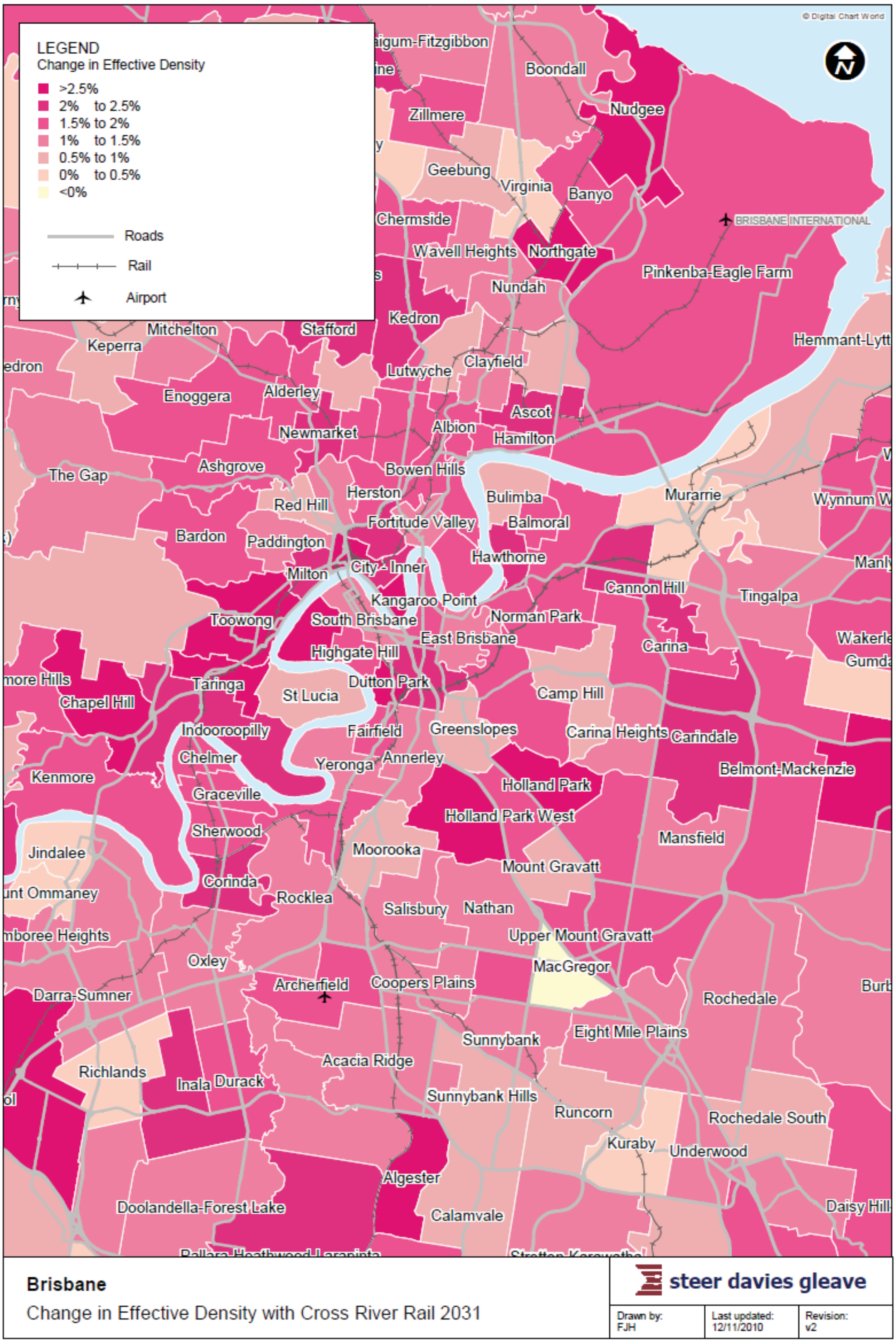
The impact of Cross River Rail on Effective Density will naturally be greatest along the study corridor. For a public transport improvement, it is, in particular, the effect of lower cost for workers of accessing locations of employment along the route that contributes to increased productivity, by increasing the pool of workers that firms can choose from. This enables firms to find workers more suitable to their requirements quicker.

Figure 8-1 plots the percentage increase in Effective Density that Cross River Rail delivers for Brisbane. The strongest improvements (the darkest shades) can be seen in the city centre and along the Cross River Rail corridor. In addition, there are improvements to parts of Brisbane that are not along the corridor, but either benefit directly though connecting public transport or indirectly though lower congestion on the road network. These include the Australia Trade Coast precinct as well as the western corridor. Figure 8-2 and Figure 8-3 show the distribution of the time and cost savings to public transport and car users, illustrating that car user benefits extend over a wider geographical area.

Evidence for Brisbane on the impact of an increase in Effective Density on productivity suggest elasticities from less than 1.5% to about 4.5% for the SLAs in inner Brisbane[37]. These variations by location reflect how more dense SLA's tend to attract the type of economic activity that particularly benefit from agglomeration, such as financial and business services. The estimates are within, albeit towards the lower end of the range of elasticities found internationally.

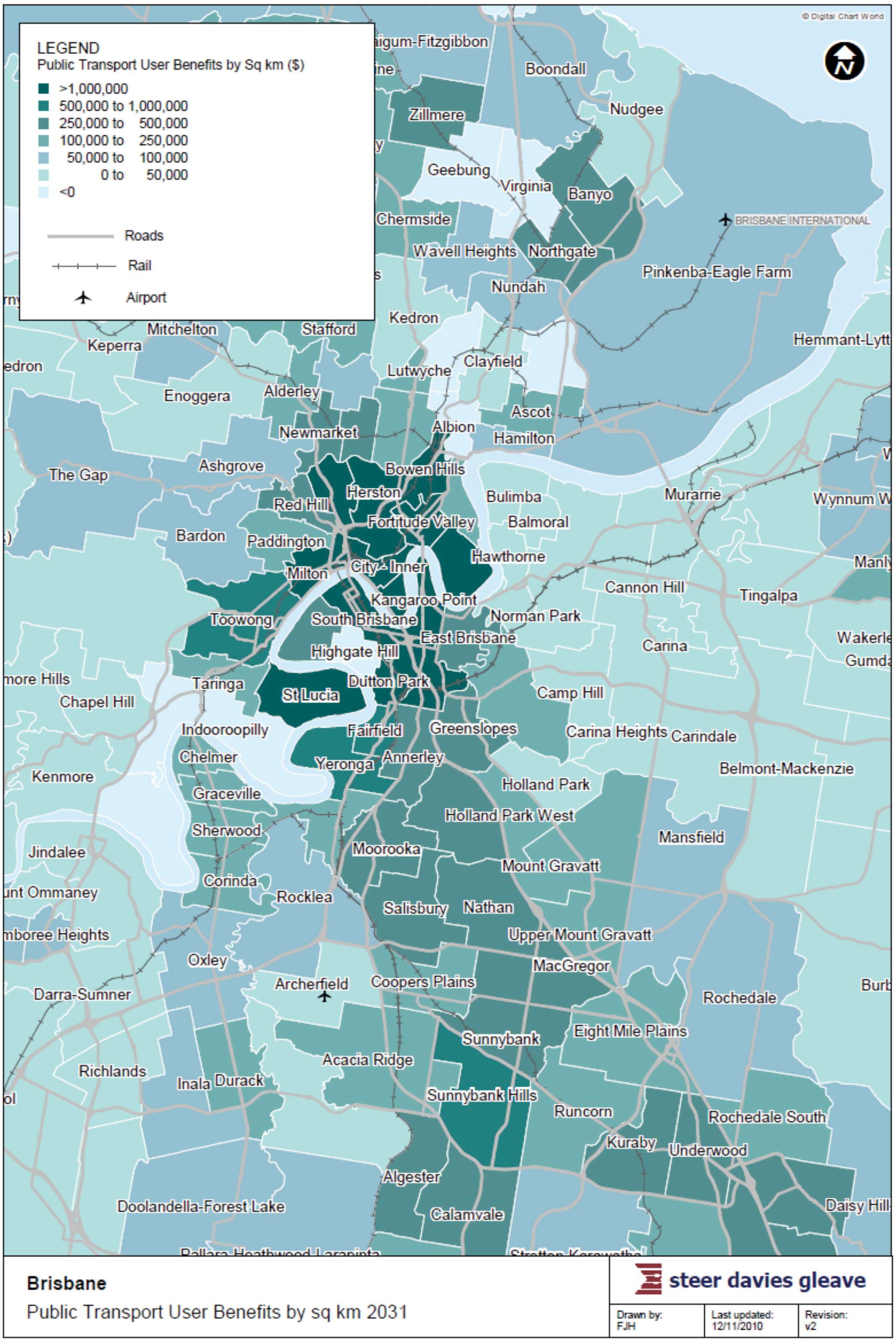
[37] An elasticity of 4% would mean that a 10% increase in effective density in a location results in a 0.4% increase in productivity of the average firm located there.

Figure 8-1: Change in Effective Density – 2031



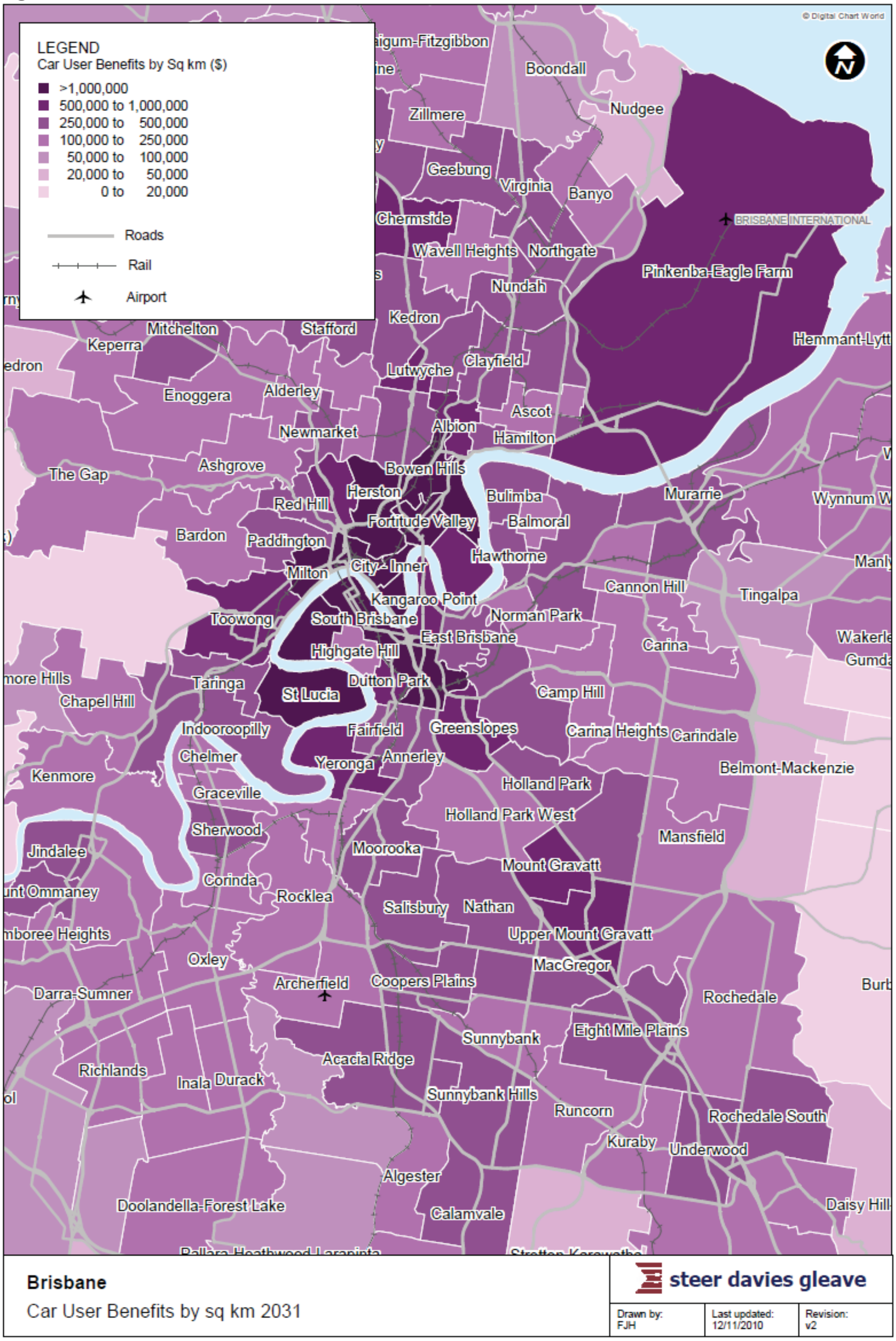
Source: Study team

Figure 8-2: Distribution of Public Transport Benefits - 2031



Source: Study team

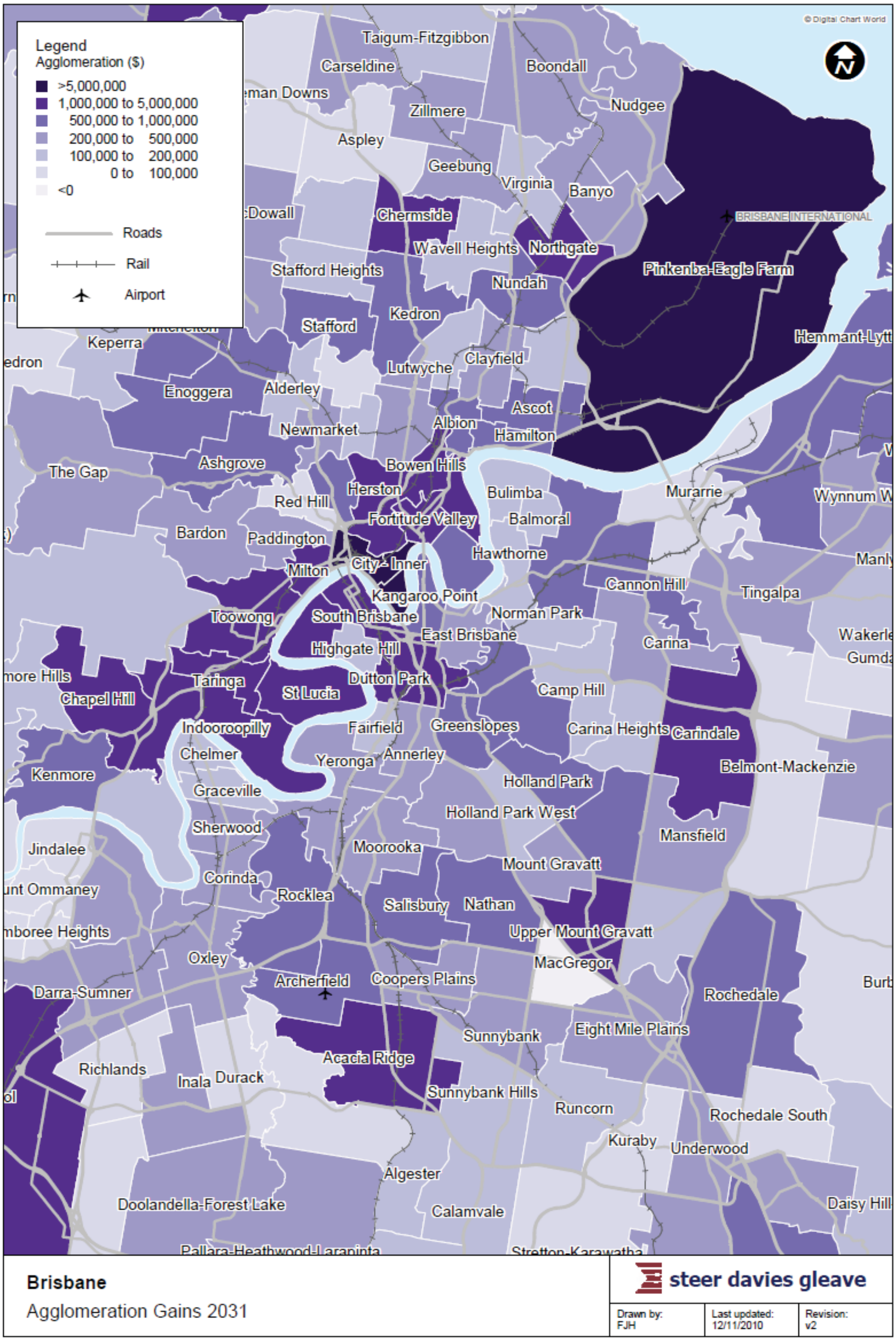
Figure 8-3: Distribution of Car User Benefits – 2031



Source: Study team

The increases in Effective Densities shown in Figure 8-1 above determine the increases in productivity or agglomeration benefits. The amount of overall agglomeration benefit in a zone depends on how much Cross River Rail increases its employment accessibility, how strong the agglomeration response is, how productive activity in the zone is in the base scenario as well as the number of jobs located there. Figure 8-4 plots the total benefits from agglomeration to Brisbane in 2031.

Figure 8-4: Agglomeration Benefits



Source: Study team

It is evident that the most of the agglomeration gains fall to the city centre as well as the Australia Trade Coast. Although there are sizable impacts also in the suburbs, this is in part caused by zones in these locations being much larger, such as Pinkenba-Eagle Farm.

Overall, the agglomeration benefits from Cross River Rail sum to $209 million per year in 2031, adding 17% to user benefits in that year. Of these, $94 million accrue to the six central zones. For 2021, the agglomeration gain adds up to $52 million, adding 14% to user benefits.

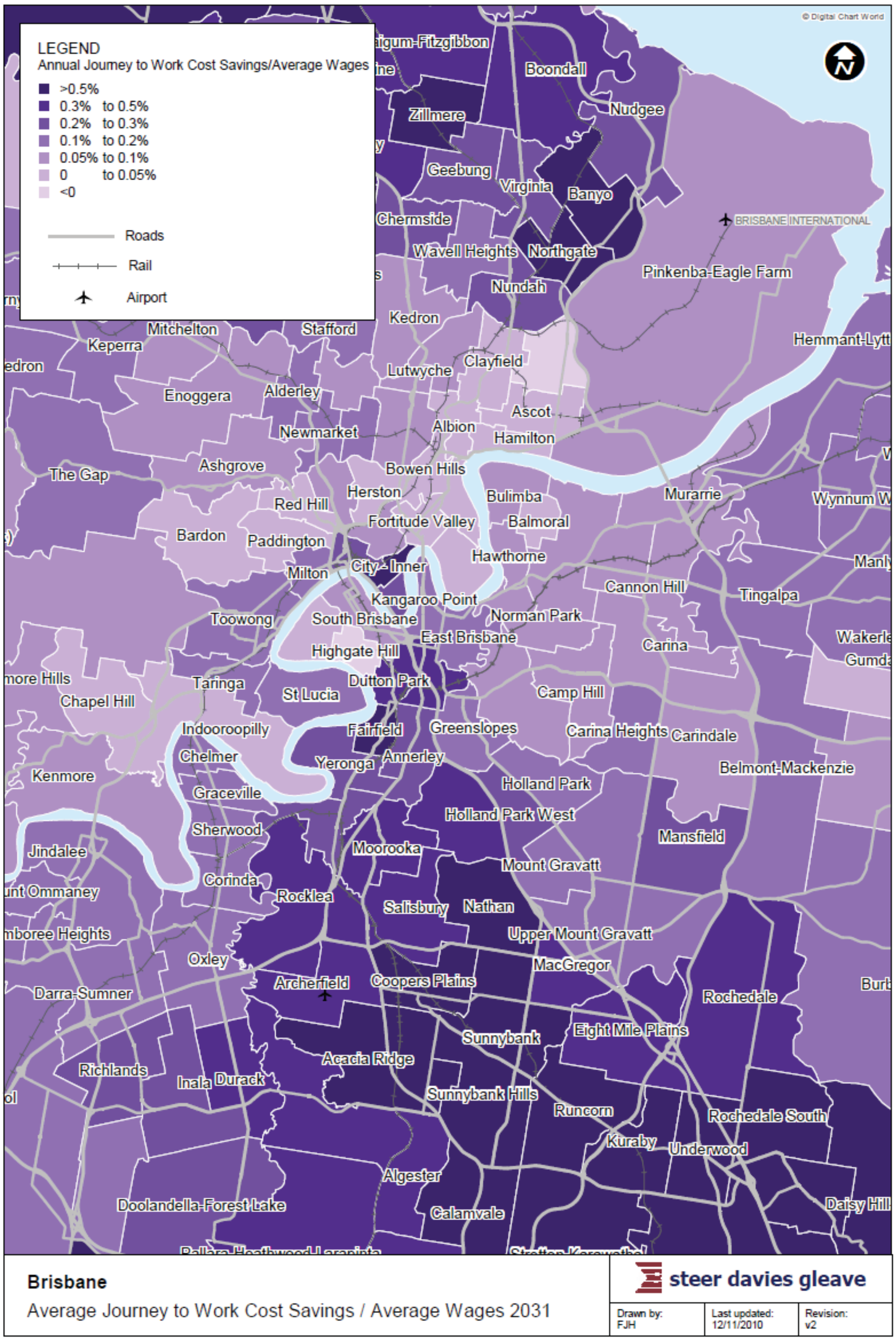
8.4.3 Labour supply benefits

Labour supply benefits are gains to society from increased taxation on the additional income earned caused by Cross River Rail. By reducing the cost of accessing jobs, improved accessibility can encourage non-participants, typical potential second-earners or family members with child care responsibilities, to take up employment. Although such change in behaviour caused by changing transport costs are only likely to be observed for a very few individuals, the societal effect for each can be significant[38].

Since income taxes are levied by government, the spatial distribution of the labour supply benefit is not very intuitive. Figure 8-5 shows the magnitude of the reduction in average travel to work costs from Cross River Rail in proportion to average net earnings in 2031.

[38] Whilst the annual reduction in journey costs may amount to $500 per worker, the income tax paid for each worker is on average about $15,000.

Figure 8-5: Annual Journey to Work Cost Savings in Proportion to Average Wage 2031



Source: Study team

It is evident that the most significant proportional impacts are for the zones along the rail lines using the Cross River Rail corridors. Workers living in the outskirts of the centre will in general have longer journeys to work and will hence will benefit from larger absolute journey time savings per journey.

The wider impacts method proposes that the behavioural response to a reduction in travel cost in proportion to earnings can be approximated to an increase in real wage. Hence it is possible to apply commonly available labour participation elasticities to estimate the labour supply response. Evidence for Australia suggests that the average labour supply elasticity is in the order of 0.4 – in other words, if real wages increase by 10%, labour participation increases by 4%.

Following this approach it is estimated that Cross River Rail will enable additional workers to join the labour market, generating a wider economic impact from additional of taxation income of $53 million in 2031, adding a further 4.5% of benefits to the conventionally measured user benefits. In 2021, the figure is $17 million.

8.4.4 Imperfect competition benefits

The wider economic impact from Imperfect Competition is a simple up-rate to business user benefits to reflect the price cost margins that cause them to be undervalued.

The study team has estimated an Imperfect Competition factor relevant to Queensland of 11.9%. However, since a very small proportion of journey savings from Cross River Rail accrue to businesses, the resulting wider economic impacts are insignificant. For 2031 the gains amount to $2.3 million, about 0.2% of conventionally measured user benefits.

8.4.5 Summary of wider economic impacts of Cross River Rail

Table 8-1 summarises the results of the wider economic impacts assessment of Cross River Rail. It is clear that the most important wider economic impact of Cross River Rail is agglomeration benefits. This result is in line with experience from previous assessments. Agglomeration adds about $20m to user benefits in 2016, rising to $209m in 2031.

Table 8-1: User Benefits and Wider Economic Impacts Summary (2010 dollars - million)[39]

Year	User benefits	Agglomeration	Labour supply	Imperfect competition	Total WEI's	Uprate (%)
2021	362	52	17	0.4	69	19%
2031	1,197	209	53	2.3	265	22%

Source: Study team

Labour supply benefits add almost 5% to user benefits. This is higher than what has been found for many other assessments. This is partly because travel to work is one of the main benefits from Cross River Rail, whilst the travel in the course of work is estimated to be small. Research has also found that the labour supply response to changing travel costs is stronger in Australia than in the UK.

Finally, the imperfect competition effect is negligible, again because of the limited use of public transport for work travel.

Overall, wider economic impacts add $265 million to the benefits of Cross River Rail by 2031, adding 22% to the perceived user benefits in that year. For 2021, the wider economic impacts amount to 19% of user benefits.

[39] Benefit estimates between 2021 and 2031 are derived through interpolation. Benefits post 2031 is assumed to remain constant. In the economic evaluation, the first full year of benefits is assumed to be 2021.

Table 8-2 compares the impacts of Cross River Rail (in 2021) against the wider impacts found in other full assessments internationally. The proportion of wider economic impacts to user benefits are lower for Cross River Rail than the average across all schemes, but similar to or higher than other comparable projects in Australia (Victoria Transport Package (19%) and Melbourne East West link Rail package (16%)).

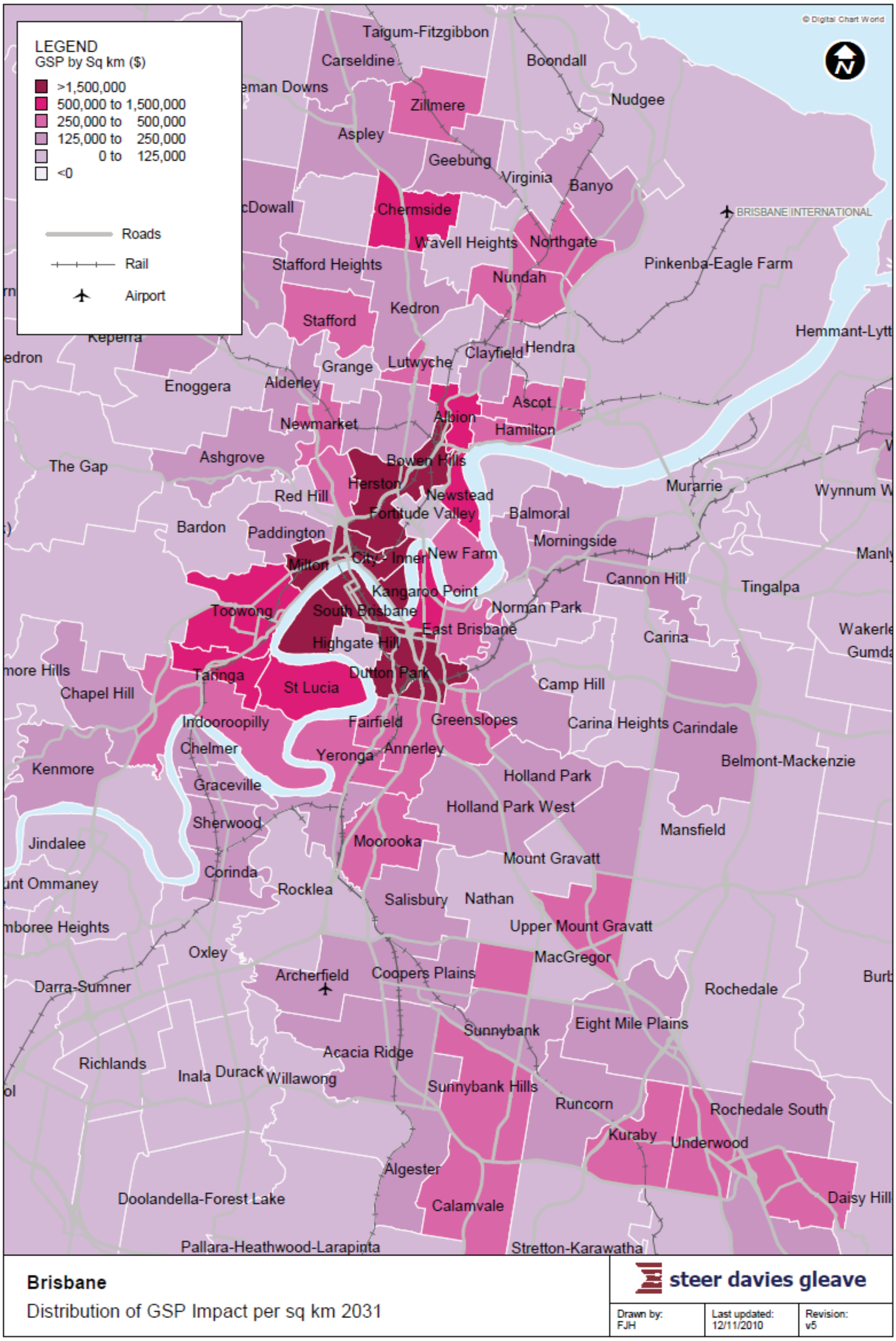
Table 8-2: Summary of Wider Economic Impacts by Project

Wider Impacts in proportion to conventional benefits						
Type of scheme	**Location**	**Scheme**	**Agglomeration**	**Imperfect competition**	**Labour market**	**Total additional**
Rail	Major City	Crossrail	24%	4%	28%	**56%**
HSR	Interurban	HSL London Birmingham	44%	8%	0%	**52%**
Road	Conurbation	Leeds to Bradford Improved Highway Connections	30%	6%	5%	**41%**
Road	Conurbation	Leeds Urban Area Highway Improvements	31%	5%	3%	**39%**
Mixed	Major City	Melbourne East West Road and Rail package	22%	2%	6%	**30%**
Rail	Major City	AirTrack	26%	2%	1%	**29%**
Road	Interurban	Leeds to Sheffield Highway Improvements	24%	6%	-2%	**28%**
HSR	Interurban	HSL Lisbon Porto	18%	8%	0%	**26%**
Average			18%	4%	3%	**25%**
HSR	Interurban	HSL Y-line London - Manchester and Leeds	18%	7%	0%	**25%**
Road	Urban	Waterview Connection	18%	5%	0%	**23%**
Bus	Conurbation	Leeds to Bradford PT Improvements	18%	3%	2%	**23%**
HSR	Interurban	HSL London - Scotland (west coast)	14%	8%	0%	**22%**
Road	Interurban	A46 interurban road	13%	6%	1%	**20%**
Mixed	Conurbation	Victoria Transport Plan package	17%	1%	1%	**19%**
Rail	**Major City**	**Cross River Rail, Brisbane (2021)**	**14%**	**0%**	**5%**	**19%**
Bus	Urban	Intra Leeds Bus Fare Reduction and Frequency	13%	2%	2%	**18%**
Road	Interurban	M6 shoulder	11%	5%	0%	**17%**
Rail	Major City	Melbourne East West Rail package	14%	1%	2%	**16%**
PT	Conurbation	Leeds Urban Area Major PT Investment	11%	3%	2%	**16%**
Bus	Area-wide	W Yorkshire Bus Fares and Frequency	10%	2%	2%	**15%**
Bus	Area-wide	Sth and W Yorkshire Bus Fares and Frequency	8%	3%	2%	**12%**
Bus	Area-wide	Sth Yorkshire Bus Fares and Frequency	3%	3%	0%	**5%**

Source: Study team

Figure 8-6 shows the distribution of wider economic impacts across Brisbane SLAs ($s per year in 2031, 2010 values), where darker colours represent larger benefits. In this plot benefits are shown per square kilometre in order to neutralise the impact of zone size. It is apparent how the benefits are concentrated around the centre and along the rail corridors running through it.

Figure 8-6: Gross State Product per Square Kilometre by SLA 2031



Source: Study team

9 Other Benefits

9.1 Introduction

In addition to the benefits outlined in the previous sections, there could be a number of other benefits arising as part of the project. However, due to limitations in data availability or appropriate methodologies to quantify their impact, it is not be possible to fully monetise their value for inclusion in the analysis. However, it should be noted that their inclusion would strengthen the results of the economic evaluation.

9.2 New rolling stock ambience benefits

In order to realise the full potential capacity increase provided by the Cross River Rail project, new rolling stock will be required. Rail users derive amenity and comfort benefits from the refurbishment and upgrade or purchase of new rolling stock. The effect of rolling stock improvements varies greatly according to the condition of the stock being replaced and of that replacing it. An indication of the overall magnitude of the effect of the new cars can be gained from the British Rail[40], [41] experience.

Research undertaken in the UK indicated that replacing old Network South East inner suburban slam door stock with new sliding door stock was worth around 8 per cent of the passenger fare. Steer Davies and Gleave (NZ) (1991)[42] estimated that the benefit to rail users was equivalent to a fare reduction of 20 per cent for replacing Johnsonville trains (pre-WWII stock) with new trains.

Pacific Consulting Infrastructure Economists (1995),[43] Douglas Economics (2006),[44] and Douglas and Karpouzis (2006)[45] have undertaken research in Sydney which estimated the values that CityRail passengers attached to each of the rolling stock types in CityRail revenue service using stated preference techniques. The research estimated that new rolling stock could be worth up to the equivalent of 5 minutes of passenger in-vehicle time which based on a value of time of around $12 per hour could be worth up to $1 per passenger trip.

Given the differences in rolling stock operated in Sydney and Brisbane, this benefit has not been quantified in the economic evaluation, however, with the potential introduction of new rolling stock on the Brisbane network such benefits are likely to occur.

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[40] British Railway Board 1990, Passenger Demand handbook, Director Policy Unit.

[41] Passenger Demand Forecast Handbook – August 2002.

[42] Steer Davies and Gleave (NZ) Ltd, The Effects of Quality Improvements in Public Transport: Part IIB — Detailed Market Research Results and Parameter Estimates, Final Report, Prepared for the Wellington Regional Council, April 1991.

[43] Pacific Consulting Infrastructure Economists Ltd 1995, *Value of Rail Service Quality* for CityRail Planning and Business Development.

[44] Douglas Economics 2006, Value and Demand Effects of Rail Service Attributes, Report to RailCorp, December.

[45] Douglas, N., Karpouzis, G. (2006), Valuing Rail Service Quality Attributes through Rating Surveys, 29th Australasian Transport Research Forum, Gold Coast, access at www.patrec.org/atrf on Sep 4, 2008.

9.3 Health benefits

Cross River Rail will promote more walking and cycling as people use public transport in preference to private car travel. This increase in walking and cycling will facilitate improvements in health, well being and labour productivity. These benefits are difficult to quantify directly, but evidence from other studies in Australia and elsewhere indicate that they could be significant.

Recent research[46] indicates that the benefits of increased physical activity can be significant with the main conclusions being that active-travel cities, which encourage people to walk or cycle, have more productive workforces by over 6%, which could equate to up to $4 billion.

9.4 Brisbane's international prestige

Whilst attracting economic activity from elsewhere in Queensland or Australia would not result in economic benefits arising to Queensland or Australia respectively, Brisbane is an international city and competes internationally for investment across a range of economic areas, high net worth residents and tourist/conference activity. Surveys[47] confirm that a world class transport system is an important factor in business decisions, both at a simple attractiveness level but also as a location decision for investors keen to access strong and productive labour markets.

This issue is discussed at length in Sir Rod Eddington's report[48] on the future of the UK transport system, and would likely result in a potential increase in benefits attributable to Cross River Rail.

9.5 Supporting Brisbane's knowledge corridor

Brisbane has a growing knowledge-based economy, also known as the Smart Community, which is built around biomedical research, healthcare and education facilities runs from Bowen Hills in the north through the CBD to Buranda south of the river. A large proportion of Brisbane's research is undertaken in this corridor with Queensland University of Technology (QUT) campuses in the north at Kelvin Grove and in the CBD at Gardens Point, and the University of Queensland at the southern end of the precinct at St Lucia.

In addition, the corridor also boasts a significant health precinct which includes the Royal Brisbane and Women's Hospital at Herston as well as the current site of the Royal Children's Hospital. At the southern end of the corridor the Princess Alexandra Hospital site hosts biomedical research institutes including the new Pharmacy Australia Centre of Excellence and will soon host the Translational Research Institute. According to the Queensland Government Planning Information Forecasting Unit (PIFU), Brisbane's population is forecast to undergo ageing in the next two decades which will increase the demand for medical services which will largely be located within Brisbane's Knowledge Corridor. In order to facilitate movement in and out of the corridor there will be a need to improve transport infrastructure in the area.

The Brisbane River, which runs between the CBD and the south of the precinct, acts as a major barrier to access between the northern and southern ends of the Corridor and could inhibit future growth due to lack of accessibility.

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[46] The Costs of Urban Sprawl (3): Physical Activity Links to Health Care Costs and Productivity, Roman Trubke, Peter Newman and Darren Bilsborough - http://www.pb.com.au/NR/rdonlyres/F0D6B16E-9595-44E3-B66D-958F08C3FD21/0/CUSPActivityHealthLR.pdf. (Accessed 7 October 2010).

[47] See a recent report by PriceWaterhouse Coopers in partnership with New York City – Cities of Opportunity (2009).

[48] UK HM Treasury/ Department for Transport, The Eddington Transport Study, 2006.

Cross River Rail will improve accessibility and mobility to and within the Knowledge Corridor and will thus promote improvements in access to the health and education facilities in the corridor. Moreover, Cross River Rail will also contribute to increased productivity and efficiency of the workforce employed in these industries as well as facilitating knowledge sharing and promoting further innovation through increased knowledge sharing.

9.6 Urban development benefits

Cross River Rail will enable higher urban densities within the city's existing urban footprint. Whilst simply moving residential or economic activity around a city is not an economic benefit, long term effects such as higher densities can have an important efficiency impact in the provision of public services and utilities.

There have been a number of recent studies which analysed the economic and financial implications of infill or increased density, for example:

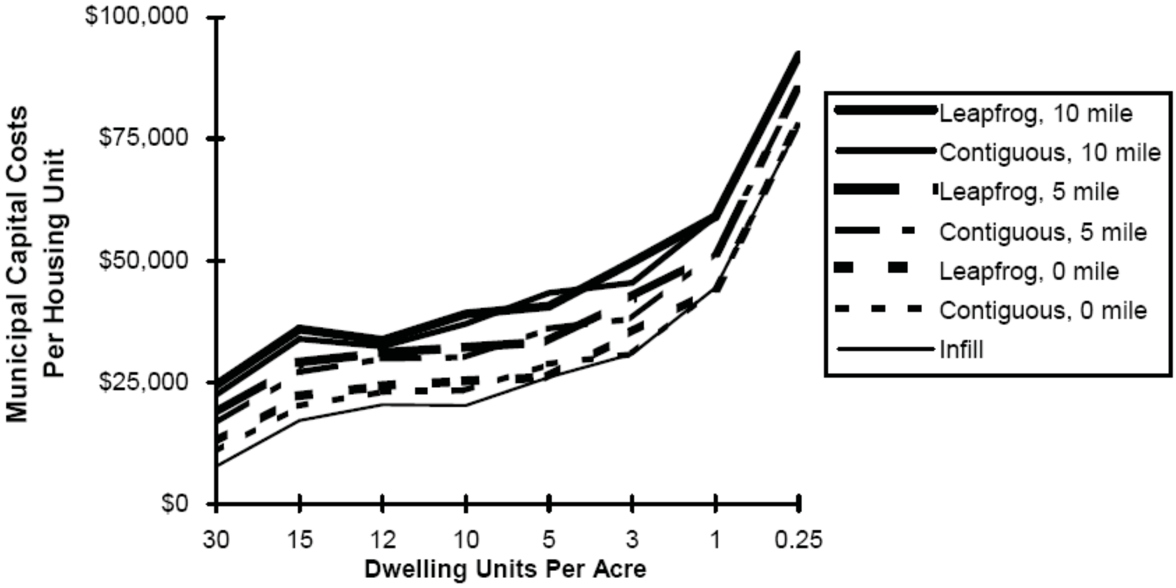
1. Curtin University research[49] which analysed the economic implications of greenfield verse infill development and took into consideration matters such as infrastructure costs, transportation costs, greenfield gas emissions, water, sewerage and other utility service provision costs and health related costs.
2. Parramatta Rail Link Study which used analysis undertaken by Professor Peter Ableson and Economic Research Associates to analyse the higher land use densification benefits which would accrue from the development of the Parramatta Rail Link project.
3. US Department of Transportation sponsored research[50] which showed a 15% increase in the cost of transportation, water, sewer, storm water and energy cost difference between metro sprawl and metro regional plan scenarios.
4. Urban Land Institute research[51] undertaken by Frank James which analysed the impact of the cost of public service provision depending on density and alternative settlement patterns (see Figure 9 - 1).

[49] Parsons Brinckerhoff, Assessing the Costs of Alternative Development Paths in Australian Cities, Roman Trubke, Peter Newman and Darren Bilsbrough, Curtin University Sustainability Polity Institute Fremantle

[50] Parsons Brinckerhoff Quade & Douglas, The Costs of Alternative Land Use Patterns, Conrad, Seskin 1998

[51] Frank, James (1989) The Costs of Alternative Development Patterns, Urban Land Institute

Figure 9-1: Cost of Servicing Residential Dwellings (US$)



Whilst these studies analyse the merit of increased density and increased infill verses greenfield development in a number of alternative ways they all conclude that the benefits are significant on a household by household basis, have significant upfront development benefits and have significant long term whole-of-life benefits. The benefits are both of an economic and financial nature.

Evidence from Australian based analysis has been undertaken to understand the extra cost of greenfield development compared to infill development. The analysis took into consideration the cost of additional road, sewerage, telecommunications, electricity, gas, emergency services, municipal services, education and health that would be required to support a number of greenfield development areas and the number of dwellings that could be developed in each areas. The analysis showed that the potential cost saving of infill versus greenfield development ranged from $20,000 - $89,000 per household.

The above infrastructure cost savings were applied to the number of infill dwellings supported by Cross River Rail which estimated that there would be 70,000 dwellings which would be located in infill locations with Cross River Rail, rather than greenfield, without Cross River Rail. The resulting cost saving is summarised in Table 9-1. The analysis indicates that the potential saving could range from $450 million to $2.0 billion over a 15 year period between 2020 and 2034 following the implementation of Cross River Rail and its impact on residential development.

Table 9-1: Potential Urban Development Benefits from Cross River Rail

	Urban infrastructure cost saving – NPV terms ($ million)	
	$20,000 per dwelling	**$89,000 per dwelling**
Urban development benefits	450	2,000

Source: Study estimates

Whilst these urban development benefits are significant, there is a high likelihood of double counting with the transport user benefits contained within the conventional cost benefit analysis as many of the urban development benefits will accrue to either public transport or private vehicle users. Consequently, these benefits are excluded from the economic evaluation.

10 Regional Economic Modelling

10.1 Introduction

This section provides a summary of the regional economic impacts analysis relating to Cross River Rail. This analysis was undertaken by EconSearch who are nationally recognised experts in the area of assessing the regional economic impacts of major transport projects. The section includes a description of the components contributing to regional economic impacts, as well as their quantification for the current analysis. The methodology used in the quantification together with supporting information for the key assumptions are contained in Appendix G.

The analysis is based on demand model and construction and operating cost outputs which were provided for the without project case and project case for the model years 2021 and 2031. Consequently, in this section, 2016 results relate to the construction impacts of Cross River Rail, whilst results from 2021 onwards relate to the operational impacts of Cross River Rail.

It is important to note that the results of the CGE analysis should be considered independently from the main economic evaluation results (conventional benefits plus wider economic impacts) as there is a high risk of double counting if all benefits are considered together. This is especially the case for CGE estimated impacts on Gross State Product (GSP) and agglomeration benefits from the wider economic impacts analysis. This approach is consistent with the Infrastructure Australia guidelines which state that these different measures of project impacts are not additive.

10.2 Background

The regional economic analysis for Cross River Rail involved the identification and quantification of the indirect impacts of the identified options on the Queensland economy using an equilibrium modelling framework. Economic impact analysis based on the input-output approach takes into account the direct impact of the project on regional economic activity, and some of the downstream effects of the induced demand for goods and services elsewhere in the economy. But it does not take into account structural adjustments brought about by the project. For this, the project team has developed a Computable General Equilibrium (CGE) model to examine the flow-on effects arising from Cross River Rail on the broader economy. Estimates of indirect impacts have been made for key economic indicators including GSP and employment.

Flow-on impacts to other industries at the state level, where significant, have been estimated using the CGE modelling framework. This provides the best approach to directly estimating the indirect impacts arising from improving the transport sector through investment in the Cross River Rail project. Further, developing the modelling framework in this way has enabled the project team to better link the various components and phases of the project to ensure a comprehensive assessment of the project.

10.3 Regional economic impact components

The types of economic stimulus that are expected to result from the options will most likely be divided into the following categories:

- Construction costs
- Operating costs
- Productivity improvements in form of time savings
- Increased passenger revenue for the rail system
- Reduced vehicle operating costs
- Reduced crash costs.

The impacts of capital expenditure were estimated with adjustments for expenditure on land purchases and estimated expenditure on imported capital items. Capital expenditure was assumed to consist entirely of expenditure in the construction industry, while operating costs were assumed to consist entirely of expenditure within the rail transport industry. For both capital and operating expenditure, the planned and unplanned risk costs were excluded from the impact analysis.

Productivity improvements in the form of commercial time savings are assumed to reduce labour costs in the transport sector and the wider economy. This is measured as labour costs per unit of output. The components that comprise labour productivity improvements are:

- The road freight benefit of perceived costs (road transport)
- The decongestion costs component of the unperceived road freight benefit (road transport)
- The work trips component of travel time savings for public transport users (economy wide)
- The works trip component of rail reliability (economy wide)
- The works trip component of travel time savings for road users (economy wide).

Private time savings are ignored as they are assumed to have no significant economic impact (increased leisure time). Improved net revenue for the rail system (compared to the base case) has been modelled as total productivity improvement in public transport productivity, specifically the rail transport sector. Reduced crash costs are calculated as the sum of:

- The crash costs reduction benefit (unperceived benefit)
- The accident cost reduction benefit component of the freight benefit (unperceived benefit).

Vehicle operating cost savings are the sum of:

- Work trips component of vehicle operating cost savings in the road user costs reduction benefit (perceived benefit)
- The reduced unperceived vehicle operating costs.

Reduced vehicle operating costs (which includes reduced fuel consumption) and reduced crash costs are modelled as reduced inputs for the machinery and equipment (includes cars and car parts), trade (includes motor vehicle repairs), financial and business services and capital costs.

Rail freight productivity improvements are calculated as the operating costs savings component of the freight benefit (unperceived benefit).

The above project benefits are quantified in the cost benefit analysis and these are summarised in Table 10-1. The table shows the benefits values sourced from the cost benefit analysis and re-classified for the purposes of the CGE modelling.

Table 10-1: Conventional Benefits used in CGE Analysis ($ million)

Category	Incremental to without project case			
	2016	**2021**	**2031**	**2041**
Fixed capital expenditure (Qld)	776	8	29	0
Operational expenditure	0	41	70	115
Public transport productivity	0	23	73	83
Road toll revenue	0	-1	-2	-2
Reduced crash costs	0	19	51	53
Vehicle operating cost savings	0	16	64	79
Rail freight productivity	0	49	133	133
Labour productivity - road transport	0	7	61	79
Labour productivity - economy wide	0	3	13	17
Total	**776**	**167**	**492**	**555**

Source: Study team

Table 10-2 shows the impact of these project benefits on the state economy and the percentage change in each sector. The table shows the percentage increase, as a result of Cross River Rail, in each sector. For example, the category with the largest percentage increase is “State government final consumption expenditure: transport” which shows a 10.7% increase by 2041. However, it is not true to say that this percentage increase represents the largest increase in absolute terms as a result of the project. This depends on the size of each category. In 2041, for example, over 40% of the project impacts are generated by improvements in rail transport productivity, more than 20% from labour productivity in the road transport sector and another 20% result from trade sector cost savings. Each of the other categories listed in Table 10-2 contribute varyingly to the balance of the economy wide impacts (approximately 15% in total).

Table 10-2: Conventional Benefits Impact on Queensland Economy (% change)

Category	Incremental to without project case			
	2016	2021	2031	2041
Fixed capital expenditure	0.915%	0.011%	0.034%	0.000%
State govt. final consumption expenditure: transport	0.000%	3.902%	6.572%	10.784%
Rail transport productivity	0.000%	2.520%	7.257%	7.610%
Private final consumption expenditure – road transport	0.000%	-0.035%	-0.098%	-0.111%
Trade sector cost saving	0.000%	0.086%	0.238%	0.257%
Petroleum sector cost saving	0.000%	0.050%	0.196%	0.241%
Motor vehicle and parts sector cost saving	0.000%	0.020%	0.076%	0.094%
Financial and business sector cost saving	0.000%	0.003%	0.011%	0.013%
Capital cost saving – road transport	0.000%	0.379%	1.479%	1.816%
Labour productivity – road transport	0.000%	0.239%	2.068%	2.647%
Labour productivity – economy wide	0.000%	0.002%	0.010%	0.013%

Source: Study team

10.4 Results

The CGE modelling provides an indication of the economic effects of Cross River Rail on the Queensland economy. During a typical year of the construction phase (2016), GSP for Queensland is estimated to increase $653 million as a result of the project. Similarly, a number of other industry sectors are projected to experience positive effects resulting from Cross River Rail during the construction phase with additional employment of almost 5,900 jobs in Queensland.

In the operating phase, GSP is projected to be over $260 million higher by 2021, rising to $937 million by 2031 and $1,047 million by 2041 as a result of Cross River Rail compared to the without project case. The results are presented at the state and national levels for a range of key economic indicators in Table 10-3.

Table 10-3: Summary CGE Modelling Results

Category	Incremental to without project case			
	2016	**2021**	**2031**	**2041**
Queensland Economic Effects				
Gross State Product[52] ($m)	653	262	937	1,047
Gross State Product (%)	0.27%	0.11%	0.38%	0.43%
Real consumption[53] ($m)	255	63	233	248
Real consumption (%)	0.21%	0.04%	0.18%	0.20%
Employment (no.)	5,901	1,522	5,036	5,439
Employment (%)	0.25%	0.07%	0.22%	0.23%
Australian Economic Effects:				
Gross Domestic Product ($m)	(1)	84	508	590
Gross Domestic Product (%)		0.007%	0.041%	0.047%
Real consumption ($m)		54	202	248
Real consumption (%)		0.008%	0.031%	0.200%
Employment (no.)		167	654	729
Employment (%)		0.001%	0.006%	0.006%

Source: Study team. (1) – construction impacts assumed to occur in Queensland economy.

In the labour market, during the project's operational phase, Cross River Rail will lead to an additional 1,520 jobs in Queensland by 2021 which is forecast to increase to approximately 5,000 by 2031. However the analysis indicates some of this increase will be partially offset by employment reductions in other states. In 2021, for example, the net increase in national employment is projected to be around 170 above the without project projections. By 2031, the net employment impact is forecast to be approximately 650 additional jobs.

Table 10-4 shows that in the construction phase of the project the highest increases in GSP are received by the construction sector which adds $211 million to GSP and financial, business services which adds $126 million to GSP in 2016 respectively.

In 2021 and beyond, the majority of the economic impact of Cross River Rail is in the form of productivity improvements in the rail and road transport sectors, as well as some economy wide labour productivity improvements. Because labour and transport are inputs in all industries, the impacts tend to be relatively evenly distributed across the economy. As can be seen in Table 10-4, the increase in industry value added is projected to occur in sectors that are significant direct users of transport (road and rail) services (construction, mining, other manufacturing) or are industries that will benefit from the economic growth generated by improved transport industry productivity (financial and business services, ownership of dwellings and trade).

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[52] Gross State Product is the value of final goods and services produced annually in a state (valued at market prices).

[53] Consumption refers to expenditure by households on goods and services.

By 2031, the financial and business services sector benefits most from Cross River Rail with an additional $179 million contribution to GSP. This result appears reasonable since this sector is concentrated in the Brisbane CBD which is the area likely to benefit most from Cross River Rail.

Table 10-4: CGE Results Summary by Sector for Queensland (Gross State Product)

Category	Incremental to without project case			
	2016	**2021**	**2031**	**2041**
Financial, business services	126	51	179	199
Mining	11	40	130	143
Construction	211	26	106	117
Dwellings	45	24	82	90
Government services	10	18	58	65
Other manufacturing	41	16	57	63
Other sectors	208	86	326	369
Total	**653**	**262**	**937**	**1,047**

Source: Study team

The employment impacts by sector follow a similar pattern (Table 10-5) although labour intensive industries, such as trade and government services, gain proportionately higher impacts. An interesting exception is the road transport industry. As shown in Table 10-2 the project is expected to generate significant improvements in labour productivity in the road transport industry resulting from reduced congestion and, therefore, travel times. Road transport sector employment is expected to be significantly lower than that under the without project case, especially by 2031 and 2041, although the negative employment impact does not necessarily mean that that jobs will be lost, rather that there will be that less jobs in the industry than there would have been without Cross River Rail. The more detailed sector results in Appendix G show that although employment in that sector is negative, projected value added is positive (against the without project case), reflecting the improved productivity in the industry.

Table 10-5: Summary of CGE Modelling by Sector for Queensland (Employment)

Category	Incremental to without project case			
	2016	2021	2031	2041
Financial, business services	928	349	1,219	1,349
Construction	2,686	286	1,167	1,290
Government services	83	239	758	836
Trade	767	142	700	792
Other manufacturing	524	175	648	730
Machinery & equipment	28	84	271	298
Road transport	100	-99	-953	-1,238
Other sectors	783	345	1,226	1,380
Total	**5,901**	**1,522**	**5,036**	**5,439**

Source: Study team

11 Economic Evaluation Results

11.1 Introduction

The Cross River Rail project option was compared with the without project case using a discounted cash flow technique on the basis of a real discount rate of 7% in accordance with ATC and Infrastructure Australia investment appraisal guidelines. Project capital expenditure is assumed to take effect from 2012 and all values are expressed in 2010 dollars. The benefits of the project were assessed over a 30 year evaluation period.

11.2 Economic evaluation results

11.2.1 Reference project

Table 11-1 summarises the results of the economic evaluation for the Reference Project at a 7% real discount rate and indicates the results incremental to the without project case. A more detailed presentation of the results is given in the spreadsheet in Appendix H.

The economic evaluation results show that Cross River Rail Reference Project produces a positive economic return with a NPV of $2.3 billion and a BCR of 1.42. The largest component of benefit is perceived benefits to public transport users (time savings and improved amenity from reduced train and bus crowding) which accounts for 39% of benefits. The next largest component is travel time and cost savings to private transport users who gain from the reduction in road congestion leading to higher vehicle speeds and reduced operating costs.

In addition to passenger related travel benefits, Cross River Rail also results in benefits to rail freight as a result of providing dedicated rail freight paths to the port as well as to Acacia Ridge. This allows more intermodal freight to be transported by rail rather than by road in the with project case which results in operating cost, externality, crash cost and road decongestion benefits.

The inclusion of wider economic impacts increases the NPV of Cross River Rail from $2.3 billion to $3.5 billion whilst the BCR increases from 1.42 to 1.63. The main contributor to the wider economic impacts is agglomeration benefits which are discussed in more detail in section 8.

Table 11-1: Economic Evaluation Results – Cross River Rail Reference Project

Incremental to base case	$2010 million	Percentage
Project Costs (present value)		
Infrastructure capital costs	4,463	79%
Rolling stock	450	8%
Whole of life costs	705	13%
Total Project Costs	**5,617**	**100%**
Project Benefits (present value)		
Perceived public transport benefits	3,094	39%
Perceived highway benefits	1,942	24%
Rail reliability benefits	688	9%
Perceived road freight benefits	363	5%
Incremental fare revenue	355	4%
Change in toll revenue	-10	0%
Vehicle operating resource cost correction	172	2%
Externality cost reductions	172	2%
Crash cost reductions	89	1%
Rail freight benefits	962	12%
Residual value	135	2%
Total Benefits	**7,962**	**100%**
Summary excluding wider economic impacts:		
NPV ($million)	2,345	
NPV/I	0.53	
BCR (ratio)[54]	1.42	
IRR (%)	10%	

Source: study estimates.

[54] The most common estimation of the benefit cost ratio is that both capital and whole of life costs are shown on the bottom line whilst benefits are shown on the top line. ATC guidelines require that only capital costs are shown on the bottom line, with whole of life costs shown as a negative benefit on the top line. Under this approach the BCR for the project would be 1.48.

11.2.2 Alternative alignment

An economic evaluation has also been undertaken for the Alternative Alignment option. Preliminary costing, which was undertaken by Turner & Townsend to include costs for the inner city works between Milton and the Exhibition Loop. Additional infrastructure components required for grade separations at Corinda and Yeerongpilly plus additional tracks on Tennyson Loop are estimated to increase the overall total cost of this option to $6.5 billion (excluding escalation and including risk) which is assumed to be incurred between 2011 and 2019. This equates to a present value of $5.1 billion. Under this option the same rolling stock requirement as is assumed in the Reference Project and this cost is also included in the evaluation.

Turner & Townsend also provided estimates for the whole of life costs for this option which is estimated at $2.4 billion over 30 years (including real escalation) or $461 million in present value terms.

The demand forecasting model was used to estimate patronage forecasts and user benefits for the Alternative Alignment option. The analysis indicated that passenger kilometres, hours and patronage would all be between 5%-10% lower for the Alternative Alignment option, compared to the Reference Case, although the average trip length increased. This is due to the longer trip length from the south via Corinda (additional travel time for Gold Coast services is estimated to be approximately 5 minutes longer compared to the Cross River Rail option). In terms of the benefits, the demand modelling estimates that these are 50% of those estimated for the Cross River Rail option. This is due to the disproportionate impact of crowding and congestion that occurs once trip levels reach a certain point and which are mitigated to a lesser extent with the Alternative Alignment option.

Table11-2 shows the breakdown of the economic evaluation for the Alternative Alignment option. The economic evaluation results show that the Alternative Alignment produces a negative economic return with a NPV of -$2.1 billion and a BCR of 0.65.

Table 11-2: Economic Evaluation Summary – Alternative Alignment Option

Incremental to base case	$2010 million	Percentage
Project Costs (present value)		
Infrastructure capital costs	5,117	84%
Rolling stock	480	8%
Whole of life costs	461	8%
Total Project Costs	**6,057**	**100%**
Project Benefits (present value)		
Perceived public transport benefits	1,229	31%
Perceived highway benefits	942	24%
Rail reliability benefits	698	18%
Perceived road freight benefits	156	4%
Incremental fare revenue	155	4%
Change in toll revenue	-5	0%
Vehicle operating resource cost correction	67	2%
Externality cost reductions	47	1%
Crash cost reductions	35	1%
Rail freight benefits	439	11%
Residual value	164	4%
Total Benefits	**3,928**	**100%**
Summary excluding wider economic impacts:		
NPV ($million)	-2,129	
NPV/I	0.42	
BCR (ratio)	0.65	
IRR (%)	4%	

Source: study estimates.

11.2.3 Staging Analysis

11.2.3.1 Introduction

In addition to the full implementation of Cross River Rail by 2020, a Staged Option was also assessed in the economic evaluation. This involved a phased implementation of the project as follows:

- Stage 1 (2015-20): Surface works, construction of the main tunnel between Yeerongpilly and Roma Street and construction of the Southern Freight Line
- Stage 2 (2025-28): Cross River Rail North including surface works from Roma Street to Bowen Hills
- Stage 3 (2030): Surface works between Salisbury to Clapham Rail Yard.

Based on the above construction program phasing, the costs and benefits will be incurred over a different timeframe compared to the full implementation by 2020 scenario. These are discussed below.

11.2.3.2 Project Costs

The outturn capital costs for the Staging Option were developed by Turner & Townsend based on a longer construction program as described above. The resulting capital costs are higher compared to the Reference Project as a result of higher Government costs, a different tunnelling methodology (resulting in increased usage of road header's rather than a TBM), a higher risk allowance and increased escalation reflecting the longer construction period. The outturn capital cost for the Staged Option was estimated to be $9,981 million compared to $8,393 million for the Reference Project (representing approximately a 20% increase).

As with the earlier analysis, nominal escalation and profit were removed to obtain an equivalent economic cost which was estimated at $8.1 billion compared to $7.6 billion for the Reference Project. However, under this scenario the phased implementation of the project between 2011 and 2030 means that the capital costs are discounted more significantly than under the Reference Project option. The effect is evident through a comparison the discounted present values of the two scenarios which shows that the Staged Option is 8% less expensive than the Reference Project.

The staging of the project also delays the requirement for additional rolling stock compared to the Reference Project by 2 years with the present value of rolling stock purchase costs reduced from $450 million to $362 million.

The whole of life costs for the Staged Option have been provided by the project cost estimator, Turner & Townsend. These are estimated to be $4.2 billion (undiscounted) for the 30 year evaluation period. The equivalent discounted value is $660 million. This represents a 6% reduction compared to the full 2020 implementation option.

11.2.3.3 Project Benefits

The demand forecasting model was used to estimate patronage forecasts and benefits for the Staged Option. The project benefits include the same items as estimated for the full scheme. However, the phased implementation of the project means that the ramp-up of benefits is slower between 2021 and 2031. Overall, the total discounted project benefits are estimated to be 17% lower than the Reference Case. This is the result of lower benefits between 2021 and 2031, after which the benefit estimates are the same between the two options.

The impact on this slower benefit realisation is summarised in the economic evaluation results shown below.

11.2.3.4 Staged Option Results

Based on the above analysis, the economic evaluation results for the Staged Option are summarised in Table 11-3. Overall, the results indicate that the Stage Option produces a positive economic return with a NPV of $1.5 billion and a BCR of 1.29. However, this result is significantly lower than the Reference Project as a result of the marginally lower capital cost (as a result of higher discounting) being offset by the significant reduction in project benefits between 2021 and 2031.

Table 11-3: Staged Option Economic Evaluation Results

Incremental to base case	$2010 million	Percentage
Project Costs (present value)		
Infrastructure capital costs	4,106	80%
Rolling stock	362	7%
Whole of life costs	660	13%
Total Project Costs	**5,128**	**100%**
Project Benefits (present value)		
Perceived public transport benefits	2,203	33%
Perceived highway benefits	1,667	25%
Rail reliability benefits	816	12%
Perceived road freight benefits	345	5%
Incremental fare revenue	289	4%
Change in toll revenue	-7	0%
Vehicle operating resource cost correction	136	2%
Externality cost reductions	137	2%
Crash cost reductions	70	1%
Rail freight benefits	836	13%
Residual value	146	2%
Total Benefits	**6,636**	**100%**
Summary excluding wider economic impacts:		
NPV ($million)	**1,508**	
NPV/I	**0.37**	
BCR (ratio)	**1.29**	
IRR (%)	**9%**	

Source: study estimates.

11.3 Sensitivity testing

The results reported are based on the best estimates of costs and benefits. Different outcomes could occur in practice because of different behavioural responses by the community and changes in exogenous issues such as fuel prices, environmental concerns and the state of the economy. Consequently, the robustness of the economic evaluation results are assessed in a series of sensitivity results including variations in the following:

- Discount rate
- Construction costs
- Project benefits
- Exclusion of public transport crowding benefits
- Exclusion of rail freight benefits
- Project benefit growth beyond the last modelling year
- 50 year evaluation period
- Operating costs
- Benefit annualisation factors
- Inclusion of benefits ramp-up profile
- Alternative generalised cost weighting factors
- Alternative road decongestion cost estimate parameters
- Exclusion of real parameter escalation
- Treatment of contractor profit in project costs.

The sensitivity scenarios assessed have been informed by the suggested tests to be undertaken as part of the Infrastructure Australia guidelines to economic evaluation as well as more project specific related scenarios such as the exclusion of public transport passenger crowding benefits and rail freight benefits. The results of the sensitivity analysis are shown in Table 11-4.

The sensitivity test analysis indicates that the results are most sensitive to the assumptions regarding discount rate, capital costs and benefit assumptions. The economic evaluation results under different discount rates are broad ranging from 0.96 under the 10% discount rate, to 2.14 for the 4% discount rate. The exclusion of public transport passenger crowding benefits gives a BCR of 1.20, and the exclusion of rail freight benefits reduces the BCR to 1.25.

Under the high cost scenario, the BCR drops to 1.17 but given the already included 25% cost contingency in the core analysis, this represent an extreme scenario with in effect, a 50% cost contingency. This level of contingency represents a project at a pre-feasibility stage where limited design work has been undertaken. However, in the case of Cross River Rail, the project design is far more advanced and therefore a significantly lower cost contingency is warranted in the core scenario.

A number of other scenarios have also been tested and these all result in project BCR's greater than 1.0.

Table 11-4: Sensitivity Testing Summary

Scenario	BCR
Core scenario	1.42
Core scenario plus wider economic impacts	1.63
4% discount rate	2.14
10% discount rate	0.96
Capital costs + 30%	1.17
Capital costs - 30%	1.81
Benefits + 30%	1.86
Benefits - 30%	1.02
Capital costs + 30%, benefits - 30%	0.83
Capital costs - 30%, benefits + 30%	2.38
No public transport crowding benefits	1.20
No rail freight benefits	1.25
No growth in benefits beyond 2031	1.34
50 year evaluation period	1.68
Operating costs +30%	1.37
Operating costs -30%	1.47
Lower public transport annualisation factor (250)	1.36
Lower highway annualisation factor (250)	1.31
Inclusion of ramp-up profile (75% benefit in opening year, 90% of benefit in second year, 100% thereafter)	1.40
Lower generalised cost weightings[55]	1.38
Road decongestion cost (VKT approach)[56]	1.30
Excluding real parameter escalation	1.25
Inclusion of contractor profit in project costs	1.36

Source: study estimates.

[55] In the core evaluation the generalised cost weighting assumptions (in-vehicle time equivalent were wait time = 2.0, access time = 1.7 and interchange = 10. In the sensitivity test described above, these assumptions were changed to wait time = 1.4, access time = 1.4 and interchange = 7. These sensitivity test assumptions are based on applying the lower range estimates from the Australian Transport Council Guidelines to Transport System Management in Australia.

[56] Reduction in car VKT approach applied based on a standard decongestion benefit from NSW RailCorp methodology of $0.414 per reduction in VKT.

11.4 Other impacts

Cross River Rail will result in additional users of public transport as well as fewer (compared to the without project case) private vehicle trips. Given the role of state government in subsidising passenger rail travel in Queensland, the project will have a negative impact on government finances. The extent of these impacts is quantified in broad terms below.

For public transport, advice received from government indicates that, on average, the cost recovery for each public transport trip is currently between 25% and 30%, implying a subsidy of 70-75% of the average fare per trip. The demand modelling assumptions incorporate a real increase in fares as planned to be implemented by TransLink over the next four years which will lead to an increase in the level of cost recovery over time. In the analysis, the level of cost recovery is assumed to increase to, on average, 30% per trip.

Based on the above assumptions and output from the SKM – Aurecon JV demand model, an estimate was made of the potential increase in government subsidy required as a result of Cross River Rail and this is summarised in Table 11-5.

Table 11-5: Increased Public Transport Subsidy Requirement

	2021	2031
Additional PT trips (/day)	17,579	46,897
Additional PT trips (million p.a.)	4.9	13.1
Incremental fare revenue ($ million p.a.)	22.0	71.0
Average fare ($)[57]	4.47	5.37
- Proportion subsidised (70%)	3.13	3.76
- Proportion non subsidised (30%)	1.34	1.61
Net additional PT subsidy requirement ($ million p.a.)	**15.4**	**49.4**

Source: study estimates.

The above analysis indicates a minor funding requirement increase of approximately $50 million per annum by 2031. This estimate assumes, however, that there would be no real increase in fares post 2014. If this were not the case, the additional subsidy requirement from government would be lower.

Advice from Queensland Government indicates that given the existing level of public transport subsidy, the marginal excess burden of taxation (MEB)[58] is 0.1 times the subsidy as a disbenefit. Given the incremental increase in public transport subsidy identified in Table 11-5, the net impact on the economic evaluation is to reduce the BCR of the project from 1.42 to 1.41.

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[57] The average fare was derived based on the demand modelling output relating to incremental public transport trips.

[58] The marginal excess burden (MEB) of taxation is a loss of economic efficiency that can occur when the equilibrium of a good or service is not optimal. In the case of government providing a subsidy for public transport use, this encourages usage which is higher than would occur without a subsidy. In this situation, the price (fare) of public transport is lower than without the subsidy which leads to a reduction in producer surplus. However, this reduction is not fully offset by an equal and opposite increase in consumer surplus leading to a net loss in economic efficiency.

12 Summary and Conclusions

The economic evaluation of the Cross River Rail project has included a broad assessment of the likely impacts of the project including its impact on both public transport passengers as well as private vehicle highway users. In addition, the assessment has examined the impact of the project on freight markets and the likely additional freight volumes which might be transported by rail rather than road. The benefits quantified as a result of impacts in the passenger and freight markets are significant amounting to $7.9 billion in present value terms (over a 30 year benefit assessment period). The largest components of these benefits are time savings and amenity improvements to public transport and car users which together amount to nearly 63% of total conventional benefits.

In addition to the direct impacts on the transport sector, Cross River Rail will also contribute to city building in the Brisbane economy with an additional $1.2 billion generated due to the wider economic impacts of the project. This benefit is the largely comprised of agglomeration impacts, or put another way, improvements in productivity as a result of workers being located closer together as a result of improved accessibility.

The estimated present value of project costs of the project is $4.5 billion for infrastructure construction, $0.5 for additional rolling stock and $0.7 billion whole of life costs giving a total cost of $5.7 billion.

Based on the above costs and benefits, Cross River Rail generates a strong economic return with a NPV of $2.3 billion and a BCR of 1.42 based on transport system benefits alone and a NPV of $3.5 billion and a BCR of 1.63 including the wider economic impacts of the project. The economic evaluation results are summarised in Table 12-1.

Table 12-1: Summary of Economic Evaluation Results

Scenario	Net present value ($ million)	Benefit cost ratio
Core evaluation	2,345	1.42
Core evaluation + wider economic impacts	3,521	1.63

Source: study estimates.

13 Limitation of our work

General use restriction

This report is prepared solely for the internal use of Department of Transport and Main Roads. This report is not intended to and should not be used or relied upon by anyone else and we accept no duty of care to any other person or entity. The report has been prepared for the purpose set out in our contract dated 11 May 2010. You should not refer to or use our name or the advice for any other purpose.

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Appendix B: Day to Year Expansion Factor Derivation

- Benefits are calculated for an average working weekday in 2016, 2021 and 2031, using output from demand model
- Annualisation factors are applied to these average working weekday benefits to determine annual benefits
- Average working weekday benefits is increased by a factor of 280 for public transport users and by 318 for private vehicle users
- The following method was used to derive the annualisation factors for Public Transport demand, based on data from the ATC Guidelines (2006):
    - ATC guidelines provide the number of days by type (working weekdays, Saturdays, Sundays and public holidays), and the share of total public transport demand for each type of day
    - The ATC estimated share of total public transport demand is used to derive the number of days per annum that have the equivalent amount of public transport demand as a working weekday (i.e. 100% of working week days = 251 work days, 33% of Saturdays = 17.3 work days, and 18% of Sundays and public holidays = 11.2 work days)
    - Therefore the annualisation factor for public transport demand in an average working week day is equal to the sum of equivalent workdays per annum = 280.
- The following method was used to derive the annualisation factors for car travel demand, based on ATC Guidelines and consultant experience:
    - ATC guidelines provide the number of days by type (working week days, Saturdays, Sundays and public holidays).
    - The proportion of each type of day that has the equivalent demand for car travel as a working week day is estimated as 100%, 70% and 50% for working week days, Saturdays and Sundays/ public holidays respectively.
    - The annualisation factor for car travel demand in an average working weekday is equal to the sum of equivalent workdays per annum = 318.

Table B.1: Expansion Factor Calculations: Working Weekdays to Annual

		PUBLIC TRANSPORT		CAR TRAVEL	
		Demand		Demand and Supply	
Type of Day	Annual number	Share of working weekday	No. of working weekdays/-year	Share of working weekday	No. of working weekdays/-year
Working weekday	251	100%	251.0	100%	251.0
Saturday	52	33%	17.3	70%	36.4
Sunday & Public Holiday	62	18%	11.2	50%	31.0
Total	365		279.5		318.4

Source: ATC Guidelines (2006), Tables 1.6.14, 1.6.16 for public transport.

Appendix C: Transport System Benefit Estimation

Perceived consumer surplus benefits

The benefit perceived by travellers (including public transport users, car users and commercial vehicle users) is measured by the change in their perceived consumer surplus. This is derived by examining every trip for each origin – destination pair in the transport network and comparing the change in generalised costs between the with project and the without project case. This utilises the rule-of-a-half convention which is outlined in section 8.

Perceived consumer surplus benefits have been measured on an origin – destination basis. This means that the number of trips can vary by mode and by origin and destination between the with and without project cases. This provides a more realistic assessment of the project impacts, as such a significant investment in Brisbane's rail infrastructure should lead to both changed modal choice as well as potential trip redistribution[59] impacts as a result of changes in accessibility. In addition, this approach is consistent with international best practice in public transport scheme appraisal[60]. The demand model, however, has the same overall number of transport trips (all modes) in the with and without project case and therefore does not measure any induced demand that might arise as a result of the project.

In terms of the benefit calculations, these are summarised below:

1. **Existing rail users**

The benefit to existing rail users is given by the following equation:

Benefit = $(GC_{w/o} – GC_{with}) * trips_{ij}$

Where:

$GC_{w/o}$ = Generalised cost between an origin – destination pair in the without project case

GC_{with} = Generalised cost between an origin – destination pair in the project case

$trip_{ij}$ = Number of existing rail trips between and origin (i) and a destination (j)

This total benefit is subsequently derived for a given time period, by summing the above calculation for all rail trip origin – destination pairs in the transport model network.

2. **Diverted public transport users**

The benefit to rail users who divert from other public transport modes is given by the following equation:

Benefit = $(GC_{w/o} – GC_{with})$ * diverted PT $trips_{ij}$ * 0.5

Where:

$GC_{w/o}$ = Generalised cost between an origin – destination pair in the without project case for existing rail users

GC_{with} = Generalised cost between an origin – destination pair in the project case for existing rail users

PT $trip_{ij}$ = Number of diverted public transport trips between and origin (i) and a destination (j)

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[59] Trip redistribution is defined as where either/both the trip origin or destination changes as a result of the project.

[60] See guidance papers published by McIntosh and Quarmby.

This total benefit is subsequently derived for a given time period, by summing the above calculation for all diverted rail trip origin – destination pairs in the transport model network.

3. **Former car drivers and car passengers**

The benefit to public transport users who divert from car travel (both drivers and passengers) is given by the following equation:

Benefit = $(GC_{w/o} – GC_{with})$ * diverted RD $trips_{ij}$ * 0.5

Where:

$GC_{w/o}$ = Generalised cost between an origin – destination pair in the without project case for existing rail users

GC_{with} = Generalised cost between an origin – destination pair in the project case for existing rail users

RD $trip_{ij}$ = Number of diverted car trips between and origin (i) and a destination (j)

This total benefit is subsequently derived for a given time period, by summing the above calculation for all diverted car trip origin – destination pairs in the transport model network.

4. **Remaining road users:**

The decongestion and reduced operating cost benefit to remaining road users is given by the following equation:

Benefit = $(GC_{w/o} – GC_{with})$ * car $trips_{ij}$

Where:

$GC_{w/o}$ = Generalised cost between an origin – destination pair in the without project case for car trips

GC_{with} = Generalised cost between an origin – destination pair in the project case for car trips

$trip_{ij}$ = Number of car trips between and origin (i) and a destination (j)

This total decongestion and operating cost benefit is subsequently derived for a given time period, by summing the above calculation for all car trip origin – destination pairs in the transport model network.

Producer surplus

5. **Incremental rail operating costs**

The other impact of increased public transport usage is through the increase in rail operating costs as a result of the potential requirement to run additional services which requires more rolling stock. The additional resource operating cost of running additional services will be included as an incremental cost of the project.

Resource cost corrections

These benefits occur as a result of a mode shift from road to rail due to the Cross River Rail. The main benefits include toll revenue impacts, incremental passenger fare revenue, a reduction in the resource private vehicle operating cost and the reduction in private vehicle externalities. The benefit calculations are described below.

6. **Incremental toll road impacts**

As a result of a shift in road to rail in the with project case compared to the without project case, there will be a reduction in toll road usage which will impact on toll road operators. In the evaluation, this impact is treated as a loss in producer surplus. The calculation of this impact is described below:

Loss in producer surplus = (VKT Toll $_{w/o\_car}$ * Toll $_{car}$) – (VKT Toll $_{with\_car}$ * Toll$_{car}$) + (VKT Toll $_{w/o\_cv}$ * Toll $_{cv}$) – (VKT Toll $_{with\_cv}$ * Toll $_{cv}$)

Where:

VKT Toll $_{w/o\_car}$ = Vehicle kilometres travelled (VKT) by car in the without project case on toll roads

Toll $_{car}$ = Toll rate for car

VKT Toll $_{with\_car}$ = VKT by car in the project case on toll roads

Toll $_{cv}$ = Toll rate for commercial vehicle

VKT Toll $_{w/o\_cv}$ = VKT by commercial vehicle in the without project case on toll roads

VKT Toll $_{with\_cv}$ = VKT travelled by commercial vehicle in the project case on toll roads

7. **Incremental public transport fare revenue**

This producer surplus benefit occurs because the public transport fare for new public transport users is already included in the consumer surplus calculation described above. Consequently, the increased fare revenue needs to be accounted for in the benefit estimation in order to offset this inclusion. The calculation is as follows:

Benefit = generated PT trips$_{ij}$ * fare$_{ij}$

Where:

Generated PT trips$_{ij}$ = Generated number of public transport trips between an origin (i) – destination (j) pair in the project case.

Fare$_{ij}$ = Public transport fare between an origin – destination pair in the project case.

This total fare revenue is subsequently derived for a given time period, by summing the above calculation for all generated public transport trip origin – destination pairs in the transport model network.

8. **Private vehicle operating costs**

Benefit = (VKT$_{w/o_car}$ * VOC$_{resource_car}$) – (VKT$_{with_car}$ * VOC$_{resource_car}$) + (VKT$_{w/o_cv}$ * VOC$_{resource_cv}$) – (VKT$_{with_cv}$ * VOC$_{resource_cv}$)

Where:

VKT$_{w/o_car}$ = Vehicle kilometres travelled (VKT) by car in the without project case across the transport network

VOC$_{resource_ car}$ = Resource vehicle operating cost correction for car

VKT$_{with_car}$ = VKT by car in the project case across the transport network

VKT$_{w/o_cv}$ = VKT by commercial vehicle in the without project case across the transport network

VOC$_{resource_ cv}$ = Resource vehicle operating cost correction for commercial vehicle

VKT$_{with_cv}$ = VKT travelled by commercial vehicle in the project case across the transport network

9. **Externality cost reduction**

Benefit = (VKT$_{w/o_car}$ * EXT$_{car}$) – (VKT$_{with_car}$ * EXT$_{car}$) + (VKT$_{w/o_cv}$ * EXT$_{cv}$) – (VKT$_{with_cv}$ * EXT$_{cv}$)

Where:

VKT_{w/o_car} = VKT by car in the without project case across the transport network

EXT_{car} = Externality cost correction for car

VKT_{with_car} = VKT by car in the project case across the transport network

VKT_{w/o_cv} = VKT by commercial vehicle in the without project case across the transport network

EXT_{cv} = Externality cost correction for commercial vehicle

VKT_{with_cv} = VKT travelled by commercial vehicle in the project case across the transport network

Appendix D: Vehicle Operating Cost Assumptions

The vehicle operating cost parameters are sourced from the Austroads guidance as summarised in Tables D.1 and D.2. This shows the operating cost parameter values for the 'freeways' and 'all road' categories. The Brisbane Strategic Multi Modal Model assumes a demand split of 45% of road traffic on freeways and 55% on all roads[61]. Based on these assumptions the weighted average operating cost parameters are shown in Table D.3. These values were then converted to 2009 equivalents by applying a CPI uplift factor of 1.1. The resultant vehicle operating cost parameter values are shown in Table D.4.

Table D.1: Parameter Values for Freeway Vehicle Operating Cost Models – cents/km (2007 values)

Vehicle	A	B	C	D
Car	-16.262	1,553.78	0.23531	0.0000501
LCV	-30.00	3,396.74	0.25629	0.001262
MCV	-30.00	8,544.38	0.01850	0.006029
Car	-16.262	1,553.78	0.23531	0.0000501

Source: Austroads, Guide to Project Evaluation Part 4: Project Evaluation Data, Table 6.1.

Table D.2: Parameter Values for All At Grade Roads Vehicle Operating Cost Models – cents/km (2007 values)

Vehicle	A	B	C	D
Car	2.185	976.21	0.05711	0.0005795
LCV	-3.096	2,092.48	0.19609	0.0005658
MCV	5.885	5,471.53	0.58625	0.000218
Car	2.185	976.21	0.05711	0.0005795

Source: Austroads, Guide to Project Evaluation Part 4: Project Evaluation Data, Table 6.2.

[61] AECOM, Connecting SEQ 2031: An Integrated Regional Transport Plan for South East Queensland, Economic Appraisal of Investment Scenarios, Economic Analysis Paper, November 2009.

Table D.3: Weighted Average Parameter Values for All Roads Vehicle Operating Cost Models – cents/km (2007 values)

Vehicle	A	B	C	D
Car	-6.116	1,236.117	0.1373	0.0003413
LCV	-15.2028	2,679.397	0.22318	0.0008791
MCV	-10.2633	6,854.313	0.330763	0.002833
Car	-6.116	1,236.117	0.1373	0.0003413

Source: Deloitte estimates based on Austroads data.

Table D.4: Weighted Average Parameter Values for All Roads Vehicle Operating Cost Models – cents/km (2009 values)

Vehicle	A	B	C	D
Car	-6.722	1,358.492	0.1509	0.000375
LCV	-16.708	2,944.657	0.2453	0.000966
MCV	-11.279	7,532.889	0.3635	0.003113
Car	-6.722	1,358.492	0.1509	0.000375

Source: Deloitte estimates based on Austroads data.

Appendix E: Transport Benefit Calculations

This appendix provides a detailed description of how the various benefit components have been calculated. These are included below.

Table E.1: Perceived Consumer Surplus Benefits – Public Transport Users

	Value		Comment
Demand model output: Change in consumer surplus (measured in passenger hours per day)	Non-work trips hours saved: 2021: 61,549 2031: 115,561 Work trips hours saved: 2021: 30 2031: 63		Source: SKM –Aurecon demand model.
Valuation parameters: Value of travel time	*Non Work ($/hr):* 2021:14.5 2031: 16.8	*Work ($/hr):* 2021: 34.1 2031: 39.6	Base value of times (2010 values) are: Non-work - $12.3/hr. Work: $29.0/hr. Source: ATC guidelines, study estimates.
Annualisation factor	280		Day to year – source study team.
Algorithm:	Benefit = time saving per day (hours) * value of time * annualisation factor		
Calculation:	*Non-work trips:* 2021: 61,549 * 14.5 * 280 = 249.9m 2031: 115,561 * 16.8 * 280 = 543.6m *Work trips:* 2021: 30 * 34.1 * 280 = 0.3m 2031: 63 * 39.6 * 280 = 0.7m		
Total economic benefit:	*Non work + work:* 2021: 249.9 + 0.3 = $250m 2031: 543.6 + 0.7 = $544m		

Source: Study assumptions

Table E.2: Perceived Consumer Surplus Benefits – Car Users Time (Decongestion Benefit)

	Value	Comment
Demand model output: Change in consumer surplus (measured in car driver and passenger hours per day)	Non-work trips hours saved: 2021: 8,511 2031: 45,251 Work trips hours saved: 2021: 213 2031: 996	Source: SKM –Aurecon demand model.
Valuation parameters: Value of travel time	*Non Work ($/hr):* 2021:14.5 2031: 16.8 *Work ($/hr):* 2021: 34.1 2031: 39.6	Base value of times (2010 values) are: Non-work - $12.3/hr. Work: $29.0/hr. Source: ATC guidelines, study estimates.
Annualisation factor	318	Day to year – source study team.
Algorithm:	Benefit = time saving per day (hours) * value of time * annualisation factor	
Calculation:	*Non-work trips:* 2021: 8,511 * 14.5 * 318 = 39.2m 2031: 45,251 * 16.8 * 318 = 241.7m *Work trips:* 2021: 213 * 34.1 * 318 = 2.3m 2031: 996 * 39.6 * 318 = 12.5m	
Total economic benefit:	*Non work + work:* 2021: 39.2 + 2.3 = $42m 2031: 241.7 + 12.5 = $254m	

Source: Study assumptions

Table E.3: Perceived Consumer Surplus Benefits – Car Users Operating Cost (Decongestion Benefit)

	Value		Comment
Demand model output: Change in consumer surplus (measured in car operating costs $ per day)	Non-work trips $ saved: 2021: 83,813 2031: 490,047 Work trips $ saved: 2021: 2,333 2031: 10,765		Source: SKM –Aurecon demand model.
Valuation parameters: Value of operating cost	*Non Work ($/hr):* VOC parameters based on Austroads guidance	*Work ($/hr):* VOC parameters based on Austroads guidance	Source: Austroads guidance.
Annualisation factor	318		Day to year – source study team.
Algorithm:	Benefit = operating cost ($) * annualisation factor * 1.032 (used to uplift model outputs from 2009 values to 2010 dollars.		
Calculation:	*Non-work trips:* 2021: 83,813 * 318 * 1.032 = 27.5m 2031: 490,047 * 318 * 1.032 = 160.8m *Work trips:* 2021: 2,333 * 318 * 1.032 = 0.8m 2031: 10,765 * 318 * 1.032 = 3.5m		
Total economic benefit:	*Non work + work:* 2021: 27.5 + 0.8 = $28m 2031: 160.8 + 3.5 = $164m		

Source: Study assumptions

Table E.4: Perceived Consumer Surplus Benefits – Road Freight Travel Time Car Users Operating Cost (Decongestion Benefit)

	Value	Comment
Demand model output: Change in commercial vehicle hours (hours per day)	Work trips hours saved: 2021: 503 2031: 5,491[62]	Source: SKM –Aurecon demand model.
Valuation parameters: Value of travel time	*Work ($/hr):* 2021: 26.9 2031: 31.2	Base value of time (2010 values) is: Work - $22.8/hr. Source: NSW RTA Economic Analysis parameters.
Annualisation factor	318	Day to year – source study team.
Algorithm:	Benefit = time saving per day (hours) * value of time * annualisation factor	
Calculation:	*Work trips:* 2021: 503 * 26.9 * 318 = 4.3m 2031: 5,491 * 31.2 * 318 = 54.5m	
Total economic benefit:	2021: $4.3m 2031: $54.5m	

Source: Study assumptions

[62] The commercial vehicle hours estimate was adjusted to correct for a modelling result anomaly which indicated a marked difference in the average network speeds between commercial vehicle and car users in 2031. The adjustment resulted in the commercial vehicle hours being reduced by 25% to equate the network speeds in 2031 for cars and commercial vehicles.

Table E.5: Perceived Consumer Surplus Benefits – Road Freight Operating Cost Benefits (Decongestion Benefit)

	Value	Comment
Demand model output: Change in commercial vehicle operating costs ($ per day)	Work trips $ saved: 2021: 5,868 2031: 84,190	Source: SKM –Aurecon demand model.
Valuation parameters: Value of operating cost	*Work ($/hr):* VOC parameters based on Austroads guidance	Source: Austroads guidance.
Annualisation factor	318	Day to year – source study team.
Algorithm:	Benefit = operating cost ($) * annualisation factor * 1.032 (used to uplift model outputs from 2009 values to 2010 dollars.	
Calculation:	*Work trips:* 2021: 5,868 * 318 * 1.032 = 1.9m 2031: 84,190 * 318 * 1.032 = 27.3m	
Total economic benefit:	2021: $1.9m 2031: $27.3m	

Source: Study assumptions

Table E.6: Perceived Consumer Surplus Benefits – Passenger Rail Reliability Benefits

	Value		Comment
Demand model output: Change in passenger delay time (hours per day – am peak period)	Without project: 2016: 4,124 2031: 15,536	With project: 2016: 2,822 2031: 6,653	Source: Systemwide operations modelling.
Valuation parameters: Value of travel time	*Non Work ($/hr):* 2016: 13.4 2031: 16.8		Base value of time (2010 values) is: Non-work - $12.3/hr. Source: ATC guidelines, study estimates.
Annualisation factor	250		Source: Study estimate (5 days per week * 50 weeks per year).
Algorithm:	Passenger delay time * 2 (AM peak to day factor[63]) * annualisation factor * passenger wait time weighting * non work value of time.		
Calculation:	*Without project:* 2016: 4,124 * 2 * 250 * 2 * 13.4 = $55.3m 2031: 15,536 *2 * 250 *2 * 16.8 = $261.0m *With project:* 2016: 2,822 * 2 * 250 * 2 * 13.4 = 37.8m 2031: 6,653 * 2 * 250 * 2 * 16.8 = 111.8m		
Total economic benefit:	*Without project – with project:* 2016: 55.3 – 37.8 = $18m 2021: $36m (derived through interpolation) 2031: 261.0 – 111.8 = $149m		

Source: Study assumptions

[63] Includes an allowance for the PM peak period.

Table E.7: Resource Cost Correction – Toll Revenue Impacts

	Value	Comment
Demand model output: Change in toll revenue ($ per day)	Toll revenue $ saved: 2021: -2,236 2031: -6,288	Source: SKM –Aurecon demand model.
Valuation parameters:		
Annualisation factor	318	Day to year – study team
Algorithm:	Benefit = toll revenue ($) * annualisation factor * 1.032 (used to uplift model outputs from 2009 values to 2010 dollars.	
Calculation:	2021: -2,236 * 318 * 1.032 = -0.7m 2031: -6,288 * 318 * 1.032 = -2.1m	
Total economic benefit:	Toll revenue impact: 2021: -$0.7m 2031: -$2.1m	

Source: Study assumptions

Table E.8: Resource Cost Correction – Incremental Fare Revenue

	Value		Comment
Demand model output: Change in passenger revenue ($ per year - million)	Without project: 2021: 891.0m 2031: 1,191.7m	With project: 2021: 913.0m 2031: 1,262.2m	Source: SKM –Aurecon demand model.
Valuation parameters:			
Annualisation factor	Not applicable since annual values provided by the demand model.		
Algorithm:	Benefit = fare revenue ($) * 1.032 (used to uplift model outputs from 2009 values to 2010 dollars.		
Calculation:	*Without project:* 2021: 891.0 * 1.032 = 919.5m 2031: 1,191.7 * 1.032 = 1,229.8m *With project:* 2021: 913.0 * 1.032 = 942.2m 2031: 1,262.2 * 1.032 = 1,302.6m		
Total economic benefit:	*With project – without project:* 2021: 942.2 – 919.5 = $22.7m 2031: 1,302.6 – 1,229.8 = $72.8m		

Source: Study assumptions

Table E.9: Resource Cost Correction – Operating Cost Resource Cost Correction Benefits

	Value		Comment
Demand model output: Change in car kilometres travelled (per day)	Without project: 2021: 67.3m 2031: 82.8m	With project: 2021: 67.0m 2031: 82.1m	Source: SKM –Aurecon demand model.
Valuation parameters:			
Car unperceived operating cost correction factor	$0.143	Source: NSW RTA Economic Analysis parameters.	Car unperceived operating cost correction factor
Annualisation factor	318		Day to year – source: study team
Algorithm:	(Car VKT without project * VOC correction factor * annualisation factor) – (Car VKT with project * VOC correction factor * annualisation factor)		
Calculation:	*Without project:* 2021: 67.3 * 0.143 * 318 = 3,060 2031: 82.8 *0.143 *318 = 3,765 *With project:* 2021: 67.0 * 0.143 * 318 = 3,046 2031: 82.1 *0.143 *318 = 3,733		
Total economic benefit:	*Without cost – with project cost:* 2021: 3,060 – 3,046 = $14m 2031: 3,765 – 3,733 = $34m		

Source: Study assumptions

Table E.10: Resource Cost Correction – Externality Cost Benefits

	Value		Comment
Demand model output: Change in car kilometres travelled (per day)	Without project: 2021: 67.3m 2031: 82.8m	With project: 2021: 67.0m 2031: 82.1m	Source: SKM –Aurecon demand model.
Valuation parameters:			
Externality cost ($/km)	$0.15	Source: Austroads (updated to 2010 values).	Externality cost ($/km)
Annualisation factor	318		Day to year – source study team.
Algorithm:	(Car VKT without project * externality cost * annualisation factor) – (Car VKT with project * externality cost * annualisation factor)		
Calculation:	*Without project:* 2021: 67.3 * 0.15 * 318 = 3,210 2031: 82.8 *0.15 *318 = 3,949 *With project:* 2021: 67.0 * 0.15 * 314 = 3,195 2031: 82.1 *0.15 * 314 = 3,916		
Total economic benefit:	*Without cost – with project cost:* 2021: 3,210 – 3,195 = $15m 2031: 3,949 – 3,916 = $33m		

Source: Study assumptions

Table E.11: Resource Cost Correction – Crash Cost Benefits

	Value	Comment
Demand model output: Change in car kilometres travelled (per day)	Saving in VKT: 2021: 0.3m 2031: 0.7m	Source: SKM –Aurecon demand model.
Valuation parameters:		
Crash rates (crashes per million VKT)	Fatal: 0.007166 Injury: 0.086946 Minor injury: 0.193080 Property damage only: 0.212011	Source: Austroads
Crash cost ($ per incident)	Fatal: $2,352,371 Injury: $565,005 Minor injury: $24,296 Property damage only: $8,880	Source: Austroads (updated to 2010 values).
Annualisation factor	318	Day to year – source study team.
Algorithm:	(Change in VKT * fatal crash rate * fatal crash cost) + (change in VKT * injury crash rate * injury crash cost) + (change in VKT * minor injury crash rate * minor injury crash cost) + (change in VKT * property damage only crash rate * property damage only crash cost)	
Calculation:	*Fatal:* 2021: 0.3 * 0.007166 * 2.35m * 318 = 1.6m 2031: 0.7 * 0.007166 * 2.35m * 318 = 3.7m *Injury:* 2021: 0.3 * 0.086946 * 0.56m * 318 = 4.6m 2031: 0.7 * 0.086946 * 0.56m * 318 = 10.8m *Minor Injury:* 2021: 0.3 * 0.19308 * 0.024m * 318 = 0.4m 2031: 0.7 * 0.19308 * 0.024m * 318 = 1.0m *Property damage:* 2021: 0.3 * 0.212 * 0.0088m * 318 = 0.2m 2031: 0.7 * 0.212 * 0.0088m * 318 = 0.4m	
Total economic benefit:	*Fatal + Injury + Minor injury + property damage:* 2021: 2 + 5 + 0 + 0 = $7m 2031: 4 + 12 + 1 + 0 = $17m	

Source: Study assumptions

Table E.12: Rail Freight Benefits – Operating Cost Benefits

	Value		Comment
Demand model output: Change in freight tonnages by rail and road (net-tonne kilometres (ntk) per year)	*Without project:* 2016: rail ntk: 5,149m 2016: road ntk: 1,493m *Without project:* 2031: rail ntk: 364m 2031: road ntk: 7,924m	*With project:* 2016: rail ntk: 6,642m 2016: road ntk: 0m *With project:* 2031: rail ntk: 8,288m 2031: road ntk: 0m	Source: Freight demand modelling based on Systemwide freight operations modelling.
Valuation parameters: Unit operating cost ($/ntk)	Rail: $0.033 (assumes 50% uplift for PUD cost) Road: $0.048		Source: Melbourne to Brisbane Inland Rail Alignment Study, ARTC, 2010.
Algorithm:	Benefit = ((Without rail ntk * rail op. cost) + (without road ntk * road op. cost) – (With rail ntk * rail op. cost) + (with road ntk * road op. cost))		
Calculation:	*Without project:* 2016: rail ntk: 5,149m * 0.033 = 169.9 2016: road ntk: 1,493m * 0.048 = 71.7 Sub total: 241.6 *Without project:* 2031: rail ntk: 364m * 0.033 = 12.0 2031: road ntk: 7,924m * 0.048 = 380.3 Sub total: 392.3 *With project:* 2016: rail ntk: 6,642m * 0.033 = 219.2 2016: road ntk: 0m * 0.048 = 0 Sub total: 219.2 *With project:* 2031: rail ntk: 8,288m * 0.033 = 273.5 2031: road ntk: 0m * 0.048 = 0 Sub total: 273.5		
Total economic benefit:	2016: $241.6m – $219.2m = $22.4m 2021: $39m (interpolated benefit) 2031: $392.3m - $273.5m = $118.9m		

Source: Study assumptions

Table E.13: Rail Freight Benefits – Externality Cost Benefits

	Value		Comment
Demand model output: Change in freight tonnages by rail and road (net-tonne kilometres (ntk) per year)	*Without project:* 2016: rail ntk: 5,149m 2016: road ntk: 1,493m *Without project:* 2031: rail ntk: 364m 2031: road ntk: 7,924m	*With project:* 2016: rail ntk: 6,642m 2016: road ntk: 0m *With project:* 2031: rail ntk: 8,288m 2031: road ntk: 0m	Source: Freight demand modelling based on Systemwide freight operations modelling.
Valuation parameters: Unit externality cost ($/ntk)	**2016:** Rail: $0.0058 Road: $0.0162	**2031:** Rail: $0.0032 Road: $0.0092	Source: ATC guidelines, Deloitte estimates
Algorithm:	Benefit = ((Without rail ntk * rail externality cost) + (without road ntk * road externality cost) – (With rail ntk * rail externality cost) + (with road ntk * road externality cost))		
Calculation:	*Without project:* 2016: rail ntk: 5,149m * 0.0058 = 29.9 2016: road ntk: 1,493m * 0.0162 = 24.2 Sub total: 54.1 *Without project:* 2031: rail ntk: 364m * 0.0032 = 1.2 2031: road ntk: 7,924m * 0.0092 = 72.9 Sub total: 74.1 *With project:* 2016: rail ntk: 6,642m * 0.0058 = 38.5 2016: road ntk: 0m * 0.0162 = 0 Sub total: 38.5 *With project:* 2031: rail ntk: 8,288m * 0.0032 = 26.5 2031: road ntk: 0m * 0.0092 = 0 Sub total: 26.5		
Total economic benefit:	2016: $54.1m – $38.5m = $15.6m 2021: $23m (interpolated benefit) 2031: $74.1m - $26.5m = $47.6m		

Source: Study assumptions

Note: the unit externality value is based on a weighted average of the proportion of urban and rural trips. This percentage split is based on the volume of port IMEX and interstate traffic. For IMEX traffic, it is assumed that 70% of traffic is urban (i.e. 70% of the trip occurs within an urban environment), whilst for interstate traffic, the proportion of urban traffic is assumed to be 20%. Given the change in volume of these two categories of freight demand in 2016 and 2031, the overall percentage urban/ rural split applied in the analysis is as follows:

- 2016: 70%
- 2031: 32%

These percentage splits are applied to the unit parameter values for externality costs to (as shown in Table 6.20) derive externality cost values in each year which are subsequently applied to the change in private vehicle kilometres.

Table E.14: Rail Freight Benefits – Road Freight Crash Benefits

	Value		Comment
Demand model output: Change in freight tonnages by rail and road (net-tonne kilometres (ntk) per year)	*Without project:* 2016: rail ntk: 5,149m 2016: road ntk: 1,493m *Without project:* 2031: rail ntk: 364m 2031: road ntk: 7,924m	*With project:* 2016: rail ntk: 6,642m 2016: road ntk: 0m *With project:* 2031: rail ntk: 8,288m 2031: road ntk: 0m	Source: Freight demand modelling based on Systemwide freight operations modelling.
Valuation parameters: Net accident cost ($/ntk)	Road: $0.003737		Source: Melbourne to Brisbane Inland Rail Alignment Study, ARTC, 2010.
Algorithm:	Benefit = Change in road ntk * unit accident cost		
Calculation:	2016: road ntk: (1,493 – 0) * 0.003737 = 5.6 2031: road ntk: (7,924 – 0) * 0.003737 = 29.6		
Total economic benefit:	2016: $5.6m 2021: $10.0m (interpolated benefit) 2031:$29.6m		

Source: Study assumptions

Table E.15: Rail Freight Benefits – Road Freight Crash Benefits

	Value		Comment
Demand model output: Change in freight tonnages by rail and road (net-tonne kilometres (ntk) per year)	*Without project:* 2016: rail ntk: 5,149m 2016: road ntk: 1,493m *Without project:* 2031: rail ntk: 364m 2031: road ntk: 7,924m	*With project:* 2016: rail ntk: 6,642m 2016: road ntk: 0m *With project:* 2031: rail ntk: 8,288m 2031: road ntk: 0m	Source: Freight demand modelling based on Systemwide freight operations modelling.
Valuation parameters: Net accident cost ($/ntk)	Road: $0.78 Truck payload = 22 tonnes[64]		Source: Study assumptions based on RailCorp unit values. Study assumptions.
Algorithm:	Benefit = (Change in road ntk/average payload) * trip length congested * % of day congested * unit decongestion value		
Calculation:	2016: road: ((1,493 – 0)/22) * 10% * 20% * 0.78 = 1.1 2031: road: ((7,924 – 0)/22) * 10% *20% * 0.78 = 5.6		
Total economic benefit:	2016: $1.1m 2021: $2m (interpolated benefit) 2031:$5.6m		

Source: Study assumptions

[64] Assumes 12 tonnes per TEU and an average of 1.8 TEU per truck.

Appendix F: Wider Economic Impacts

Introduction

This appendix provides further background to the methodology applied in the analysis as well as justification of the inputs to the analysis. In particular, this section provides details of the application of local datasets to the wider economic impacts analysis.

Agglomeration Impacts

Background

The assessment of agglomeration impacts relies on the estimation of an employment accessibility variable called ‘effective density’:

$$ED_i^s = \sum_j \frac{E_j^s}{AGC_{ij}^s}, \qquad \textbf{(1)}$$

where subscripts i and j are origins and destinations, superscript s is scenario, ED is ‘effective density’, E is employment and AGC is the trip-weighted average generalised costs for business and commuter trip purposes.

The effective density is calculated for each forecast year, for each model zone (and then aggregated into the relevant Statistical Local Area (SLA)[65] and for each scenario. The increase in density between two scenarios within a given year and zone is converted to a relative productivity gain using agglomeration elasticities:

$$Agg_i^{WEB} = \left[\left(\frac{ED_i^{ds}}{ED_i^{dm}}\right)^{\beta_i} - 1\right] \times GSP_i \qquad \textbf{(2)}$$

where B is the agglomeration elasticity, GSP is Gross State Product and *Agg* is the agglomeration benefit.

The overall agglomeration benefit is then the sum of the benefits across all travel zones.

Supporting data

The key evidence required for assessing agglomeration benefits is transport model outputs, national statistics on employment and GSP and agglomeration elasticities. Transport model outputs were available from the SKM – Aurecon JV demand modelling team. Economic statistics for Brisbane and Queensland have been sourced from the Australian Bureau of Statistics, State Accounts and the 2006 Census. Finally, Brisbane specific evidence on agglomeration elasticities has been derived as part of the study.

As part of this study, Dr Dan Graham at Imperial College London[66] was commissioned to review the evidence base relating to agglomeration in Australia. His findings were that there is currently no robust evidence available. However, Dr Graham gave advice on a preferred approach to deriving best estimates for Brisbane based on international data. From his

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[65] This is an area definition used by the Australian Bureau of Statistics.

[66] Dr Dan Graham is an acknowledged world expert in the field of wider economic impact estimation. He has provided ongoing advice to the UK Department for Transport in the development of their guidance as well as publishing a number of academic papers in this area.

previous review of, and work in developing, evidence on agglomeration economies, it is clear that the variation in the strength of agglomeration effects between sectors is much stronger than variation across countries and cities. In other words, the main driver in variation in the strength of agglomeration across location is in fact sectoral composition. This suggests that it is more reliable to estimate Brisbane specific agglomeration elasticities based on detailed international evidence together with data on sectoral composition of the city's industry than using evidence from the still emerging work on estimating elasticities using Australian data.

The analysis has therefore applied UK sectoral elasticities[67], which are outputs of the one of most rigorous agglomeration estimation undertaken so far, together with employment data by sector by SLA in Brisbane to estimate average agglomeration elasticity for each Brisbane SLA. The figure below shows the 10 SLAs with highest and lowest agglomeration elasticities.

Agglomeration elasticity	Highest SLA	Agglomeration elasticity	Lowest SLA
0.043	City – inner	0.004	Herston
0.043	Milton	0.006	Nathan
0.037	Upper Kedron	0.010	Wooloowin
0.036	Chapel Hill	0.011	Enoggera
0.036	Bridgeman Downs	0.011	St Lucia
0.035	Anstead	0.012	Dutton Park
0.035	Newstead	0.012	Deagon
0.034	Fortitude Valley	0.013	Loganlea
0.034	Paddington	0.014	Durack
0.034	Wilston	0.014	Bray Park

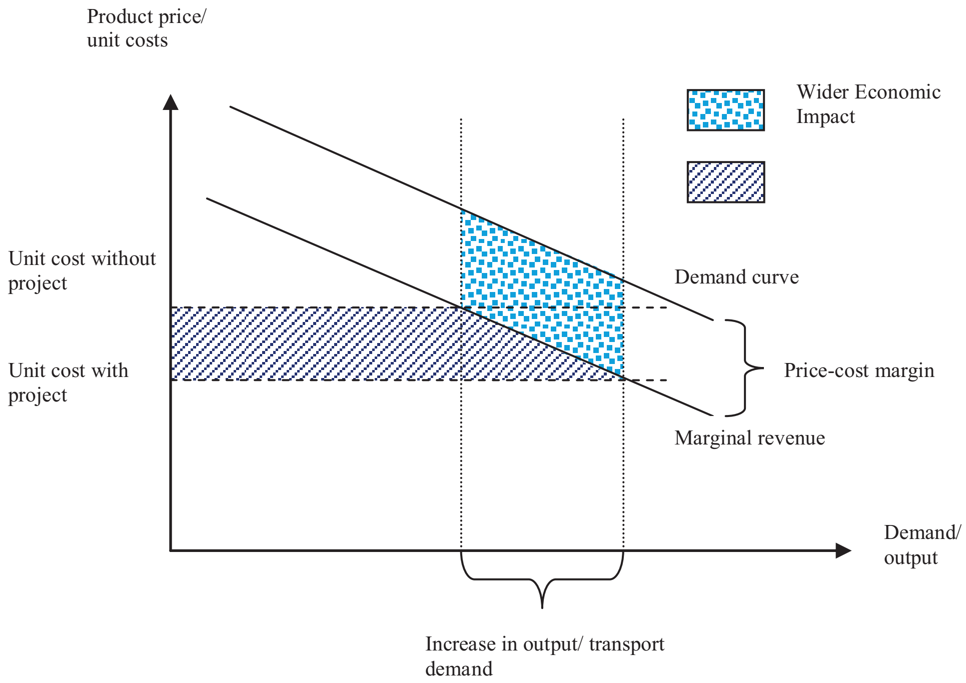
Imperfect competition

The wider economic impact from Imperfect Competition can occur if a transport improvement causes output to increase in sectors where there are price-cost margins. If a transport improvement causes a reduction in travel time for in-work travel it is fair to assume that the time saved will be put to productive use. The value of one hour saved for a business traveller is therefore the market value of what the workers can produce in that hour. Because conventional cost benefit analysis assumes all transport-using sectors operate in perfect competition, where price equals marginal costs, the value of the additional production is identical to the gross marginal labour cost of the additional hour worked. CBA therefore measures the value of the travel time saving as a saving in gross labour cost.

However, if price-cost margins exist, they, by definition, cause a wedge between the hourly gross labour costs and the market value of what is produced in that hour. Hence, where there are price-cost margins, a transport-induced increase in output will cause a wider economic impact identical to the size of this wedge. The figure below illustrates the conventionally measured user benefits in light blue and the 'missing' benefit in light green.

[67] Graham D.J., Gibbons S. and Martin R. (2009) "Transport Investment and the Distance Decay of Agglomeration Benefits", Centre for Transport Studies, Imperial College.

Figure F.1: Wider Economic Impacts from Imperfect Competition



The figure shows the market for a good for which the production requires transport as an input (such as freight or business travel). The demand curve shows consumers' willingness to pay for one additional unit at different levels of demand. Inherent in a market with market power is that the net additional revenue each firm receives if it reduces the price sufficiently to sell one additional unit is lower than the price. This is because it will have to reduce price on all units in order to increase its sales. The marginal revenue curve tracks the net additional revenue the firm receives for each additional unit sold at different levels of sales. The firm will maximise its profits where the marginal revenue is equal to the unit production cost. At this point consumers' willingness to pay exceeds the unit production cost, implying that output in this imperfect market is below what is socially optimal.

Now if it mistakenly assumed that this market is perfectly competitive, an individual will perceive the marginal revenue curve as the demand curve. Hence, a transport project that reduces unit costs as shown in the figure will, according to conventional CBA, deliver benefits equal to the blue area.

However, the existence of imperfect competition means that the increased output delivered by the project will lead to further gains, shown as light green in the figure. It is clear from the figure that the magnitude of this wider economic impact is equal to the price cost margin multiplied by the increased output. That said, the output increase from a given transport improvement would be difficult to measure directly.

On the other hand, it can be shown that the additional benefits are closely related to the magnitude of conventionally measured benefits to in-work travel. In fact, the wider economic impact from imperfect competition turns out to be a fixed proportion of business time savings. This proportion is equal to:

$$IC = \left(\frac{PCM \cdot e}{PCM \cdot (e-1)}\right) = \frac{1}{n+1}$$

Where **pcm** is the price cost margin (defined as (price – marginal cost) / price), **e** the market aggregate demand elasticity (i.e. the elasticity of total output with respect to a change in overall prices) and **n** the 'notional' number of firms competing in the market.

Hence, to enable the assessment of imperfect competition benefits we need estimates of price-cost margins and the aggregate demand elasticity in the study area. We also use evidence on the average number of firms competing in each market as a cross check of our results.

Price-cost margins in Queensland

There is a significant literature on price-cost margins, but only two papers have been identified that produces results for Australia. Boulhol (2005) estimates price cost margins for the manufacturing sectors in 18 countries[68]. The table below shows that average margins vary between countries from less than 10% in Norway and Sweden, to close to 15% in New Zealand and Japan. The price cost margin for Australia is estimated to be 13%. The table also shows that the variations between sectors are more significant, from about 6% to nearly 16%. Note that these estimates ignore the service sectors where price-cost margins are likely to be higher. For instance, the UK Department for Trade and Industry (reported in DfT (2005)[69]) found price-cost margins across both manufacturing and services in the UK to be about 20%, which is double the result from Boulhol. The other main source for price-cost margins in Australia is work undertaken by Olive (2002[70] and 2004[71]) who estimates the mark-up of eight manufacturing industries in Australia, concluding that the average mark-up rate is 26%.

[68] Boulhol (2005): Why haven't Price Cost Margins Decreased with Globalisation? Paris University, Panthéon-Sorbonne and CNRS).

[69] Department for Transport (2005): *Transport, Wider Economic Benefits, and Impacts on GDP.*

[70] Olive, M: Mark-up, returns to scale, the business cycle and openness: evidence from Australian manufacturing, Department of Economics, Macquarie University, 2002.

[71] Olive, M: Mark-up, returns to scale, the business cycle and openness: evidence from Australian manufacturing, Economic Papers (Economics Society of Australia), Vol 23 No. 1, March 2004.

a) All sectors by country

	Level	
	Average	Standard-deviation
Australia	0.131	0.051
Austria	0.123	0.031
Belgium	0.107	0.031
Canada	0.120	0.041
Denmark	0.103	0.033
Spain	0.133	0.052
Finland	0.130	0.037
France	0.106	0.035
UK	0.106	0.026
Germany	0.095	0.037
Italy	0.140	0.049
Japan	0.149	0.045
Netherlands	0.107	0.036
Norway	0.089	0.023
New Zealand	0.148	0.033
Sweden	0.098	0.071
USA	0.111	0.048
Total	0.116	0.044

b) All countries, by sector

	Level	
	Average	Standard-deviation
Food and Beverages	0.106	0.021
Textiles	0.111	0.028
Wearing Apparel	0.110	0.022
Leather and Footwear	0.098	0.030
Wood and Cork	0.123	0.039
Pulp and Paper	0.137	0.029
Printing and Publishing	0.134	0.036
Coke, Refined Petroleum	0.113	0.078
Chemical	0.161	0.036
Rubber and Plastics	0.123	0.023
Other non-metallic mineral	0.155	0.035
Basic metals	0.095	0.024
Fabricated Metal	0.120	0.024
Machinery and Equipment,	0.108	0.024
Office, Accounting and Comp. Mach.	0.117	0.047
Electrical Machinery	0.119	0.022
Radio, TV and Comm. Equip.	0.119	0.058
Medical, Precision and Optical	0.120	0.049
Motor Vehicles	0.080	0.024
Other Transport	0.063	0.047
Manuf. Nec and Recycling	0.113	0.057
Total	0.116	0.044

However, DTI's work ignored two elements; the cost of capital and the value appreciation of fixed capital. The relevant price-cost margins for our purposes should be the margins in excess of 'normal' profits; that is, over and above what is required to give investors a normal rate of return. Hence the cost of capital should be included as a cost. Also, appreciations to the value of capital stock should be deducted from the cost-base as it is a gain to the capital stock owner. To supplement Bouhol's findings, average price-cost margins for Queensland have been derived based on national accounts data, similar to the UK Department for Transport analysis. However, we have also included an assessment of both the cost of capital and the appreciation of asset values.

The average price-cost margin for a sector can be defined as:

> *(Operating Surplus – Depreciation - Capital Costs + Appreciation of the value of capital)/ Gross Value Added.*

National accounts data was sourced for Gross Operating surplus, Depreciation, Capital Stocks and Gross Value Added, all by sector and over time, from the Australian Bureau of Statistics' State Accounts. An estimate of the current weighted average cost of capital is based on PWC (2010)[72], whilst historical data is sourced from Bao (2008)[73].

The appreciation of the value of capital has been estimated from national and capital accounting data as the difference between nominal growth in capital stock and net investment. The figure below summarises the findings of this analysis. It summarises the evolution of the price cost margins in Queensland between 1990 and 2009. Clearly there is a substantial variation over the business cycle, but the average margins are around15% - 25%. There also appears to be evidence of a downwards shift in margins from about 2004.

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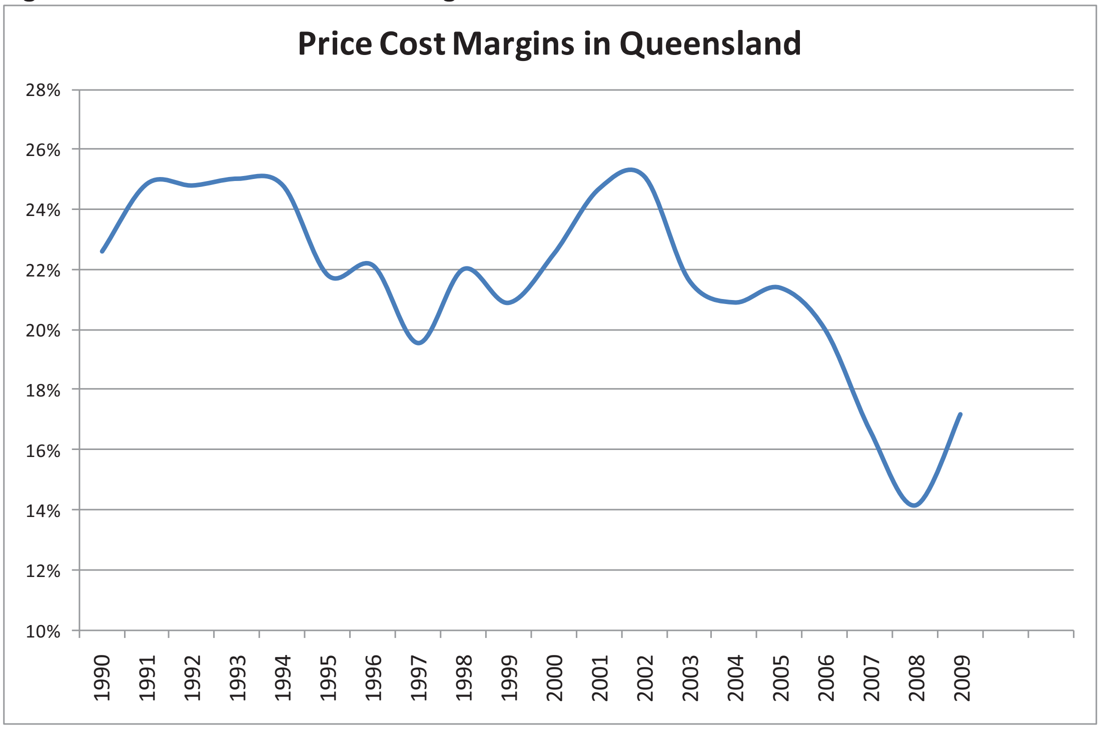
[72] PWC (2010), The Cost of Capital Report.

[73] BAO (2008): Time-Varying Market Leverage and the Market Risk Premium in New Zealand: Victoria University of Wellington.

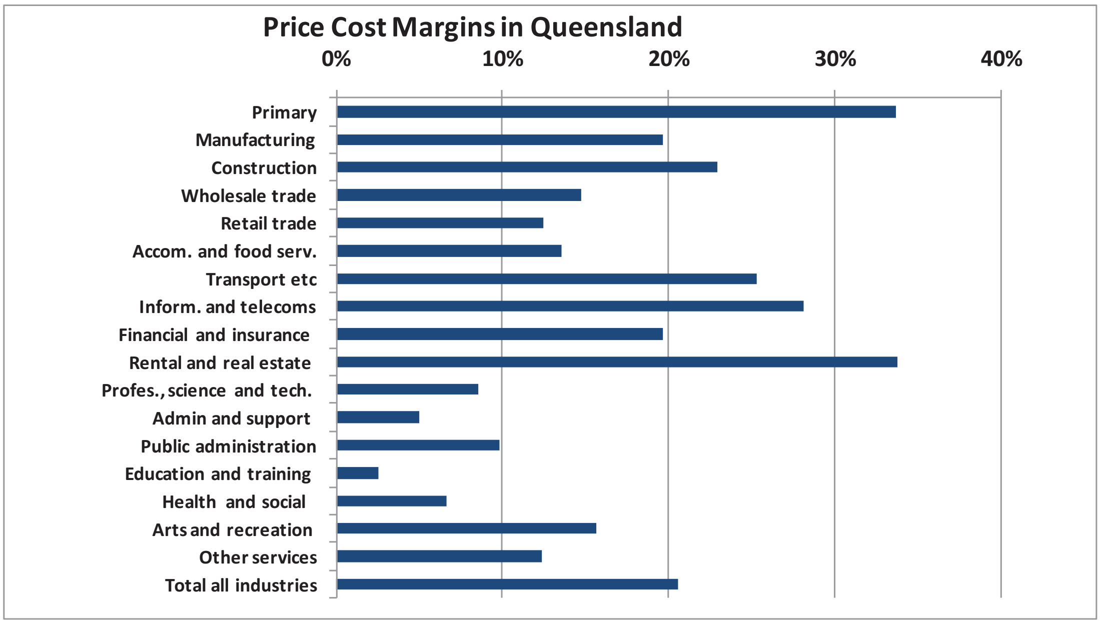
Figure F.2: National Price Cost Margins in Queensland



Source: SDG analysis

The figure below shows the variation in average margins between sectors from 1990 to 2007. Once again a substantial variation is evident. The largest margins are found in the primary sector, where typically a larger proportion of earnings are taken as operating surplus and it also includes profits made from the exploitation of raw materials. The high margins in real estate are most likely caused by value appreciation of property stocks that are not fully captured by the capital gains adjustment.

Figure F.3: Price Cost Margins in Queensland by Sector



Source: SDG analysis

Despite the variation and across sectors, there are too many uncertainties and data constraints to attempt to apply sector or time specific values as part of a wider economic impacts methodology. The most appropriate price-cost margin is therefore the long term, whole economy average across business cycles and sectors. Following a review of the data, this was found to be just over 21% over the period from 1990 to 2010 for Queensland. However, given the downward shift in margins over the last years, it was determined that it is appropriate to estimate the margins over the last 5 years only, yielding a slightly lower estimate of 18%. This result is slightly lower than the price-cost margin found by UK Department for Transport (2005) to be the appropriate value for the UK.

Aggregate demand elasticity

Despite the importance of the elasticity of aggregate demand with respect to price within economics, surprisingly little empirical work exists to help understand its magnitude (see Kyer and Maggs (2008)[74] for an overview).

There is some international evidence, for example Green (1991)[75] found the long-term elasticities to be -0.4 for the US, whilst Kyer and Maggs (1997)[76] found values in excess of -1. Apergis et al (2000)[77] found the aggregate demand elasticity in Greece to vary over time, ranging from -0.05 to -0.4, with values for the most recent years (1990 to 1995) of around -0.2 to – 0.35.

Work for SACTRA (1998) suggested the most appropriate value for the UK was -0.5, based on an informal application of a Cournot-style economy.

None of this evidence is specific for Australia. However, there is another set of evidence that is useful to assess. The aggregate demand elasticity explains changes in total demand in an economy caused by changes in overall real prices. However, a change in overall real price levels is equivalent to the opposite change in real incomes. It is therefore possible to use income elasticities of demand as a proxy for price elasticities (with the opposite sign).

Pesaran et al (1997) estimates income elasticities for 15 OECD countries and find the across-country value to between 0.9 and 1. Specifically for Australia the estimate was 1.05. Other estimates exist for New Zealand; Szeto (2009) describes the empirical work underlying the consumption function in the New Zealand Treasury Model, where they find the income elasticity to vary between 0.56 and 0.98 depending on the time period over which the relationship is estimated. Model simulations suggest a equilibrium income elasticity of 0.55, equivalent to a price elasticity of aggregate demand of -0.55.

Given the scarcity of established evidence and the wide range of estimates, it appears reasonable to select a conservative value for the aggregate demand elasticity. In the evaluation a value of -0.75 was chosen, which is a midpoint of the range of estimates from the findings in New Zealand, the elasticity applied in the UK methods and Pesaran's estimate of -1.05.

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[74] Kyer & Maggs (2008): On Indexed Bonds and Aggregate Demand Elasticity: International Atlantic Economic Society.

[75] Green, Hickman, Howey, Hymus & Donihue (1991): The IS-LM Cores of Three Econometric Models (Extract from Comparative Performance of US Econometric Models): Oxford University Press.

[76] Kyer & Maggs (1997): Price level elasticity of aggregate demand in the United States: quarterly estimates, 1955-1991: International Review of Economics and Business, 44(2), 407-417 (June).

[77] Apergis et al (2000): Measuring Price Elasticity of Aggregate Demand in Greece 1961-1995: University of Ioannina, Thessaloniki Stock Exchange Centre.

Application for the appraisal of wider economic impacts

The WEIs from imperfect competition can now be estimated as a fixed proportion of conventionally measured time and cost savings to in-work travel. The fixed proportion is equal to:

$$IC = \frac{pcm \cdot e}{pcm \cdot e - 1} = \frac{(0.18) \cdot (-0.75)}{(0.18) \cdot (-075) - 1} = 0.119$$

This indicates that the WEIs from imperfect competition, WEI^{IC} , can be estimated as:

WEI^{IC} = BUB x 0.119,

Where **BUB** is Business User Benefits; i.e. time and cost savings to in-work travel.

Labour supply impacts

Transport links play a crucial role in the movement and supply of labour. Typically transport networks are most congested during morning and afternoon periods when workers are moving to and from work; for many transport projects therefore commuters are the main beneficiaries, and it is clear that the travel to work experience is a key factor in the labour market decisions of workers and can often be a significant deterrent for those not in employment.

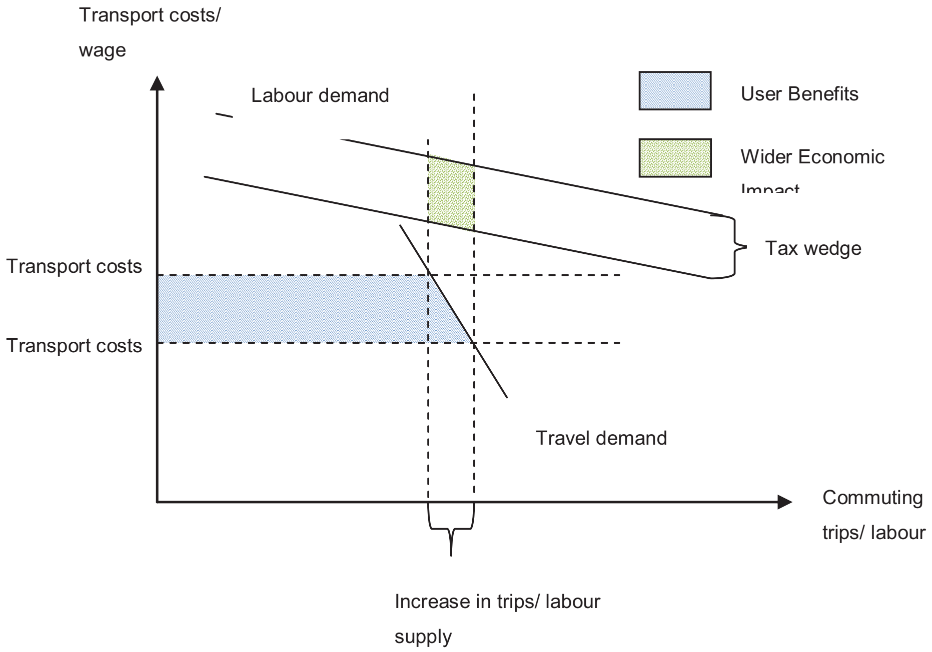
Reduced time and cost of commuting can enable easier access to work and increased separation between places of work and places of residence. In either case, it is natural to assume that a reduction in the perceived cost of working can induce more people to work than would otherwise be the case. This could either be by encouraging previously inactive individuals to join the labour market or by reducing the likelihood that workers leave the labour market, for instance to retire or to take up family responsibilities. Similarly, it is conceivable that a proportion of a commuting time saving will be allocated to productive activities; more work and higher pay (This is part of the basis for value of time benefits in standard appraisal).

Whist the labour supply decision of an individual is clearly important from a personal point of view, individual labour supply decisions do not in themselves produce any welfare gains to the individuals beyond what is already captured in standard appraisal. It is a private decision that presumably maximises an individual’s happiness in terms of income and leisure, which means the maximum the individual can gain is the potential travel time and cost savings.

However there are some important externalities in labour supply decisions, the main one being increased tax revenue. Since individuals make their labour supply decisions based on the returns to work net of income tax and other forgone benefits, there is a wedge between societal and private gains from a person working. This wedge is neglected in transport appraisal so if it can be shown that a transport improvement increases the total supply of labour, there would be an associated wider economic impact equal to the tax take on the additional supply of labour.

Figure F.4 illustrates the presence of the tax externality (the “tax wedge”) on labour supply. A reduction in travel costs increases the number of trips and the labour supply. Increased labour supply increases the levels of income, and tax which is a direct social benefit.

Figure F.4: Wider Economic Impacts from Increased Labour Supply



The two key pieces of evidence required to assess the magnitude of the wider economic impacts from labour supply are therefore:

- The change in labour supply following a transport improvement; and
- The tax wedge.

The following sections discuss how existing evidence can be brought to bear to enable such an assessment.

Transport and labour supply

Despite the apparent importance of travel times to labour supply decisions; formal quantitative evidence on the relationship is rare. The evidence that does exist, such as Solberg and Wong (2010)[78], finds that the proportion of discretionary time spent working is, in fact, positively related to commuting time amongst working individuals. However, the study considered travel time only as a cost, not as a complementary use of time to travel. It is a common finding that a change in the fixed cost of working may increase the amount of work supplied as the individuals may want to compensate for the loss of disposable income.

Other research, such as Laird (2006)[79], finds labour supply amongst working individuals unresponsive to commuting time, mainly because travel time savings are exchanged into longer commuting distances; an effect apparent in the tendency for individuals to choose to live further from work as travel links improve.

The links between travel time and labour supply are therefore complex, and potentially contradictory between different segments of the labour market. The UK Department for Transport's guidelines on assessing wider economic impacts conclude that there is not sufficient evidence to support an assessment of how time savings in travel to work can impact on hours worked for existing workers.

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[78] Solberg, Eric J. and David C. Wong. 1992. "Family Time Use: Leisure, Home Production, Market Work, and Work Related Travel." Journal of Human Resources 27(3):485-510.

[79] Laird (2006): Commuting Costs and Impacts on Wage Rates: Institute of Transport Studies, University of Leeds, Working Paper 587.

This finding is partially explained by the practical restrictions of the labour market. For example, it is rare for workers to be able to select precisely the number of hours they wish to work and so there is often an institutional barrier between labour supply at a microeconomic level and an improvement in commuting times.

In reality, the majority of workers face a discrete choice between working full time, part time or not at all. These choices have significant consequences in terms of job type, earnings and career development which mean that marginal changes in commuting time have relatively little impact on labour supply decisions and are more readily converted into wider residential catchment areas for employment centres. Effectively people utilise travel time savings through the housing market rather than the labour market, converting travel time savings into a better home location and working roughly the same number of hours.

Because of these complexities, the strongest potential effect of changes in commuting time on the labour supply is via changes to the likelihood that individuals choose to work, i.e. on the participation rate rather than the number of hours each worker supplies.

There is some indirect evidence for this link, for example Kolodziejczyk (2006)[80] finds that there is a relationship between the fixed costs of working and the retirement age based on French employment data. Gonzalez (2008)[81] finds that workers living further away from urban centres are more likely to retire earlier, although this did not control for the possibility that individuals change residential location in anticipation of retirement.

For the purpose of assessing wider economic impacts, more concrete evidence is required. One of the most widely researched determinants of labour supply and participation in the literature is the effect of wage rates and fixed costs on labour supply. To apply such evidence to transport appraisal, it would be necessary to consider commuting time savings as equivalent to an increase in the wage rate or a reduction in the fixed costs of working.

This is not necessarily unproblematic, because time savings, wage increases and cost savings can each cause quite different behavioural responses. This is mainly an issue when attempting to assess the small changes in work leisure time allocation from a commuting time saving between work and leisure for those already in work.

It is more relevant to consider the impacts of travel times on participation rates and treating a commuting time saving as a change in the fixed cost of working or in the wage rate is much less problematic than when considering the direct change. The following section formalises the theoretical relationship between commuting time savings and the labour participation rate.

Formalising the relationship between commuting time and labour participation

The general relationship between earnings and labour participation can be written as follows:

$$\frac{\partial E}{E} = \frac{\partial w}{w} \cdot e$$

Where **E** is employment or participation, **w** is the average gross wage, **e** is the labour participation elasticity with respect to gross wages and **d** in front of a variable signifies change or differential in that variable.

[80] Kolodziejcyk (2006): Retirement and Fixed Costs to Work: An Empirical Analysis: University of Copenhagen.

[81] Gonzalez, J. (2008): Commuting costs and labour force retirement: Instituto Valenciano de Investigaciones Economicas, S.A. (Ivie).

Since the value of a commuting time saving can be considered as a change in net wage, this leads to the following equation:

$$\frac{\partial E}{E} = \frac{V^c \partial t / (1-\tau^l)}{w} \cdot e = \frac{V^c \partial t}{w(1-\tau^l)} \cdot e$$

Where $\mathbf{V^c}$ is commuting value of time, **dt** is the average commuting time saving and τ^L the average tax on labour.

The additional output from increased employment is the average GDP per worker for the new entrants, $\mathbf{GDP_w^e}$, times the additional employment, **dE**, so:

$$\partial GDP = \partial E \cdot GDP_W^E = \frac{V^c \delta t}{w(1-\tau^l)} \cdot e \cdot E \cdot GDP_W^E$$

Each worker is, by definition, a commuter, so we can write:

$$\partial GDP = \frac{CV^c \partial t}{w(1-\tau^l)} \cdot e \cdot GDP_W^E$$

Where **C** is the number of commuters. The tax take on this additional output, $\boldsymbol{\tau^{LS}}$, is the Wider Economic Impact from increased labour supply:

$$WEI^{LS} = \frac{CV^c \partial t}{w(1-\tau^{l)}} \cdot e \cdot GDP_W^E \cdot \tau^{LS}$$

The assessment requires evidence on each of the parameters and variables:

- $\mathbf{CV^C dt}$: The value of commuting time savings
- **w**: Average earnings
- $\boldsymbol{\tau^L}$: Average tax rate on labour
- **e**: The elasticity of labour participation with respect to wages
- $\mathbf{GDP_W^E}$: Average output per worker for new entrants, which can be estimated based on evidence from literature and data from national accounts
- $\boldsymbol{\tau^{LS}}$: The tax take on output from increased labour supply.

The following section includes a discussion on the availability of data and evidence for each of these parameters for Queensland.

Data and Evidence for Labour Supply Impacts

The following sets out the parameters and evidence that have used in order to apply the above methodology to Cross River Rail using as much local evidence as possible.

- Commuting time savings ($CV^C dt$) - the value of commuting time savings have been calculated from the transport model outputs
- Average earnings (w) - sourced earnings by SLA from the Australian Bureau of Statistics
- Average tax rate on labour income (τ^L) – sourced from ABS's state accounts we have calculated average income tax in Queensland in 2009 as 34% of income
- The Elasticity of Labour Participation with respect to Wage (e) - there is relatively little evidence for labour market participation. One of the few studies found (Kalb (2003)[82]) develops labour supply and participation elasticities with respect to wages for Australian workers by age and demographic group. The average elasticity of participation with respect to wages was found to be about 0.15 – 0.20 for married men with children and singles, about 0.25 for married individuals without children and about 0.3 for sole parents and married women with children. Kidd and Ferko (2001)[83] estimate an elasticity of participation with respect to wages in Australia of between 0.11 to 1.20 for women and men. Based on the demographic composition of the labour force, we calculate an average participation elasticity of 0.2
- Average output per worker for new entrants - output per worker has been estimated based on Queensland data from ABS State Accounts.

Somewhat more challenging is to correct for the fact that new entrants to the labour market are likely to be less productive than existing workers. This is for several reasons, including:

- Self-selection; higher skilled individuals are more attractive to employers and / or have more incentives to work because they can earn better wages
- Skills dispersion; those who work have more opportunities and incentives to develop their skills, whilst the skills of those who do not work deteriorate over time without continuous practise
- Endogenous effort; It is likely that inactive individuals on the margins of participation in the labour market are more likely to desire jobs that require lower levels of effort and productivity, such as part time work or jobs with more work flexibility for instance because of child care responsibilities, these choices tend to result in lower average wages.

There is some evidence for this effect. Gregg et al (1999)[84] examined the UK Labour Force Survey and found that new entrants have earnings 31% below the average of existing workers.

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[82] Kalb (2009): Modelling Labour Supply Responses in Australia and New Zealand: University of Melbourne.

[83] Kidd & Ferko (2001): The Employment Effects of Gender Discrimination in Australia 1994-95: The Economic Record 77.

[84] Gregg, Johnson & Reed (1999): Entering work and the British tax and benefit system: Institute for Fiscal Studies.

For New Zealand, Kalb and Scutella (2003)[85] use data from the Household Economic Survey from 1991 to 2001 to establish how employees' detailed characteristics determine differences in wages and use this evidence to predict wages for non-employed individuals. They find the differential to be 29%.

The available evidence suggests a differential around 30%. However, since no Australia specific evidence has been found, it is proposed to adjust this value down in order to approach the uncertainty with conservativeness. We use a value for new entrants' productivity at 60% of the average employed worker, consistent with a productivity differential of 40%.

Tax take on output from increased labour supply (τ^{LS})

Based on data from ABS National Accounts we find that the total taxation raised in Australia in 2010 was $93,760 million against a total GSP of $303,000 million. This implies a total tax take on output of 30%.

[85] Kalb & Scutella (2003): Wage and Employment Rates in New Zealand from 1991 to 2001: New Zealand Treasury Working Paper 03/13.

Appendix G: Regional Economic Modelling

Introduction

Computable General Equilibrium (CGE) models usually consist of a database that represents an economy benchmarked for a particular time period based on input-output tables. The database specifies the interactions and relationships between various economic agents including firms, workers, households, the government and overseas markets.

The CGE model is then ‘shocked’ by changing a policy variable or an assumption about one or more parameters outside the model (so-called exogenous variables). Values for all other variables inside the model (so-called endogenous variables) are calculated from equations describing the economy, given numerical values for the parameters and the variables outside the model (Peterson, 2003).

The equations describing the relationships between economic agents exhibit a number of common features based on neoclassical economics (Peterson, 2003):

- Consumers maximise their utility subject to their budget constraints. They purchase goods and services from firms, and provide firms with their labour inputs;
- Producers maximise their profits by buying intermediate goods and inputs (labour and capital) and selling outputs to other domestic and international firms, households and government;
- There is a market for each commodity (goods and intermediates) and in equilibrium market prices are such that demand equals supply in all input and output markets;
- Under the standard assumption of constant returns to scale firms earn zero pure profit; and
- By comparing the pre- and post-shock databases, it is possible to measure the effects of the shock in terms of changes to GDP/ GSP, employment, wages, etc.

CGE model structure

The EconSearch model recognises:

- Producers classified by industry and domestic region
- Investors similarly classified
- Multiple region-specific household sectors
- Aggregate foreign purchaser of the domestic economy’s exports.

The model contains explicit representation of intraregional and interregional trade flows based on the EconSearch in-house input-output database. As each region has been modelled separately, the model captures the changes in economic activity resulting from a reduction in transport costs as a result of Cross River Rail. Second and subsequent round effects are captured via the model’s input-output linkages and account for economy-wide and international constraints.

The core input-output database of the four region CGE model is presented in Table G.1. It is based on the Monash MRF model (MMRF), a multi-region model of the Australian economy. Table G.1 shows the basic structure of the model using the MMRF notation. The seven columns identify the principal categories of demand:

1. Domestic producers - there are 30 industries (I) in each of the 4 regions (R)
2. Investors - there are 30 industries (I) in each of the 4 regions (R)
3. Households - there is one aggregate household sector in each of the 4 regions (R)
4. Purchaser of exports - a single aggregate foreign entity
5. Regional government demand - one set of regional government demands in each of the 4 regions (R)
6. Federal government demand - one set of federal government demands in each of the 4 regions (R)
7. Change in stocks – inventory accumulation in each of the 4 regions (R).

The nine rows show the supply of commodities to each category of demand, the margins associated with those sales, various forms of taxes applied to those sales and the supply of primary inputs to the production sector as follows:

- **(1) Basic flows** – each of the 30 commodities (C) identified in the model can be obtained from the 4 sources (S), i.e. the region itself, the other three regions or imported from overseas. The commodities are used as inputs into current production (V1BAS), inputs to capital formation (V2BAS), consumed by households (V3BAS), are exported (V4BAS), consumed by governments (V5BAS and V6BAS) and accumulate as inventories (V7BAS).
- **(2) Margins** – there are 9 domestically produced “goods” (M) that are defined as margin services. These services are necessary to transfer commodities from their sources to the various users (V1MAR, V2MAR, etc.). The most significant margins specified in the model are the services provided by the trade and transport sectors.
- **(3 - 5) Taxes** - there is a range of commodity taxes that are payable on the purchase of commodities from each source. These include regional and federal commodity taxes, as well as GST. For example, the cell V3GST represents a 3-dimensional array showing the cost of GST paid on the flows of 30 goods (C), from 5 sources both domestically and imports (S), in 4 regions (R).
- **(6 – 8)** Primary factors – as well as intermediate inputs and the margins and taxes paid on those inputs, current production requires three types of primary inputs: labour (V1LAB), capital (V1CAP) and land (V1LND).
- **(9) Other costs** – this category covers various miscellaneous industry expenses.

Table G.1: The Input – Output Database

		ABSORPTION MATRIX						
		1	**2**	**3**	**4**	**5**	**6**	**7**
		Producers	**Investors**	**Households**	**Exports**	**Regional Govt**	**Federal Govt**	**Stocks**
	Size	**I x R**	**I x R**	**R**	**1**	**R**	**R**	**R**
1. Basic Flows	C x S	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS	V7BAS
2. Margins	C x S x M	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	V6MAR	
3. Taxes: Regional	C x S	V1TAXS	V2TAXS	V3TAXS	V4TAXS			
4. Taxes: Federal	C x S	V1TAXF	V2TAXF	V3TAXF	V4TAXF			
5. Taxes: GST	C x S	V1GST	V2GST	V3GST	V4GST			
6. Labour	O	V1LAB						
7. Capital	1	V1CAP						
8. Land	1	V1LND						
9. Other Costs	1	VIOCT						

C = Number of commodities = 30
I = Number of Industries = 30
O = Number of occupation types = 8
M = Number of commodities used as margins = 9
R = Number of regions = 4
S = Number of sources = R+1: Domestic regions plus foreign imports = 5

The equations that comprise the core of three region CGE model are based on the Monash MRF model and can be classified according to the following broad sets:

- Producers' demands for intermediate inputs and primary inputs
- Demands for inputs to capital creation
- Household demand
- Export demands
- Government demands
- Demands for margins
- Zero pure profits in production and distribution
- Indirect taxes
- Market clearing conditions for commodities and primary factors
- Regional and national macroeconomic variables and price indices.

Model application

The model has been applied by:

- Aligning the CGE model database and study data (economic evaluation output data, infrastructure development data, price index data, other data) so they are consistent in form and time
- Model calibration to current state and industry data using GEMPACK software (software for CGE modelling)
- Checking that the modified CGE model is consistent with outputs of the detailed economic evaluation.

Aggregate outputs

The types of economic stimulus assessed in the CGE modelling are obtained from the conventional economic evaluation and include the following:

- Project construction costs
- Project operating costs
- Productivity improvements in form of travel time savings for commercial vehicles
- Incremental public transport passenger fare revenue as a result of the project
- Reduced vehicle operating costs for private vehicles
- Reduced crash costs for private vehicles.

Productivity improvements in the form of commercial time savings are assumed to reduce labour costs in the road transport sector. This is measured as labour costs per unit of output. Private time savings are ignored as they are assumed to have no significant economic impact (increased leisure time). Increased net revenue for the rail system (compared to the without project case) is modelled as total productivity improvement in the rail sector.

Reduced vehicle operating costs (which includes reduced fuel consumption) and reduced crash costs are modelled as reduced inputs for the machinery and equipment (includes cars and car parts), trade (includes motor vehicle repairs), financial and business services and capital costs.

The results generated for each CGE model simulation (‘’with project’’ option) are presented at national and state levels for a range of key economic indicators, e.g. gross domestic (state) product, real consumption and %) and employment.

Results

The disaggregated results of the CGE modelling are shown in Tables G.2 and G.3.

Table G.2: GSP Impacts on the Queensland Economy - $ million

Industry	2016	2021	2031	2041
Agriculture	6	4	13	15
Mining	11	40	130	143
Petroleum	2	1	2	2
Machinery & equipment	13	6	18	20
Other manufacturing	41	16	57	63
Utilities	10	6	21	23
Construction	211	26	106	117
Trade	51	11	48	55
Hotels, restaurants	11	5	19	22
Road transport	9	8	39	47
Rail transport	2	-1	-3	-3
Other transport	15	9	32	36
Communications	13	8	27	30
Financial, business services	126	51	179	199
Government services	10	18	58	65
Other services	9	4	14	15
Dwellings	45	24	82	90
Taxes less subsidies	67	27	96	108
Gross State Product	**653**	**262**	**937**	**1,047**

Source: Study team

Table G.3: Employment Impacts on the Queensland Economy

Industry	2016	2021	2031	2041
Agriculture	75	44	160	182
Mining	28	84	271	298
Petroleum	6	1	4	5
Machinery & equipment	202	78	255	279
Other manufacturing	524	175	648	730
Utilities	56	29	96	105
Construction	2,686	286	1,167	1,290
Trade	767	142	700	792
Hotels, restaurants	137	63	244	279
Road transport	100	-99	-953	-1,238
Rail transport	11	-15	-51	-52
Other transport	84	48	181	208
Communications	54	36	123	136
Financial, business services	928	349	1,219	1,349
Government services	83	239	758	836
Other services	158	61	213	237
Total Employment	**5,901**	**1,522**	**5,036**	**5,439**

Source: Study team

Appendix H: Economic Evaluation Results

Table H.1: Economic Evaluation Results Summary – Reference Project (excluding wider economic impacts)

YEAR	COSTS: Fixed Assets Capital	COSTS: Fixed Assets Recurrent	COSTS: Rolling stock	COSTS: Sub total	TRANSPORT BENEFITS: Residual value	Perceived costs: Public transport users	Perceived costs: Rail reliability	Perceived costs: Road users	Perceived costs: Road freight	Other benefits: Increase in public transport revenue	Other benefits: Change in toll revenue	Other benefits: Reduced unperceived VOC	Other benefits: Reduced externality costs	Other benefits: Reduced crash costs	Other benefits: Freight	Sub total	TOTAL BENEFIT	TOTAL NET BENEFIT ($M)
2010	17	-	-	17	-	-	-	-	-	-	-	-	-	-	-		-	-17
2011	54	-	-	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-54
2012	66	-	-	66	-	-	-	-	-	-	-	-	-	-	-	-	-	-66
2013	55	-	-	55	-	-	-	-	-	-	-	-	-	-	-	-	-	-55
2014	954	-	-	954	-	-	-	-	-	-	-	-	-	-	-	-	-	-954
2015	588	-	-	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-588
2016	1,294	-	-	1,294	-	-	-	-	-	-	-	-	-	-	-	-	-	-1,294
2017	1,135	-	-	1,135	-	-	-	-	-	-	-	-	-	-	-	-	-	-1,135
2018	1,097	-	44	1,140	-	-	-	-	-	-	-	-	-	-	-	-	-	-1,140
2019	1,145	-	81	1,226	-	-	-	-	-	-	-	-	-	-	-	-	-	-1,226
2020	-87	-	81	-5	-	-	-	-	-	-	-	-	-	-	-	-	-	5
2021	-38	52	81	95	-	250	36	70	7	23	-1	13	13	7	74	491	491	396
2022	-23	55	81	114	-	270	41	84	9	26	-1	15	14	7	82	546	546	433
2023	-36	58	81	103	-	292	47	100	11	29	-1	16	16	8	90	609	609	506
2024	-28	62	72	106	-	316	55	120	15	32	-1	18	17	9	100	680	680	573
2025	-	65	81	146	-	341	63	143	19	36	-1	19	19	10	110	760	760	614
2026	-6	68	81	144	-	369	73	171	24	41	-1	21	21	11	122	851	851	708
2027	363	111	81	554	-	399	84	205	31	46	-1	23	23	12	135	956	956	401
2028	363	76	81	519	-	431	96	245	39	51	-2	25	25	13	149	1,075	1,075	556
2029	363	80	72	515	-	466	111	293	50	58	-2	28	28	14	165	1,212	1,212	698
2030	363	83	90	536	-	504	128	351	64	65	-2	31	31	16	183	1,370	1,370	834
2031	-	87	72	160	-	545	148	420	82	73	-2	34	34	17	202	1,552	1,552	1,393
2032	-	181	81	262	-	560	150	430	84	74	-2	34	34	18	202	1,583	1,583	1,321
2033	-	96	81	177	-	576	152	439	87	75	-2	34	35	18	202	1,615	1,615	1,438
2034	-	145	-	145	-	592	154	449	89	76	-2	35	35	18	202	1,648	1,648	1,503
2035	-	102	-	102	-	609	156	459	92	77	-2	35	36	18	202	1,681	1,681	1,579
2036	-	104	-	104	-	626	158	469	94	78	-2	36	36	18	202	1,715	1,715	1,611
2037	-	419	-	419	-	644	160	480	97	79	-2	36	37	19	202	1,750	1,750	1,332
2038	-	124	-	124	-	662	162	491	100	80	-2	37	37	19	202	1,786	1,786	1,662
2039	-	125	-	125	-	680	164	502	102	81	-2	37	37	19	202	1,823	1,823	1,698
2040	-	344	-	344	-	700	166	513	105	82	-2	38	38	19	202	1,861	1,861	1,517
2041	-	143	-	143	-	719	168	525	108	83	-2	38	38	20	202	1,900	1,900	1,757
2042	-	249	-	249	-	740	170	537	111	84	-2	39	39	20	202	1,940	1,940	1,690
2043	-	148	-	148	-	761	173	549	115	85	-2	39	39	20	202	1,980	1,980	1,833
2044	-	150	-	150	-	782	175	562	118	86	-2	40	40	20	202	2,022	2,022	1,872
2045	-	149	-	149	-	804	177	575	121	87	-2	40	40	21	202	2,065	2,065	1,917
2046	-	208	-	208	-	827	179	588	125	88	-3	41	41	21	202	2,109	2,109	1,901
2047	-	242	-	242	-	850	182	601	128	89	-3	41	42	21	202	2,154	2,154	1,912
2048	-	159	-	159	-	874	184	615	132	91	-3	42	42	22	202	2,201	2,201	2,042
2049	-	161	-	161	-	899	186	630	135	92	-3	42	43	22	202	2,248	2,248	2,087
2050	-	164	-	164	2,018	924	189	644	139	93	-3	43	43	22	202	2,297	4,314	4,151
Total	7,636	4,209	1,244	13,090	2,018	18,011	4,085	12,261	2,433	2,055	-59	970	974	500	5,253	46,484	48,501	35,411
PV total	4,463	705	450	5,617	135	3,094	688	1,942	363	355	-10	172	172	89	962	7,827	7,962	2,345
Share	79%	13%	8%	100%	2%	39%	9%	24%	5%	4%	0%	2%	2%	1%	12%	98%	100%	

NPV ($M)	2,345
BCR	1.42
IRR (%)	10%
NPV/I	0.53

Table H.2: Economic Evaluation Results Summary – Reference Project (including wider economic impacts)

YEAR	COSTS					TRANSPORT BENEFITS												TOTAL BENEFIT	TOTAL NET BENEFIT ($M)
	Fixed Assets			Sub total	Residual value	Perceived costs				Other benefits						Sub total			
	Capital	Recurrent	Rolling stock			Public transport users	Rail reliability	Road users	Road freight	Increase in public transport revenue	Change in toll revenue	Reduced unperceived VOC	Reduced externality costs	Reduced crash costs	Freight		WEI		
2010	17	-	-	17	-	-	-	-	-	-	-	-	-	-	-		-	-	- 17
2011	54	-	-	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- 54
2012	66	-	-	66	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- 66
2013	55	-	-	55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- 55
2014	954	-	-	954	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- 954
2015	588	-	-	588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- 588
2016	1,294	-	-	1,294	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- 1,294
2017	1,135	-	-	1,135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- 1,135
2018	1,097	-	44	1,140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- 1,140
2019	1,145	-	81	1,226	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- 1,226
2020	- 87	-	81	- 5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
2021	- 38	52	81	95	-	250	36	70	7	23	- 1	13	13	7	74	491	69	560	465
2022	- 23	55	81	114	-	270	41	84	9	26	- 1	15	14	7	82	546	79	625	512
2023	- 36	58	81	103	-	292	47	100	11	29	- 1	16	16	8	90	609	90	699	596
2024	- 28	62	72	106	-	316	55	120	15	32	- 1	18	17	9	100	680	103	783	677
2025	-	65	81	146	-	341	63	143	19	36	- 1	19	19	10	110	760	118	878	732
2026	- 6	68	81	144	-	369	73	171	24	41	- 1	21	21	11	122	851	135	986	843
2027	363	111	81	554	-	399	84	205	31	46	- 1	23	23	12	135	956	155	1,110	556
2028	363	76	81	519	-	431	96	245	39	51	- 2	25	25	13	149	1,075	177	1,252	733
2029	363	80	72	515	-	466	111	293	50	58	- 2	28	28	14	165	1,212	202	1,415	900
2030	363	83	90	536	-	504	128	351	64	65	- 2	31	31	16	183	1,370	232	1,602	1,066
2031	-	87	72	160	-	545	148	420	82	73	- 2	34	34	17	202	1,552	265	1,817	1,658
2032	-	181	81	262	-	560	150	430	84	74	- 2	34	34	18	202	1,583	265	1,848	1,586
2033	-	96	81	177	-	576	152	439	87	75	- 2	34	35	18	202	1,615	265	1,880	1,703
2034	-	145	-	145	-	592	154	449	89	76	- 2	35	35	18	202	1,648	265	1,913	1,768
2035	-	102	-	102	-	609	156	459	92	77	- 2	35	36	18	202	1,681	265	1,946	1,844
2036	-	104	-	104	-	626	158	469	94	78	- 2	36	36	18	202	1,715	265	1,980	1,876
2037	-	419	-	419	-	644	160	480	97	79	- 2	36	37	19	202	1,750	265	2,015	1,597
2038	-	124	-	124	-	662	162	491	100	80	- 2	37	37	19	202	1,786	265	2,051	1,927
2039	-	125	-	125	-	680	164	502	102	81	- 2	37	37	19	202	1,823	265	2,088	1,963
2040	-	344	-	344	-	700	166	513	105	82	- 2	38	38	19	202	1,861	265	2,126	1,782
2041	-	143	-	143	-	719	168	525	108	83	- 2	38	38	20	202	1,900	265	2,165	2,022
2042	-	249	-	249	-	740	170	537	111	84	- 2	39	39	20	202	1,940	265	2,205	1,955
2043	-	148	-	148	-	761	173	549	115	85	- 2	39	39	20	202	1,980	265	2,245	2,098
2044	-	150	-	150	-	782	175	562	118	86	- 2	40	40	20	202	2,022	265	2,287	2,137
2045	-	149	-	149	-	804	177	575	121	87	- 2	40	40	21	202	2,065	265	2,330	2,182
2046	-	208	-	208	-	827	179	588	125	88	- 3	41	41	21	202	2,109	265	2,374	2,166
2047	-	242	-	242	-	850	182	601	128	89	- 3	41	42	21	202	2,154	265	2,419	2,177
2048	-	159	-	159	-	874	184	615	132	91	- 3	42	42	22	202	2,201	265	2,466	2,307
2049	-	161	-	161	-	899	186	630	135	92	- 3	42	43	22	202	2,248	265	2,513	2,352
2050	-	164	-	164	2,018	924	189	644	139	93	- 3	43	43	22	202	2,297	265	4,579	4,416
Total	7,636	4,209	1,244	13,090	2,018	18,011	4,085	12,261	2,433	2,055	- 59	970	974	500	5,253	46,484	6,660	55,162	42,072
PV total	4,463	705	450	5,617	135	3,094	688	1,942	363	355	- 10	172	172	89	962	7,827	1,177	9,139	3,521
Share	79%	13%	8%	100%	1%	34%	8%	21%	4%	4%	0%	2%	2%	1%	11%	86%	100%	100%	

NPV ($M)	3,521
BCR	1.63
IRR (%)	11%
NPV/I	0.79

Table H.3: Economic Evaluation Results Summary – Alternative Alignment (excluding wider economic impacts)

YEAR	COSTS				Residual value	TRANSPORT BENEFITS											TOTAL BENEFIT	TOTAL NET BENEFIT ($M)
	Fised Assets			Sub total		Perceived costs				Other benefits						Sub total		
	Capital	Recurrent	Rolling stock			Public transport users	Rail reliability	Road users	Road freight	Increase in public transport revenue	Change in toll revenue	Reduced unperceived VOC	Reduced externality costs	Reduced crash costs	Freight			
2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
2011	39	-	-	39	-	-	-	-	-	-	-	-	-	-	-	-	-	- 39
2012	86	-	-	86	-	-	-	-	-	-	-	-	-	-	-	-	-	- 86
2013	2,576	-	-	2,576	-	-	-	-	-	-	-	-	-	-	-	-	-	- 2,576
2014	1,163	-	-	1,163	-	-	-	-	-	-	-	-	-	-	-	-	-	- 1,163
2015	1,520	-	-	1,520	-	-	-	-	-	-	-	-	-	-	-	-	-	- 1,520
2016	428	-	41	468	-	-	-	-	-	-	-	-	-	-	-	-	-	- 468
2017	307	-	76	382	-	-	-	-	-	-	-	-	-	-	-	-	-	- 382
2018	68	30	76	173	-	54	23	33	3	5	- 0	4	3	2	21	148	148	- 25
2019	-	32	76	108	-	70	27	39	4	7	- 0	5	4	3	24	182	182	74
2020	-	34	76	110	-	91	31	48	4	9	- 0	6	4	3	27	223	223	113
2021	-	36	76	112	-	119	36	58	5	12	- 1	7	5	4	30	275	275	163
2022	-	46	67	114	-	125	41	65	6	13	- 1	8	5	4	33	300	300	186
2023	-	40	76	116	-	131	48	73	8	14	- 1	8	6	4	37	328	328	212
2024	-	40	76	116	-	138	55	81	9	16	- 1	8	6	4	41	358	358	242
2025	-	40	76	116	-	145	63	91	11	17	- 1	8	6	4	46	393	393	277
2026	-	40	76	115	-	152	73	103	14	19	- 1	9	6	5	52	431	431	315
2027	363	61	67	491	-	160	84	115	16	21	- 1	9	6	5	58	473	473	- 18
2028	363	39	84	486	-	168	97	129	20	22	- 1	9	7	5	65	521	521	36
2029	363	39	67	469	-	176	112	145	24	25	- 1	10	7	5	72	575	575	106
2030	363	39	76	477	-	185	129	163	28	27	- 1	10	7	5	81	635	635	158
2031	-	39	76	114	-	195	149	183	34	29	- 1	10	7	5	90	703	703	589
2032	-	195	-	195	-	200	151	187	35	30	- 1	10	7	5	90	716	716	521
2033	-	38	-	38	-	206	153	191	36	30	- 1	11	7	6	90	730	730	691
2034	-	39	-	39	-	212	155	195	37	31	- 1	11	8	6	90	743	743	705
2035	-	144	-	144	-	218	157	200	38	31	- 1	11	8	6	90	757	757	614
2036	-	40	-	40	-	224	159	204	39	31	- 1	11	8	6	90	772	772	732
2037	-	296	-	296	-	230	161	209	40	32	- 1	11	8	6	90	787	787	491
2038	-	41	-	41	-	237	164	214	42	32	- 1	11	8	6	90	802	802	761
2039	-	173	-	173	-	243	166	218	43	33	- 1	11	8	6	90	817	817	645
2040	-	42	-	42	-	250	168	223	44	33	- 1	12	8	6	90	833	833	791
2041	-	43	-	43	-	257	170	228	45	33	- 1	12	8	6	90	850	850	807
2042	-	54	-	54	-	264	172	233	46	34	- 1	12	8	6	90	866	866	812
2043	-	44	-	44	-	272	174	239	48	34	- 1	12	8	6	90	883	883	839
2044	-	45	-	45	-	280	177	244	49	35	- 1	12	9	6	90	901	901	856
2045	-	46	-	46	-	287	179	250	50	35	- 1	12	9	6	90	919	919	873
2046	-	46	-	46	-	296	181	256	52	36	- 1	13	9	7	90	937	937	891
2047	-	530	-	530	2,010	304	184	261	53	36	- 1	13	9	7	90	956	2,966	2,436
Total	7,636	2,371	1,158	11,166	2,010	5,889	3,642	4,878	886	762	- 21	297	208	155	2,118	18,815	20,825	9,659
PV total	5,117	461	480	6,057	164	1,229	698	942	156	155	- 5	67	47	35	439	3,764	3,928	- 2,129
Share	84%	8%	8%	100%	4%	31%	18%	24%	4%	4%	0%	2%	1%	1%	11%	96%	100%	

NPV ($M)	- 2,129
BCR	0.65
IRR (%)	4%
NPV/I	-0.42

Table H.4: Economic Evaluation Results Summary – Staged Option (excluding wider economic impacts)

YEAR	COSTS					TRANSPORT BENEFITS											TOTAL BENEFIT	TOTAL NET BENEFIT ($M)
	Fixed Assets			Sub total	Residual value	Perceived costs				Other benefits						Sub total		
	Capital	Recurrent	Rolling stock			Public transport users	Rail reliability	Road users	Road freight	Increase in public transport revenue	Change in toll revenue	Reduced unperceived VOC	Reduced externality costs	Reduced crash costs	Freight			
2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
2011	10	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	- 10
2012	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	- 2
2013	- 9	-	-	- 9	-	-	-	-	-	-	-	-	-	-	-	-	-	9
2014	574	-	-	574	-	-	-	-	-	-	-	-	-	-	-	-	-	- 574
2015	329	-	-	329	-	-	-	-	-	-	-	-	-	-	-	-	-	- 329
2016	661	-	-	661	-	-	-	-	-	-	-	-	-	-	-	-	-	- 661
2017	802	-	-	802	-	-	-	-	-	-	-	-	-	-	-	-	-	- 802
2018	1,472	-	-	1,472	-	-	-	-	-	-	-	-	-	-	-	-	-	- 1,472
2019	779	-	139	919	-	-	-	-	-	-	-	-	-	-	-	-	-	- 919
2020	364	-	9	372	-	-	-	-	-	-	-	-	-	-	-	-	-	- 372
2021	5	43	- 9	40	-	94	19	41	4	12	- 0	8	8	4	43	233	233	193
2022	106	48	9	163	-	92	24	46	6	13	- 0	8	8	4	50	250	250	87
2023	161	50	- 9	201	-	90	30	52	8	13	- 0	8	8	4	58	271	271	69
2024	367	52	9	427	-	88	38	58	10	14	- 0	8	8	4	67	296	296	- 131
2025	332	54	95	481	-	86	48	65	14	14	- 0	8	8	4	78	327	327	- 154
2026	279	56	112	447	-	84	61	73	19	15	- 0	8	8	4	91	364	364	- 83
2027	500	59	104	663	-	82	78	82	26	16	- 0	8	8	4	106	410	410	- 253
2028	523	95	104	722	-	80	99	92	35	16	- 0	8	8	4	123	467	467	- 255
2029	473	68	104	644	-	151	125	153	47	27	- 1	13	13	7	143	679	679	35
2030	407	82	104	592	-	285	158	254	61	45	- 1	21	21	11	167	1,023	1,023	431
2031	10	87	104	200	-	536	200	423	81	75	- 2	34	34	17	194	1,592	1,592	1,392
2032	-	95	104	199	-	551	202	432	83	76	- 2	34	35	18	194	1,623	1,623	1,425
2033	-	176	112	288	-	567	205	442	85	77	- 2	35	35	18	194	1,656	1,656	1,368
2034	-	106	95	201	-	583	207	452	88	78	- 2	35	36	18	194	1,689	1,689	1,488
2035	-	151	-	151	-	599	210	462	90	79	- 2	36	36	18	194	1,723	1,723	1,572
2036	-	121	-	121	-	616	213	472	93	80	- 2	36	37	19	194	1,757	1,757	1,637
2037	-	116	-	116	-	634	216	483	95	81	- 2	37	37	19	194	1,793	1,793	1,677
2038	-	361	-	361	-	651	218	494	98	82	- 2	37	38	19	194	1,829	1,829	1,468
2039	-	134	-	134	-	670	221	505	101	83	- 2	38	38	19	194	1,867	1,867	1,733
2040	-	163	-	163	-	689	224	516	104	84	- 2	38	39	20	194	1,905	1,905	1,742
2041	-	245	-	245	-	708	227	528	107	86	- 2	39	39	20	194	1,945	1,945	1,700
2042	-	129	-	129	-	728	230	540	110	87	- 2	39	40	20	194	1,985	1,985	1,855
2043	-	228	-	228	-	749	233	553	113	88	- 2	40	40	20	194	2,026	2,026	1,798
2044	-	133	-	133	-	770	236	565	116	89	- 2	40	41	21	194	2,069	2,069	1,935
2045	-	141	-	141	-	791	239	578	119	90	- 2	41	41	21	194	2,112	2,112	1,971
2046	-	258	-	258	-	814	242	591	122	91	- 2	41	42	21	194	2,156	2,156	1,898
2047	-	225	-	225	-	837	245	605	126	92	- 2	42	42	21	194	2,202	2,202	1,977
2048	-	260	-	260	-	860	249	619	129	94	- 2	42	43	22	194	2,249	2,249	1,989
2049	-	243	-	243	-	884	251.8	633	133	95	- 2	43	43	22	194	2,297	2,297	2,054
2050	-	247	-	247	2,187	909	255.0	648	137	96	- 2	43	44	22	194	2,346	4,533	4,286
Total	8,147	4,226	1,183	13,556	2,187	15,280	5,203	11,460	2,359	1,892	- 48	866	876	447	4,804	43,139	45,326	31,771
PV total	4,106	660	362	5,128	146	2,203	816	1,667	345	289	- 7	136	137	70	836	6,490	6,636	1,508
Share	80%	13%	7%	100%	2%	33%	12%	25%	5%	4%	0%	2%	2%	1%	13%	98%	100%	

NPV ($M)	1,508
BCR	1.29
IRR (%)	9%
NPV/I	0.37

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