APPENDIX 6
ECONOMIC EVALUATION

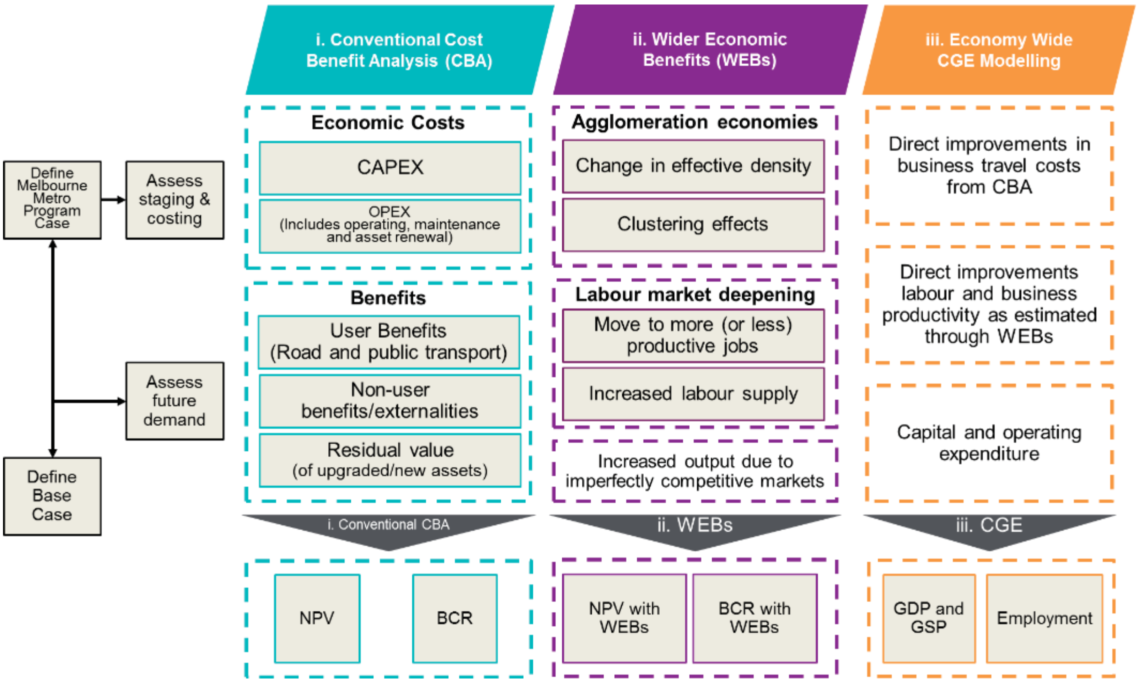
Appendix 6 - Economic Evaluation

1. Overview

This appendix provides further detail on the methodology and results of the economic evaluation undertaken for the Melbourne Metro Program and the Extended Program summarised from the *Melbourne Metro – Economic Evaluation Report* prepared by Public Transport Victoria.

Economic analysis was undertaken to understand the likely economic, social and environmental costs and benefits of both the Melbourne Metro Program and the Extended Program. The framework adopted for economic evaluation is summarised in Figure 1.

Figure 1 – Economic evaluation frameworks



Note: WEBs are cumulative to the conventional CBA. CGE modelling is not cumulative to the CBA and WEBs analysis, but provides a complementary view on the net economic contribution and productivity impacts

Three types of quantitative economic analysis were undertaken to assess the associated benefits and costs of the Extended Program:

- **Conventional cost-benefit analysis (CBA)** – This includes assessment of primarily transport-related costs and benefits such as travel time savings, reduced crowding, improved reliability, reduced crashes and environmental externalities and contrasting these against the capital and operating costs. This is used to determine the economic value from a whole of society perspective based upon its performance against two key indicators – Benefit Cost Ratio (BCR) and Net Present Value (NPV).

- **Wider Economic Benefits (WEBs)** – These are benefits arising from the presence of market imperfections and accrue to society as a whole as a result of improvements in transport connectivity. These benefits are cumulative to those calculated from the conventional CBA, and so updated BCR and NPV performance indicators that include WEBs are derived.

- **Economy-wide macro-economic modelling –** This provides an understanding of the 'economy-wide' flow-on impacts of the economic/productivity enhancing benefits using a Computable General Equilibrium (CGE) model. Economic impacts output from the CGE model are not cumulative to the economic benefits calculated in the CBA and WEBs analysis, but provide a complementary view on the net economic contribution of Melbourne Metro.

The approach and parameters adopted are consistent with relevant project evaluation guidelines published by the DTF[1], Transport and Infrastructure Council (TIC)[2], Infrastructure Australia[3] and Austroads.[4] The exception applies to the selection of the discount rate.

Benefits and operating costs are calculated over a 50-year period from the opening of Melbourne Metro in 2026 and discounted at rates of 4 and 7 per cent (real). Capital costs have been distributed across the design, planning and construction period, and discounted at 4 and 7 per cent (real).

The analysis uses a discounted cash flow analysis to compare the transport related marginal cost and benefits of delivering the Melbourne Metro Program and the Extended Program.

Following this overview, the appendix is structured as follows:

- Base Case, Melbourne Metro Program Case and Extended Program Case definitions
- Approach to economic evaluation, including assessment frameworks, key inputs, assumptions and parameters
- Economic costs
- Economic benefits, including conventional benefits, wider economic benefits and economy-wide modelling
- Detailed results, including key economic indicators and benefit results explained by category
- Sensitivity analysis
- Qualitative benefits excluded from assessment.

2. Base Case, Melbourne Metro Program Case and Extended Program Case

The cost-benefit analysis includes assessment of the incremental costs and benefits of the Melbourne Metro Program and the Extended Program Case relative to the Base Case.

The Base Case comprises a set of transport network and land use projections over the evaluation period.

The Melbourne Metro Program Case includes the costs and benefits of the Melbourne Metro tunnel, signalling upgrades and additional rolling stock.

The Extended Program Case includes the costs and benefits of the Melbourne Metro Program plus future projects on the Sunshine – Dandenong Rail Corridor which are enabled by Melbourne Metro to meet medium-term demand requirements. This approach recognises that the Melbourne Metro Program Case includes the costs of capacity enhancements that

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[1] Victorian Department of Treasury and Finance, *Economic Evaluation for Business Case Technical Guidelines* (August 2013).
[2] Transport and Infrastructure Council, *National Guidelines for Transport System Management in Australia,* (2006, 2015).
[3] Infrastructure Australia, *Reform & Investment Framework: Templates for Stage 7 - Solution Evaluation,* (2013).
[4] Austroads, *Guide to Project Evaluation Part 4: Project Evaluation Data*, (2012).

fundamentally enable these future projects to be delivered, but does not include any of the benefits.

Further detail on the Base Case, Melbourne Metro Program Case and Extended Program Case is provided in the following sections.

2.1. Base Case

The Base Case is based on the Reference Case established by the Department[5] which includes:

- Land use projections for population and employment growth
- The transport network assumed to be required to support the land use projections and accommodate forecast population growth.

The Department developed the Reference Case as a framework to evaluate all major transport projects in a consistent manner. Rather than being a 'Do Minimum' scenario, the Reference Case transport network includes committed projects plus an agreed set of projects including arterial road upgrades, rail service upgrades, motorway improvements, tram and bus upgrades and service levels to supply a reasonable capacity that is supportive of the future demand associated with reference case land use.

Inclusion of transport projects in future year networks in the Reference Case does not imply any commitment from the Government or Department to undertake these projects. It merely indicates that Department has determined that it is reasonable to represent the project, or a similar investment, in the future network for the purposes of modelling demand in the transport system. The inclusion of the Reference Case transport network ensures the future transport network is modelled to be operating as well as can be best projected by the Department and is supportive of the Reference Case land use projections. This approach ensures that Melbourne Metro does not claim spurious additional benefits that may result from adding capacity in the context of a transport network where demand is far in excess of supply.

The Reference Case transport network has been developed such that it is supportive of the Reference Case land use projections. The Reference Case projections for land use developed by the Department suggest that employment in the CBD will more than double to 500,000 by 2046.

The Base Case is the reference point for the economic analysis and consists of the Reference Case transport network but excludes Melbourne Metro and Melbourne Metro-enabled projects. Since the Base Case does not include these projects and in the absence of any other change in CBD transport system capacity, the Reference Case land use projections needed to be adjusted accordingly.

The capacity constraints in the road and public transport network servicing Melbourne's CBD suggests that the significant growth in jobs projected for the CBD under the Reference Case will not be realised without commensurate increase in commuting capacity. The analysis estimated that without Melbourne Metro Rail and other projects that are dependent on the Melbourne Metro being in place (or a similar project), approximately 47,000 jobs will not be accommodated in the CBD by 2046 as commuters would be either unable or unwilling to travel on heavily crowded lines.

The Reference Case land use was therefore amended, with the estimated 47,000 jobs redistributed to suburban centres across metropolitan Melbourne instead of the CBD.

[5] Department of Economic Development, Jobs, Transport and Resources. *2015 Reference Case* (2015).

2.2. Melbourne Metro Program Case

The Melbourne Metro Program Case consists of the Base Case transport network, plus the program of works necessary to deliver the proposed service plan. The key features of the Melbourne Metro Program (that distinguish it from the Base Case) include:

- **Melbourne Metro**
  - **Tunnel and Stations Civil Works –** twin nine-kilometre tunnels from South Kensington to South Yarra as part of a new Sunshine – Dandenong Line, with a western portal in the vicinity of South Kensington and an eastern portal in the vicinity of South Yarra; western turnback; and new underground stations at Arden, Parkville, CBD North, CDB South and Domain (for which funding is sought through this Business Case).
  - **Wider Network Enhancements –** High Capacity Signalling; other signalling and other works on Sunbury, Dandenong, Craigieburn, Upfield, Newport Corridor, Sandringham and Frankston lines; and tram network changes (for which funding is sought through this Business Case).
- **Rolling Stock –** Procurement of 7-car High Capacity Metro Trains (HCMTs) rolling stock and associated works (stabling, maintenance and power upgrades); extended platforms for 7-car HCMTs on the Sunshine – Dandenong Rail Corridor (Sunbury to South Kensington); and high capacity signalling interoperability (subject to a separate funding request).

The Melbourne Metro Program Case land use comprise the Base Case land use projections plus an additional 28,000 jobs located in the CBD in 2046 instead of suburban centres across Melbourne. This is to take into account the increase in peak hour commuting capacity provided by the Melbourne Metro Program. Total employment across metropolitan Melbourne remains the same as that projected under the Base Case.

2.3. Extended Program Case

The Extended Program Case transport network consists of the Melbourne Metro Program Case transport network, plus further incremental modifications (Enabled Investments) on the Sunshine – Dandenong Rail Corridor which are enabled by Melbourne Metro to meet medium-term demand requirements. This principally includes:

- Electrification of the Melton Line
- Sunshine to Deer Park West quadruplication
- Introduction of extended 10 car HCMTs on the Sunshine – Dandenong Line.

The Extended Program Case land use comprise the Melbourne Metro Program Case land use projections plus a further 19,000 jobs located in the CBD (additional to the 28,000 enabled by the Melbourne Metro Program) in 2046 instead of the suburban centres across Melbourne. As per the Melbourne Metro Program Case, total employment across metropolitan Melbourne is projected to remain constant.

Separate funding requests will be developed for the Enabled Investments included in the Extended Program in the future.

Table 1 and Table 2 show the most significant projects included in the Base Case, Melbourne Metro Program Case and the Extended Program Case.

Table 1 – Base Case

Scenario	Description
Base Case	Includes road and public transport projects in line with the Department's Reference Case. The most significant projects included in the Base Case include: • Public transport network – Deer Park West to Melton duplication for additional V/Line services. – Partial duplication of the Cranbourne Line. – Deployment of 37 High Capacity Metro Trains on the Cranbourne / Pakenham Line, including Pakenham East depot and maintenance facility, platform extensions, power and signalling. – Maximum service uplifts on the metropolitan network realised by the Regional Rail Link. – High capacity signalling trial. – Bayside Rail Improvement Project – Additional services on the Northern and Caulfield Group lines enabled by the full implementation of the Cross City Group (Frankston – Newport Line). – Mernda Rail Extension and subsequent improvements to the Clifton Hill Group. – Roxburgh Park to Upfield rail link for Seymour/Wallan V/Line services (by 2031). – Additional trams, buses and V/Line services to meet demand across the network. • Road network – CityLink and Tullamarine Freeway widening, and Western road capacity project (by 2021). – Outer Metropolitan Ring Road, North East Link and E6 projects to the outer north (by 2046). – Level Crossings Removal Program, including removal of level crossings at St Albans and Furlong Road on the Sunbury Line and the nine level crossings between Caulfield and Dandenong on the Cranbourne / Pakenham Line (by 2018). – Incremental development of the arterial road network. The Base Case land use projections are in line with Department's Reference Case with slight adjustments to employment growth in the CBD to account for the commuting capacity constraint that will be faced in Melbourne without significant improvement in accessibility to the CBD. The Base Case land use projections comprise: • Metropolitan Melbourne's population is projected to grow to 7.2m people by 2046 • Employment in Melbourne's CBD is expected to grow from 223,000 in 2011 to 455,000 by 2046 • Total employment across metropolitan Melbourne is projected to grow to 3.9m by 2046

Table 2 – Melbourne Metro Program Case and Extended Program Case

<table>
<tr><th>Scenario</th><th>Description</th></tr>
<tr><td>Melbourne Metro Program Case</td><td>Consists of the Base Case, plus the program of works required to deliver the proposed 2026 service plan including:
Melbourne Metro:
Tunnel and Stations Civil Works.
Wider Network Enhancements including small to medium scale works across the rail network to support the initial service plan on project completion. These works include signalling and other works on the Sunbury, Dandenong, Craigieburn, Upfield, Newport Corridor, Sandringham and Frankston Lines, and tram network changes.
Rolling Stock, including:
25 HCMTs to operate on the Sunshine – Dandenong Line, and subsequent cascade of existing fleet to operate on other metropolitan lines.
Stabling, maintenance and traction power upgrades to allow for 25 HCMT procurement and fleet cascade.
Platform extensions to allow operation of 7-car HCMTs (South Kensington to Sunbury).
High capacity signalling interoperability for HCMT rolling stock on the Sunshine – Dandenong Line.
The Melbourne Metro Program Case land use projections are as follows:
Metropolitan Melbourne’s population projected to grow to 7.2m people by 2046 as per the Base Case.
Relative to the Base Case, employment in Melbourne’s CBD is expected to grow by an additional 28,000 jobs to 483,000 by 2046.
Total employment across metropolitan Melbourne projected to grow to 3.9m by 2046 as per the Base Case.</td></tr>
<tr><td>Extended Program Case</td><td>The Extended Program Case transport network consists of the Melbourne Metro Program Case transport network, plus capacity enhancements to the Melton Line and the operation of longer 10-car trains on the Sunshine – Dandenong Line which are necessary to meet ongoing demand requirements (Enabled Investments). This principally includes:
Electrification of the Melton Line using 7 car HCMTs, and subsequent cascade of Melton V/Line trains to other regional lines (by 2031).
Sunshine to Deer Park West quadruplication (by 2031).
Platform lengthening on above ground sections of the Sunshine – Dandenong Line to allow use by extended 10 car HCMTs (by 2031).
Additional rolling stock cars and associated works (e.g. stabling, maintenance, and power upgrades) to progressively enable 7-car HCMTs to be extended to 10-car sets (from 2030 to 2042).
The Extended Program Case land use projections are as follows:
Metropolitan Melbourne’s population projected to grow to 7.2m people by 2046 as per the Base Case.
Relative to the Base Case, employment in Melbourne’s CBD is expected to grow by an additional 47,000 jobs to approximately 502,000 by 2046.
Total employment across metropolitan Melbourne projected to grow to 3.9m by 2046 as per the Base Case.</td></tr>
</table>

3. Approach to economic evaluation

3.1. Overview

The economic evaluation has been undertaken by PTV with inputs from KPMG (for WEBs) and Victoria University (for CGE modelling)[6] and draws upon the relevant guidelines and agreed assumptions from the Melbourne Metro Rail Authority (MMRA) and the Department. The relevant guidelines used in the economic evaluation include:

- Department of Treasury and Finance (2013) *Economic Evaluation for Business Cases - Technical Guidelines.*
- Infrastructure Australia (2013) *Reform & Investment Framework: Templates for Stage 7 - Solution Evaluation*.
- Transport and Infrastructure Council (2006; 2015) *National Guidelines for Transport System Management (NGTSM)*.
- Austroads (2012) *Guide to Project Evaluation Part 4: Project Evaluation Data*.
- DEDJTR (2015) *Standard approach to strategic transport modelling*.
- DEDJTR (2015) *2015 Reference Case.*

In addition to ensuring consistency with relevant guidelines, the approach to the conventional Cost Benefit Analysis (CBA) and the findings were independently peer reviewed as an additional layer of quality assurance.

3.2. Assessment frameworks

As depicted in Figure 1 the economic assessment framework adopted entails three different types of analysis. Historically, transport projects have been assessed and prioritised using a conventional Cost Benefit Analysis (CBA) framework. The objective of the CBA is to identify project or policy options that enhance societal welfare. For transport projects, conventional CBA typically examines travel time savings, reduced crowding, vehicle operating cost savings, reliability benefits, environmental externalities and crashes.

Over the last decade, transport project evaluation for significant projects have incorporated the concept of Wider Economic Benefits (WEBs). WEBs are additional sources of costs/ benefits that are not captured within conventional CBA. Both CBA and WEBs capture the direct impacts of the project or policy initiatives and are additive. In order to understand the broader flow-on impacts of Melbourne Metro, economy-wide macro-economic modelling using computable general equilibrium (CGE) modelling was undertaken[7].

A key difference between the economic analyses for this business case relative to more traditional business cases for major Australian transport infrastructure projects is the inclusion of land use impacts. In recent years, an increasing number of business cases developed by other jurisdictions have incorporated such land use impacts in the evaluation of transport projects, including the Sydney Light Rail Project (NSW), Capital Metro Light Rail Project (ACT) and Perth Light Rail/ Metro Area Express Project (WA).

The consideration of land use impacts on accessibility changes is considered international best practice and parallels the approach used in the Crossrail business case in the UK in 2007.

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[6] PTV, *Melbourne Metro – Economic Evaluation Report,* (2016).
[7] Refer to Peter Forsyth, *Using CBA and CGE in Investment and Policy Evaluation,* (2014) for a detailed discussion on the benefits of combining CBA and CGE models for project and policy evaluations.

Similar to Crossrail, a key objective of Melbourne Metro is to enable continued employment growth in Melbourne CBD by alleviating commuter rail capacity constraints.

As the business case for Crossrail in UK noted, transport problems, including overcrowded vehicles, do not simply create a poorer day-to-day experience for travellers, but constrain economic development. When demand for travel exceeds the available capacity of the transport network, people are no longer able to board the trains that are running, and not everyone who wishes to travel to certain destinations, such as central Melbourne, is able to do so. The total level of attainable employment in these destinations is therefore constrained and the size of the potential labour market that businesses in these destinations can access is reduced. Transport constraints therefore have the potential to provide a serious impediment to the competitiveness of Melbourne, highlighting the importance of measures to address them, such as Melbourne Metro.

Locating jobs in close proximity to each other in the CBD facilitates increased economic interactions between firms, and also between firms and customers. This leads to agglomeration benefits as firms are able to enhance their productivity through reaching wider markets, gaining scale economies and developing more specialised skills. Additionally, increased employment density leads to a greater number of high productivity CBD jobs being available for workers. This benefit is known as 'move to more productive jobs' and in turn leads to greater tax receipts.

Further information on each of the economic assessment frameworks is provided in Table 3.

Table 3 – Economic assessment frameworks

Economic assessment frameworks	
Conventional Cost Benefit Analysis	Cost-benefit analysis provides a robust method for evaluating both the market and non-market costs and benefits of a project or policy change. The analysis is undertaken from a whole of society perspective, regardless of who pays for the project. The estimated net benefits (total benefits minus total costs), along with any significant impacts that cannot be valued, are used to help decision-makers rank and assess options/choices available to them. The objective of the CBA is to identify project or policy options that enhance societal welfare from a utilitarian perspective. For transport projects, conventional CBA typically entails quantification of travel time savings (business and personal); vehicle operating cost savings (business and personal); travel time reliability benefits; environmental externalities and reduced crashes; and is contrasted against the capital and operating/maintenance expenditure.

Wider Economic Benefits	CBA is based on the assumption of perfect competition and no market imperfections. The presence of market imperfections means that certain additional impacts (costs and benefits) are not captured within the conventional CBA.
	
	These additional sources of impacts are referred to as Wider Economic Benefits (WEBs). These benefits are most relevant to significant transport and land (re)generation projects and typically refer to changes in productive capacity of the economy. There are four types of WEBs attributable to transport and land (re)generation projects:
	
	• WB1: Agglomeration economies;
	• WB2: Labour market deepening, including:
	  – WB2a: Increased labour supply
	  – WB2b: Move to more/less productive jobs
	• WB3: Output change in imperfectly competitive markets; and
	• WB4: Increased competition.
	
	Of the four types of WEBs, WB4 – Increased competition is not deemed relevant for Australian cities. Literature suggests that a transport project, in most developed economies that are characterised by reasonable transport access, is unlikely to have any material impact on industry competition.

Economic assessment frameworks	
Economy-wide macro-economic modelling (CGE Modelling)	Economy-wide macro-economic analysis using Computable General Equilibrium (CGE) modelling uses real economic data to estimate the 'economy-wide' impacts of a proposed project or a policy change. In line with DTF guidelines and NGTSM, CGE modelling is used to assess the flow-on impacts of economic/productivity enhancing benefits assessed through CBA and WEBs.

3.3. Key inputs and assumptions

Key inputs and assumptions used in the economic evaluation include:

- **Capital costs** – includes all non-recurrent capital costs that are expected to be incurred to deliver the Melbourne Metro Program and the Extended Program after the economic evaluation commences. Capital cost estimates were developed by Aquenta[8] for the purposes of this analysis in real (2015 dollar) terms.
- **Operation and maintenance costs** – includes all necessary recurrent costs to operate and maintain the asset over the evaluation period. Operation and maintenance cost estimates were developed by PTV for the purposes of this analysis in real (2015 dollar) terms.
- **Transport modelling and demand analysis** – Economic benefits[9] are calculated using outputs from the Victorian Integrated Transport Model (VITM). PTV and its advisers, AECOM, undertook the demand analysis and this has been peer reviewed[10]. Secondary analysis has also been undertaken using modelling outputs from the Veitch Lister Consulting (VLC) Zenith model.
- **Unit rates** – for each of the benefits calculated from the modelling outputs, primarily derived from the *National Guidelines for Transport System Management* (NGTSM)[11].

Applicable evaluation parameters are provided in Table 4.

Table 4 – Key economic evaluation assumptions and parameters

Parameter	Value	Description
Discount rate	4 and 7 per cent (real)	Further analysis provided in Section 3.5.
Cost certainty	P50	Costs have been included at the P50 level. This implies that there is a 50 per cent probability that the costs will be lower than the estimate that has been used in the modelling. A sensitivity test using P90 costs has been presented.

[8] Aquenta, *Melbourne Metro Rail Project - Capital Expenditure Estimate Report* (2016).
[9] With the exception of punctuality benefits and station crowding, which have been assessed using outputs from the ClicSIM model and RailSys model.
[10] PTV, *Melbourne Metro Public Transport Demand Forecasts for Business Case*, (2016).
[11] TIC, *National Guidelines for Transport System Management in Australia Volume 4 (for public transport benefits)*, (2006); TIC, *National Guidelines for Transport System Management in Australia – road parameter values (for road benefits)*, (2015).

Parameter	Value	Description
Evaluation period	50 years	From first year of operation of Melbourne Metro. 50 years is used in line with the NGTSM[12] for rail infrastructure. As per IA and DTF guidance, residual values of assets have been included in the last year of the evaluation period to incorporate the benefits that will continue to be delivered beyond the evaluation period.
Base year for discounting	2015	To align with price base.
Price base	2015 (Q2)	To align with price base used for construction costs.
Construction period	2018 – 2026	As per construction schedule.
First year of operation	2026	As per construction schedule.
Public transport expansion factors	AM peak and PM peak to annual demand: 242 Inter-peak and off-peak to annual demand: 357	Based on PTV patronage data.
Road expansion factors	Daily to annual demand: 330	Based on analysis of traffic counts undertaken on CityLink and the West Gate Freeway[13].
Value of time	2015: as per NGTSM Beyond 2015: indexed at 1.5% p.a. real growth (business-to-business trips) and 0.75% p.a real growth (non-business trips)	Based on productivity growth forecasts in 2015 Intergenerational Report[14]. Indexed as per NGTSM.
Modelled years	2021, 2031 and 2046	Costs and benefits were linearly interpolated between modelled years and extrapolated beyond the last modelled year. It has been assumed that there is no further growth in benefits beyond the design year (2056).

3.4. Transport models

Four transport models were used to inform the economic analysis – the Victorian Integrated Transport Model (VITM), Zenith, ClicSIM, and RailSys.

Outputs for the majority of the benefits are sourced from the VITM model, a four-step strategic transport model which forecasts travel by road and public transport from a given set of demographic/ land use inputs, road network and public transport service plan. Secondary analysis was undertaken using the Zenith model. The Zenith model is similar to VITM in its scope, use identical inputs and produce similar demand forecasts and outputs required for economic analysis. Transport network forecasts using Zenith was used as a secondary check against VITM results.

[12] TIC, *National Guidelines for Transport System Management in Australia Volume 3* (2006), 54.
[13] This factor is consistent with that being used for the Western Distributor project
[14] The Treasury, *2015 Intergenerational Report: Australia in 2055.* Australian Government (2015), 30.

Station crowding benefits were derived using outputs of ClicSIM, a mesoscopic simulation model which can model passenger movements in and around stations and loadings on individual trains. Outputs from VITM are used to inform passenger demand inputs to ClicSIM.

Train punctuality benefits were sourced from the RailSys model, a train simulation model which simulates the working timetable and tests its robustness. The software simulates individual train movements rather than passenger movements, and so outputs from VITM are used to inform passenger demand.

3.5. Discount rate

The economic analysis presented adopts a range using both 4 and 7 per cent real discount rates.

The 7 per cent real discount rate is used for the lower end of the range to be consistent with DTF and Infrastructure Australia guidelines. This rate may be considered relatively conservative in the context of emerging practice to use lower discount rates for projects of this nature.

A 4 per cent discount rate is used for the upper end of the range as it better reflects the long-lived nature of Melbourne Metro (using high discount rate penalises benefits derived by future generations potentially raising issues of intergenerational equity).

There are two main schools of thought on an appropriate basis for discounting the benefits of transport projects – the 'social time preference' (STP) approach and the 'social opportunity cost of capital' (SOC) approach. The STP approach is the rate at which consumers are willing to trade off present against future consumption, while the SOC approach uses a long term average of returns to the private sector. Different jurisdictions internationally adopt different rates based on one or either of these approaches (see Table 5). While current Victorian and Infrastructure Australia guidance for economic evaluation of transport projects recommends the use of a SOC approach, the appropriate discount rate for public projects is a matter of ongoing debate. To reflect the range of approaches currently used across Australia and elsewhere, both the 4 per cent and 7 per cent real discount rates have been presented together in this business case. The Victorian Government will continue to review and refine its approach to project discount rates over time to reflect emerging consensus in this complex area.

Table 5 – Transport sector discount rate in different countries

Jurisdiction	Type	Rate
UK	STP	0-30 years: 3.5% 31-75 years: 3% >75 years: 2%
New Zealand	SOC	8% (recommended by NZ Treasury 6% (used by NZ Transport Agency)
France	Risk adjusted STP	4.5% or project specific rate
Japan	SOC	4%
US	Certainty equivalent	2.5%, 3% and 5%

Source: Adapted from OECD/ITF (2015), Adapting Transport Policy to Climate Change: Carbon Valuation, Risk and Uncertainty, OECD Publishing, Paris.

Recent analysis by the Bureau of Infrastructure, Transport and Regional Economics (BITRE) confirmed that it recommends discount rates for the use in cost-benefit analysis within the range of 4 per cent and 7 per cent, with 5 per cent to be used if a single discount rate is desired.[15]

The selection of an appropriate discount rate is therefore critical to properly assessing the initiative. Adopting too high a discount rate for investments that are long lived assets can lead to selection of solutions that are low cost, but may not be optimal over the longer term. On the other hand, selecting a discount rate that does not appropriately take into account the opportunity cost and risks may also contribute to selection of sub-optimal solutions.

In addition, other large projects, both locally and internationally, have adopted lower discount rates in undertaking economic analysis, including:

- Inland Rail – ARTC's Business Case for Inland Rail has used a 4 per cent real discount rate for its headline numbers (with 7 per cent also provided for comparative purposes).
- Crossrail (UK) – The Crossrail project in the UK adopted a 3.5 per cent real discount rate.

4. Costs

The economic evaluation requires that only the economic costs are included in the analysis. Economic costs include incremental changes relative to the Base Case required to deliver the benefits and includes both the capital costs and operation and maintenance costs (including renewals) but exclude PTV levies. For the purpose of economic evaluation, present values (PV) have been obtained by discounting cash flows by the evaluation discount rate of 4 and 7 per cent (real) to the base year of 2015.

The economic costs for the Melbourne Metro Program Case include Melbourne Metro (Tunnel and Stations Civil Works and Wider Network Enhancements) and the Rolling Stock. The economic costs for Extended Program Case includes the costs for the Melbourne Metro Program Case plus the costs associated with the delivery, maintenance and operation of Enabled Investments. These costs are incremental to the Base Case and are detailed in Table 6.

Table 6 – Economic costs of Melbourne Metro Program and Extended Program

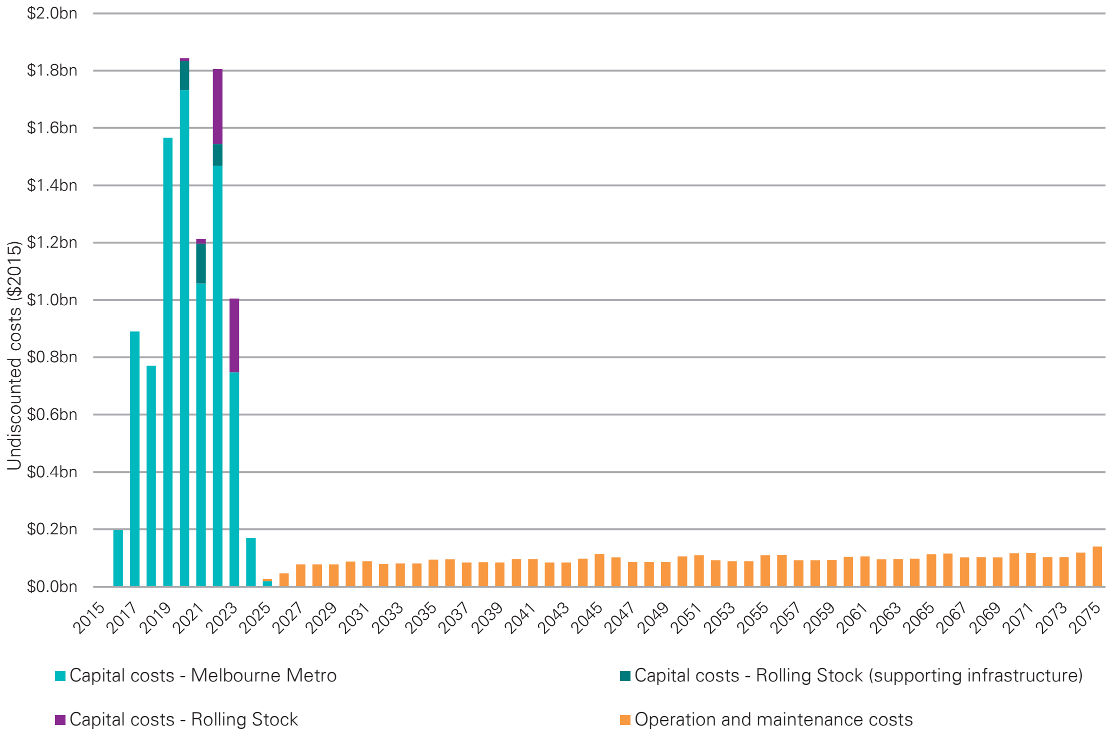
Cost	Melbourne Metro Program	Extended Program
Capital costs	Ranging from $9.5bn (P50) to $10.2bn (P90)	Ranging from $12.4bn (P50) to $13.4bn (P90)
Operation and maintenance costs	Averaging $94m per annum	Averaging $141m per annum

For the purposes of the economic evaluation, costs are expressed as real values (using a 2015 Q2 price base). A real value is a value that has been adjusted from a nominal value to remove the effects of general price level changes over time (i.e. inflation). In contrast, the financial assessment uses nominal values which retain the effects of inflation.

Figure 2 and Figure 3 show the cost profile for the Melbourne Metro Program and the Extended Program over the economic evaluation period.

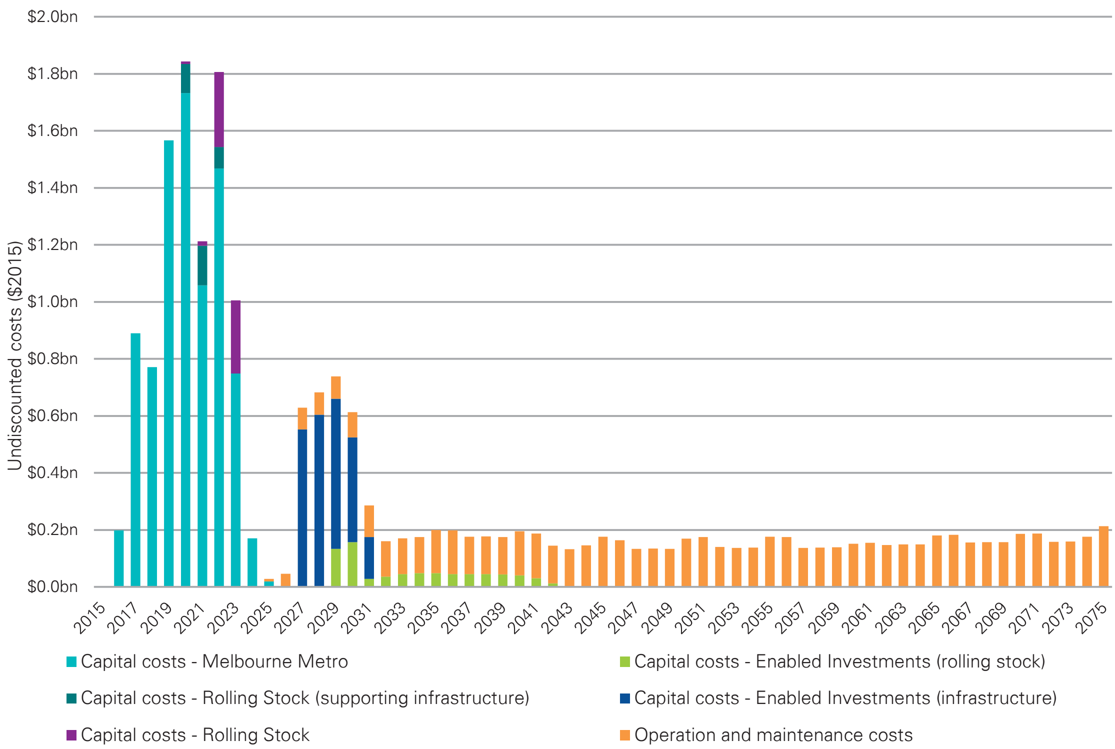
[15] Bureau of Infrastructure, Transport and Regional Economics, ND *BITRE review of the social discount rate for economic evaluation of Nation Building infrastructure projects,* (c2014).

Figure 2 – Cost profile (P50, Melbourne Metro Program Case)



Source: PTV

Figure 3 – Cost profile (P50, Extended Program Case)



Source: PTV

Table 7 shows the summary of capital costs for the Melbourne Metro Program and the Extended Program. Of the total capital expenditure estimated for the Extended Program, the costs for the Melbourne Metro Program (i.e. Melbourne Metro and Rolling Stock) represent approximately 76 per cent of the costs, and Enabled Investments comprise approximately 24 per cent.

The capital cost estimates used in this evaluation are the costs incurred in delivering and commissioning the infrastructure and rolling stock required for the Melbourne Metro Program and the Extended Program. The economic cost excludes profit margin and levies. Profit margin is excluded as it is perceived as a transfer while levies are excluded as they are not a resource cost to the project.

Table 7 – Summary of capital costs (undiscounted, real ($2015))

Redacted - commercial-in-confidence

The operation and maintenance cost estimates used in this evaluation include the incremental cost of running additional train services on the Sunshine – Dandenong Line and on other lines on the Northern, Caulfield and Cross-City Groups, operating and maintaining supporting infrastructure, the five new stations, tunnel, and new rail track & systems. Periodic refurbishment and renewal costs have also been included the economic cost excludes profit margins and PTV levies. Key assumptions are:

- Rail tunnel from South Kensington to South Yarra with five new underground stations all open on day one of operations
- Growing number of additional metropolitan train services until the capacity that is provided by this project on different lines is reached
- Increase in service kilometres from the operation of 7-car HCMTs at project opening to 10-car HCMTs from 2031 onwards on the Sunbury – Dandenong Line (in the Extended Program).
- Thirty-seven (37) 7-car HCMTs already operating on the Cranbourne / Pakenham Line before Melbourne Metro opens.

Table 8 provides a summary of the operation, maintenance and renewal costs for the Melbourne Metro Program and the Extended Program.

Table 8 – Summary of operation, maintenance and renewal costs (undiscounted, real ($2015))

Redacted - commercial-in-confidence

5. Conventional economic benefits

5.1. Overview

The following section describes the conventional economic benefits of the Melbourne Metro Program Case and the Extended Program Case and the approach adopted for calculating these using outputs from the transport models. More detail is provided in the PTV economic evaluation report[16].

The conventional economic benefits of a transport project fall into three main categories:

- **User benefits (public transport and road users**) – Benefits to public transport and remaining road users as a result of the transport project. User benefits include, for example, reducing crowding and waiting times on public transport, travel time savings and vehicle operating cost savings when people switch from travelling by car to travel by public transport. Certain benefits are unperceived by users but result in a change in consumption of resources, so resource cost corrections need to be applied
- **Non-user benefits (externalities) –** Benefits to society as a whole due to changes in travel behaviour after the transport project is introduced. For example, reducing the number of crashes, greenhouse gas emissions and improved health (due to increased walking) because people switch from car travel to public transport
- **Infrastructure residual value –** The infrastructure delivered will have an economic life beyond the end of the economic evaluation period. The residual value estimates the economic benefit of the infrastructure from the end of the evaluation period to the end of the economic life of the asset.

The user and non-user benefits are calculated from the outputs of the transport models, and valued using unit costs sourced from the *National Guidelines for Transport System Management* (NGTSM) and Austroads *Guide to Project Evaluation*.

Benefits have been calculated using outputs from the transport models for the years 2021, 2031 and 2046. Linear interpolation has been used to estimate benefits in intermediate years. Linear extrapolation has been used to estimate benefits between the final modelled year and the end of the evaluation period. No growth in benefits has been assumed beyond the design year (2056).

[16] PTV, *Melbourne Metro – Economic Evaluation Report*, (2016).

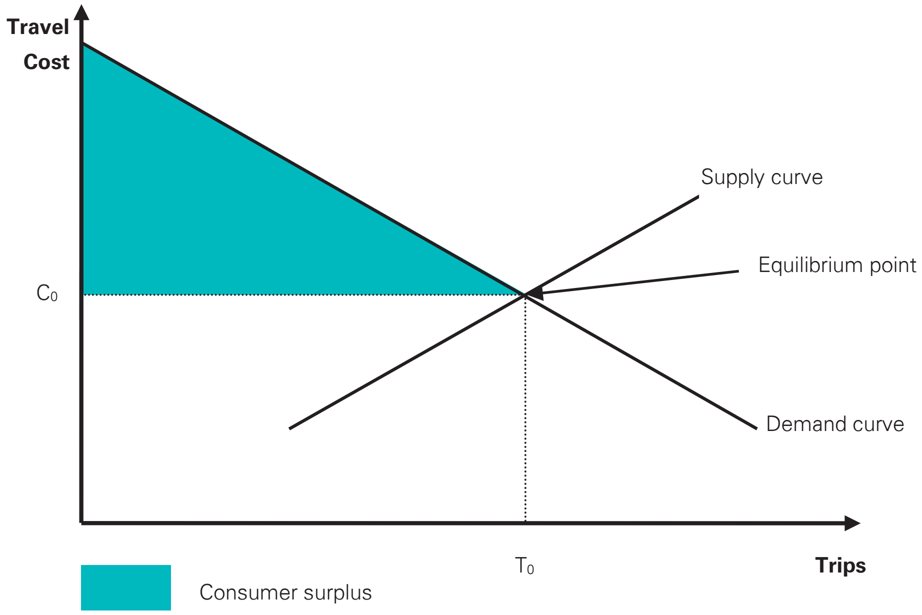
5.2. Relevant economic theory

5.2.1. Consumer surplus and the Rule of a Half

The calculation of transport user benefits is based on the consumer surplus theory. '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 it takes no more than 20 minutes, but not if it takes more than 20 minutes, then the total value of the journey is equivalent to the cost to that traveller of 20 minutes of travel time. If actual travel time for the journey is only 15 minutes, then the traveller enjoys a surplus of 5 minutes. If a new proposal reduces travel time further, to 12 minutes, then the increase in consumer surplus from the proposal is 3 minutes.

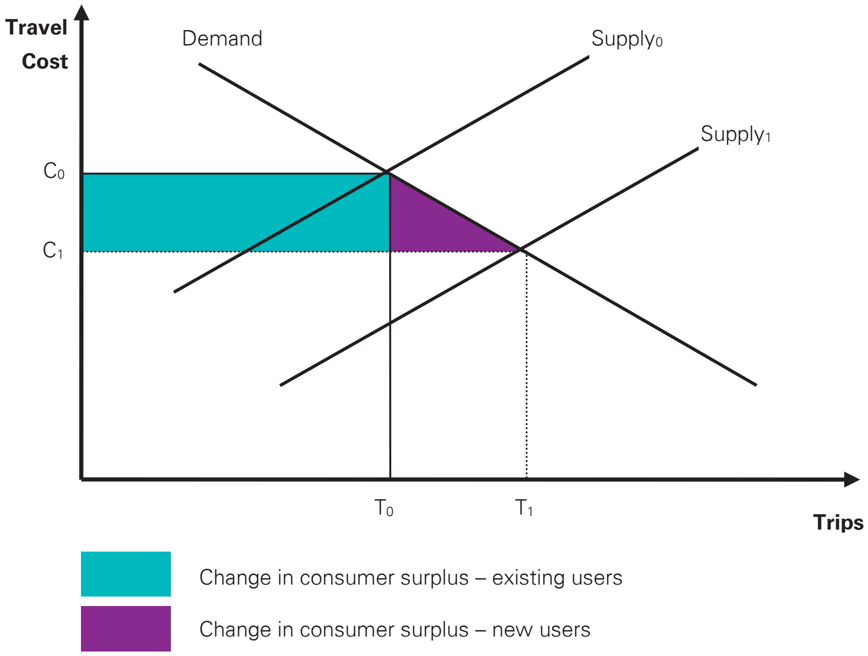
The evaluation of economic benefits to transport users relies on the transport system equilibrium being correctly assessed by the transport model. At the equilibrium point, the numbers of trips T_0 (demand) and system performance (supply) are in balance producing an average trip cost of C_0. At this equilibrium point there are benefits to the consumer over and above the actual trip costs, that is, there is a difference between what they would be willing to pay and what they actually pay. This difference is the consumer surplus and is shown diagrammatically in Figure 4.

Figure 4 – Supply/demand equilibrium showing consumer surplus



A new transport project such as Melbourne Metro will reduce travel costs. This shifts the supply curve to the right as shown in Figure 5. A new market equilibrium point is found where the demand is T_1 and the supply cost is C_1. The benefit to transport users is therefore the change in the consumer surplus, which is shown by the shaded area of the chart.

Figure 5 – Change in consumer surplus



For small changes in costs, the demand curve can be assumed to be linear. Therefore, the change in consumer surplus for existing travellers who were already making trips in the base case is given by the area of the shaded rectangle:

$$T_0 \times (C_0 - C_1).$$

The change in consumer surplus for new trips (those who switch from car to public transport or vice versa) is given by the area of the shaded triangle:

$$½ \times (T_1 - T_0) \times (C_0 - C_1)$$

This is known as the "rule of a half".

Benefits calculated using consumer surplus theory include:

- For public transport:
  - Generalised journey time savings
  - Reduced crowding on trains and trams
  - Improved punctuality
  - Improved network resilience
  - Improved customer experience
  - Reduced station crowding
- For road transport:
  - Travel time savings
  - Vehicle operating cost savings (fuel costs)
  - Travel time reliability benefits
  - Travel time in congested conditions
  - Savings in toll charges.

5.2.2. Resource cost corrections

The change in consumer surplus theory outlined in Section 5.2.1 is based on consumers' *willingness to pay* for certain goods. It can only be applied where changes to costs are fully perceived by the user. In the context of travel, transport users fully perceive time, comfort aspects and out of pocket costs such as fuel, train/bus fares and car parking. These aspects / costs are taken into account in their choice of mode and hence in the benefit enjoyed by people who change their travel behaviour as estimated by the transport model.

Transport user benefits (both public transport and road), which are obtained from the change in consumer surplus outputs, reflect perceived costs and therefore include the perceived disbenefit of paying fares, car parking or road tolls.

However, transport users do not perceive that fares, tolls or parking costs are transferred to the rest of the economy. In economic terms the exchange should be considered a financial transfer rather than an economic cost. A resource cost correction is therefore required in the economic analysis to offset the perceived disbenefit of fares, tolls and parking.

In the case of public transport, the financial transfer is from public user to public transport operator. Fares are charged to recover some of the operating and capital costs of providing public transport services (which are resource costs). Given the cost benefit analysis explicitly includes capital and operating costs associated with Melbourne Metro, a correction must be applied to avoid double counting of resource costs.

Resource costs differ from perceived costs for the following components of travel costs, requiring a resource cost correction:

- Vehicle operating cost savings (non-fuel costs)
- Car parking costs
- Road tolls
- Public transport fares.

5.3. Public transport user benefits

Public transport user benefits accrue from changes to the service levels provided resulting in improvements to capacity, quality and convenience.

Benefits to customers comprise of changes to generalised journey time (a weighted measure of the door-to-door travel time including time spent walking and waiting for a service as well as time spent on board), reduced crowding on trains, trams and in stations, improved reliability and resilience of the network, and improvements to the journey experience. Table 9 shows the public transport benefits quantified in the analysis.

Benefits to public transport users have been calculated primarily using outputs of the Victorian Integrated Transport Model, with the exception of station crowding benefits (which are calculated using the ClicSIM model), and improvements to network reliability (which were computed using the RailSys model). Benefits to users have been valued using parameters within the *National Guidelines for Transport System Management* (Transport and Infrastructure Council, 2006, 2015).

Public transport user benefits are calculated using the consumer surplus approach detailed in Section 5.2 . New public transport users (who use car in the Base Case but switch to public transport in the Melbourne Metro Program Case and the Extended Program Case) receive half of the benefit existing users receive in accordance with the 'Rule of a Half' convention. The exception is farebox revenue which is subject to a resource cost correction.

Table 9 – Public transport user benefits

Benefit type	Description
Travel time savings	The change in door-to-door travel times include time spent walking (or driving) to and from stops/stations (and interchanging between services); waiting for a train, tram or bus; and time spent on-board the vehicle. Various components of time are weighted to reflect how passengers perceive their time in accordance with weightings given in the NGTSM[17]. For example, passengers generally perceive time spent waiting for a service to be longer than time spent on board a moving vehicle. Consequently, passengers tend to value improvements in frequency (leading to reduced wait times) more than they do improvements in in-vehicle time.
Reduced crowding on trains and stations	Crowding, or crowded in-vehicle time (IVT) reflects the discomfort passengers feel from travelling in varying levels of crowded conditions. As crowding levels increase to crush capacity, the valuation of crowding in IVT minutes also increases.
Improved punctuality	Public transport users not only value travel time savings but also improvements in the reliability of travel times. Where there is significant variability in journey times, transport users may be required to allow more time for the journey to reduce the probability of arriving late at their destination. If this variability in travel time is reduced, then transport users benefit from being able to reduce the extra time allowance. It is worth noting that the weighting applied to travel time reliability for public transport tends to be higher when compared to private transport. This is because private transport users have comparatively more options to change their route/ time of travel relative to public transport as public transport user's travel times are dependent on the scheduled times.
Improved network resilience	Network resilience reflect the ability of the system to respond to and recover from out of course incidents and delays. Creation of a new inner city route will reduce the reliance on coordination and management of complex interactions between services operating across multiple lines. Prior to Melbourne Metro, interoperation of multiple lines and routes is necessary to enable lines to merge to share the limited inner city capacity available. Although carefully planned, these interactions significantly increase congestion around junctions and the likelihood that incidents (including cancellations, short-running of services or bypass) will cascade across the network when even small delays occur. By creating a new inner city line, and removing the need for planned interactions to work around congestion on other routes, Melbourne Metro will improve the resilience, punctuality and overall reliability of the network Two types of resilience have been measured: • Network resilience – the reduced likelihood of delays from one part of the network cascading to other lines. • Rolling stock reliability – the improved performance of new HCMTs operating on the Sunbury Line, which are assumed to have higher RAM[18] than the Comeng rolling stock that currently operates on the line to support PTV's improvement plans and targets for the network.
Improved customer environment	Value placed by customers on improved station environment (at the five new stations) and new rolling stock operating on the Sunbury Line (and Melton Line in Extended Program).
Reduced station crowding	Similar to crowding on trains and trams, customers also experience crowding in stations. Creation of a new inner city route will reduce the reliance on the existing City Loop stations and at key interchange stations such as Richmond and North Melbourne. This in turn will result in customers having shorter transit times between train and street.
Farebox resource cost correction	A resource cost correction to offset the perceived disbenefit of fares in the public transport user benefits.

[17] TIC, *National Guidelines for Transport System Management in Australia*. Volume 4, Appendix A, (2006).
[18] Reliability, availability and maintainability.

5.4. Road user benefits

Road user benefits accrue principally due to some road users switching from car in the Base Case to public transport in the Melbourne Metro Program Case and the Extended Program Case. Consequently, there is less congestion on roads and other road users including freight vehicles benefit from the reduced traffic on the road.

Benefits to road users consist of travel time savings, and monetary items such as vehicle operating cost savings, parking cost savings and toll savings. Road user benefits captured in the analysis are shown in Table 10.

Benefits to road users have been calculated using outputs of the Victorian Integrated Transport Model and valued using parameters given in the Transport and Infrastructure Council's *National Guidelines for Transport System Management* (2015).

Road user benefits are also calculated using the consumer surplus approach as used for public transport users. In some cases, road conditions may improve such that some public transport users divert to road in the Melbourne Metro Program Case and Extended Program Case (induced demand). Benefits to these users are also calculated according to the 'Rule of a Half' convention.

Some benefits are not directly perceived by road users (and so do not constitute part of their willingness-to-pay) but do result in a change in consumption of resources. These benefits are accounted for through resource cost corrections.

Table 10 – Road user benefits

Benefit type	Description
Travel time savings	The change in door-to-door travel times resulting from reduced levels of traffic on the road network due to some car users switching to public transport.
Vehicle operating cost savings	Operating costs of vehicles, such as fuel and maintenance, are a function of distance and speed travelled across the network. In general, fuel consumption is higher at low speeds in interrupted flow/stop-start conditions than it is on free flowing conditions. As a result of some drivers switching from car to public transport, road network speeds can increase leading to fuel savings for other road users. For vehicles which operate in fleets (such as commercial vehicles), if travel times decrease as a result of network speeds increasing, then operators will be able to undertake either the same freight task with a smaller number of fleet vehicles or undertake more trips with the same vehicle. This leads to savings related to vehicle capital costs including time-related depreciation, registration and insurance. A resource cost correction is applied to the unperceived (non-fuel) component of vehicle operating costs.
Road journey time reliability	Travel time reliability is a function of congestion in the road network. When road links are at or near capacity, then any unplanned incident, such as a crash or breakdown is more likely to result in major delays to other vehicles than if the crash or breakdown occurred on a more lightly trafficked route. Consequently, drivers must allow more buffer time before making trips to ensure that they arrive on time. As the Melbourne Metro Program and Extended Program results in some mode shift from road to public transport, then some road links will become less congested and trips by road for remaining road users will become more reliable, allowing them to reduce the buffer time and use the time saved more productively.

Benefit type	Description
Travel time in congested conditions	Research from overseas[19] shows that the value of time increases with the level of congestion, reflecting the increased stress and effort associated with driving in more congested conditions. As the Melbourne Metro Program and Extended Program results in some mode shift from road to public transport, then some road links will become less congested. Therefore remaining road users will benefit from travelling in less congested conditions.
Savings in parking and toll charges	Savings due to road users switching from car to public transport. A resource cost correction is applied to the unperceived component of tolls and parking charges.

5.5. Non-user benefits

Non-user benefits accrue when there is a reduction in the externalities of travel. Externalities are costs imposed on society that are not factored into the decision making of the transport user i.e. they are unperceived by users but are a cost to all Victorians.

Non-user benefits include reductions in roads crashes and environmental externalities (resulting from drivers switching from road to public transport), and improvements in public health due to public transport users tending to be more active than car drivers (as they will walk or cycle to or from a public transport stop as part of their journey). Table 11 shows the externalities included in the analysis.

Externality benefits have been calculated using outputs of the Victorian Integrated Transport Model and valued using parameters given in the Transport and Infrastructure Council's *National Guidelines for Transport System Management* (2015) and the Austroads *Guide to Project Evaluation* (2012).

As externalities are unperceived by transport users they are not subject to the consumer surplus calculation approach. Instead, they are calculated from the total change in consumption of resources.

Table 11 – Non-user benefits

Externality type	Description
Crashes	Crash costs are a function of the number of vehicle kilometres travelled on a particular road type. In general, limited access roads such as freeways have lower crash rates per vehicle kilometre travelled than roads in residential areas. As a result of some users switching from car to public transport, there will be fewer vehicle-kilometres travelled on the network. Consequently, fewer crashes will occur.
Environmental externalities	Environmental externalities quantified include greenhouse gas emissions, air pollution, noise pollution, water pollution, nature and landscape impacts, urban separation effects and upstream and downstream impacts. Benefits are calculated using network wide changes in vehicle kilometres travelled or net tonne kilometres travelled by road and public transport vehicles and application of valuation parameters.
Improved health by walking and cycling	Public transport users walk an average of 41 minutes per day compared to 8 minutes per day for car users. As a result of car drivers switching to public transport, these individual's levels of physical activity will increase, resulting in improved health. Increased walking and cycling undertaken by public transport users incurs a benefit.[20]

[19] See for example Wardman, M & Ibanez J N, *The congestion multiplier: Variations in motorists' valuations of travel time with traffic conditions.* Transportation Research Part A 46 (2012), 213-225.
[20] Transport and Infrastructure Council, *National Guidelines for Transport System Management Revision – Active Travel* (2015), 27-28.

5.6. Residual value

The infrastructure will have an economic life beyond the end of the 50-year project evaluation period. The residual value is an estimate of the economic benefit of the infrastructure from the end of the evaluation period to the end of the economic life of the asset.

As per the NGTSM, the analysis assumes the asset life of the Melbourne Metro tunnel to be 100 years. Given the evaluation period extends only 50 years, the asset will have a further 50 years life beyond the final year of the economic evaluation. It is therefore prudent to accurately reflect the residual value of the asset beyond the end of the evaluation period.

DTF *Economic Evaluation Technical Guidelines*[21] state the residual value should be the lower of a) the replacement cost or b) the future stream of net benefits at the earlier end of the evaluation period. For the Melbourne Metro Program and Extended Program, the analysis uses the asset replacement cost method (as the lower of the two methods favoured by DTF) as the central case.

Sensitivity testing has also been undertaken using the alternative future stream of benefits and straight-line depreciation method (recommended by Infrastructure Australia).

5.7. Key findings

Conventional benefits account for 73 per cent of the total benefits attributable to the Melbourne Metro Program and the Extended Program respectively. The magnitude and distribution of these benefits (as quantified for the economic analysis) are outlined in the following section.

5.7.1. Public transport user benefits

Public transport user benefits make up the largest component (between 37 and 43 per cent) of the conventional benefits attributable to the Melbourne Metro Program and the Extended Program. Using the VITM model, the present value of public transport benefits ranges from \$4.7bn (discounting at 7 per cent) to \$11.2bn (discounting at 4 per cent) for the Melbourne Metro Program Case and from \$6.6bn to \$16.4bn under the Extended Program Case (depending on the discount rate used).

Figure 6 and Figure 7 show the distribution of public transport user benefits (by origin) as modelled for the AM peak in 2031 for the Melbourne Metro Program Case and the Extended Program Case.

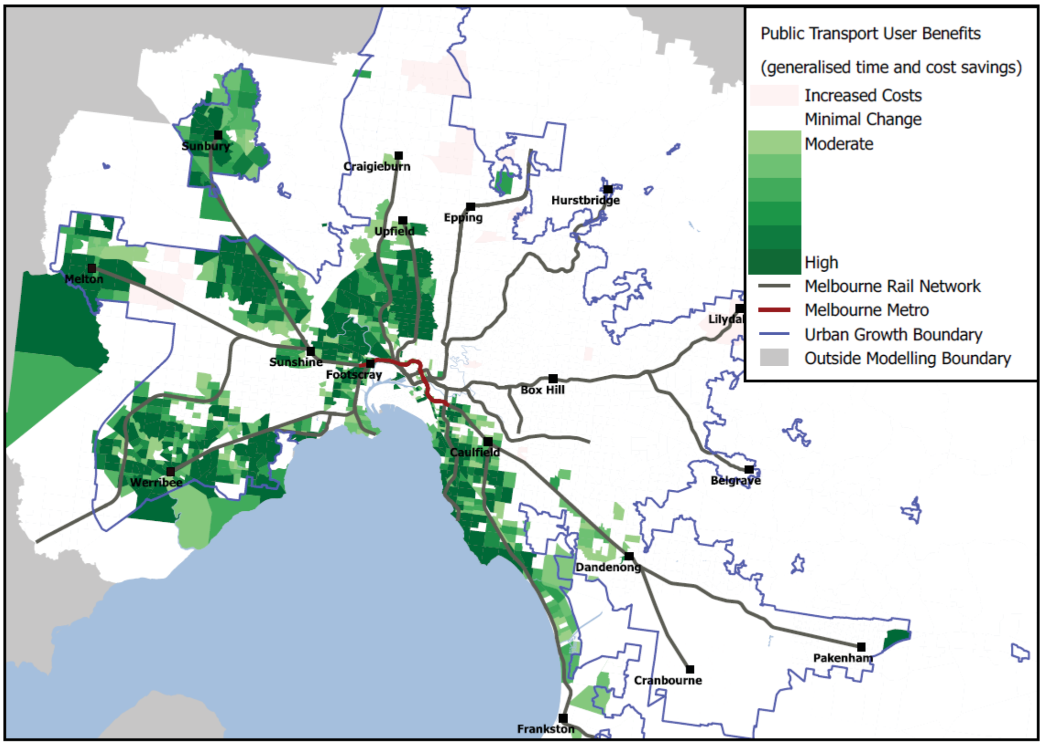
Figure 6 demonstrates that the benefits of the Melbourne Metro Program are concentrated around the Sunbury, Werribee, Upfield and Craigieburn Lines where the Melbourne Metro Program provides the greatest increases in rail capacity and increased frequency of service, and the Frankston Line which benefits from increased frequency and increased accessibility with Melbourne Metro enabling all Frankston services to travel through the City Loop. Other areas that benefit under the Melbourne Metro Program include the inner north around Parkville, North Melbourne and the inner south eastern suburbs of St. Kilda and Caulfield.

Figure 7 shows that under the Extended Program Case, most parts of Melbourne benefit, with the Melton and Sunbury lines benefitting the most from the introduction of 10-car HCMTs and the increased frequency resulting from providing electrified services to Melton. Other areas that benefit under the Extended Program include the Regional Rail Link to Tarneit and Wyndham Vale which benefits from increased service frequency resulting from the cascading of Melton rolling stock to this line. The benefits are also widespread along the Cranbourne /

[21] Department of Treasury and Finance, *Economic Evaluation Technical Guide V102*, (August 2013), 30

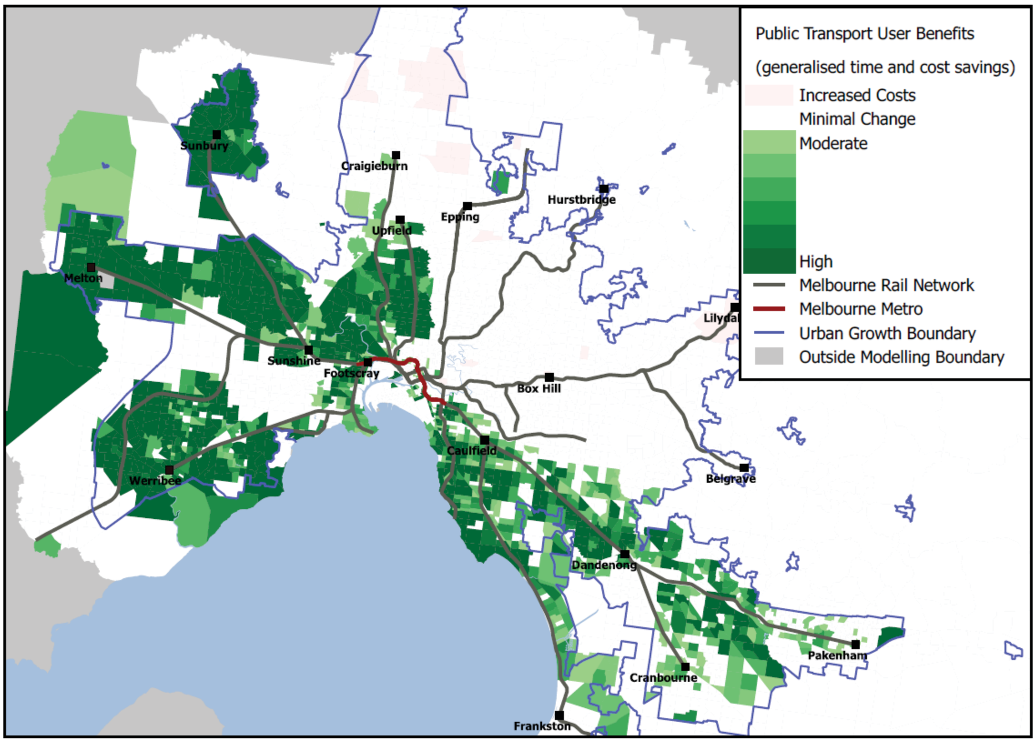
Pakenham Lines which benefit from the increased capacity provided by the introduction of 10-car HCMTs.

Figure 6 – Distribution of public transport user benefits by origin of trip, AM peak period 2031, Melbourne Metro Program



Source: PTV

Figure 7 – Distribution of public transport user benefits by origin of trip, AM peak period 2031, Extended Program



Source: PTV

5.7.2. Road user benefits

Road user benefits make up between 21 and 26 per cent of the conventional benefits attributable to the Melbourne Metro Program and the Extended Program. Using the VITM model, the present value of road transport benefits ranges from $2.3bn (discounting at 7 per cent) to $5.8bn (discounting at 4 per cent) under the Melbourne Metro Program Case and from $4.4bn to $11.3bn under the Extended Program Case (depending on the discount rate used).

Figure 8 and Figure 9 show the distribution of car user benefits (by origin) as modelled for the AM peak in 2031 for the Melbourne Metro Program Case and the Extended Program Case.

Figure 8 shows that under the Melbourne Metro Program Case benefits are predominantly spread in areas along and between the Melton, Sunbury, Craigieburn and Upfield Lines.

Figure 9 shows that in the Extended Program Case, benefits are more widespread with road users in areas along and between all the western and northern rail lines all experiencing reduced congestion. Areas along the Cranbourne and Pakenham Lines also benefit, resulting from the increased capacity on these lines which cause more people to switch from car to public transport. There are also significant benefits attributable to road users travelling to and from Melbourne Airport.

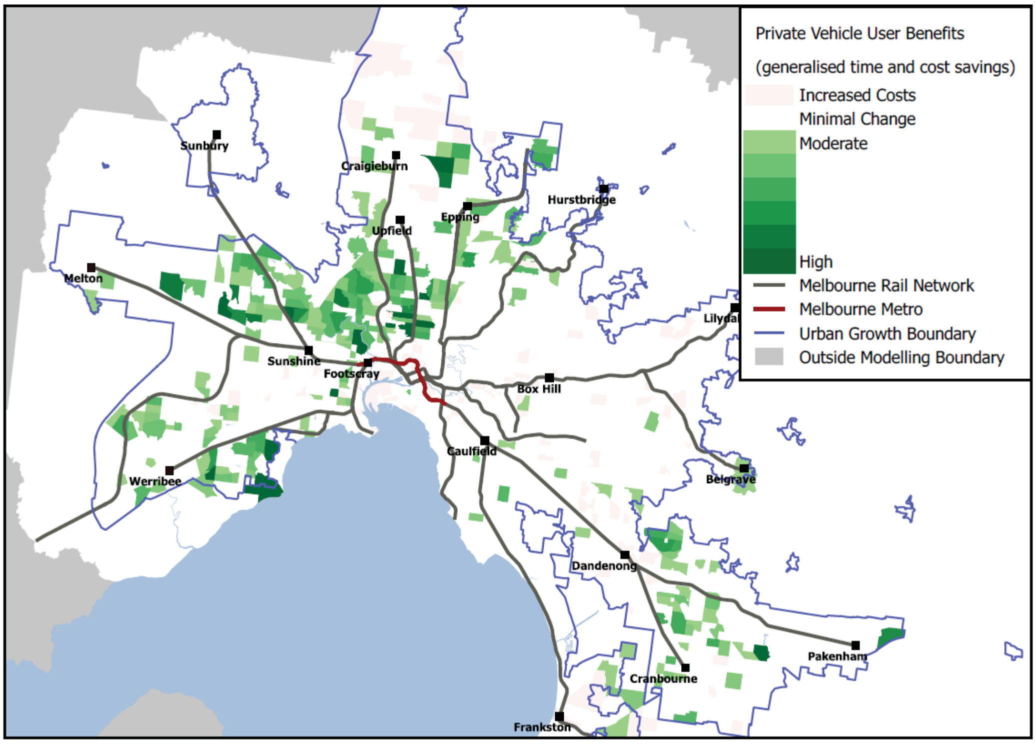
5.7.3. Non-user benefits

The quantifiable non-user benefits included in the analysis make up 7 per cent of conventional benefits attributable to the Melbourne Metro Program and the Extended Program. Using the VITM model, the present value of externality benefits ranges from $0.8bn (discounting at 7 per cent) to $1.8bn (discounting at 4 per cent) under the Melbourne Metro Program Case and from $1.2bn to $2.9bn under the Extended Program Case (depending on the discount rate used). The benefits are distributed in a similar pattern to the car user benefits shown in Figure 8 and Figure 9 for the Melbourne Metro Program Case and Extended Program Case respectively.

5.7.4. Residual value

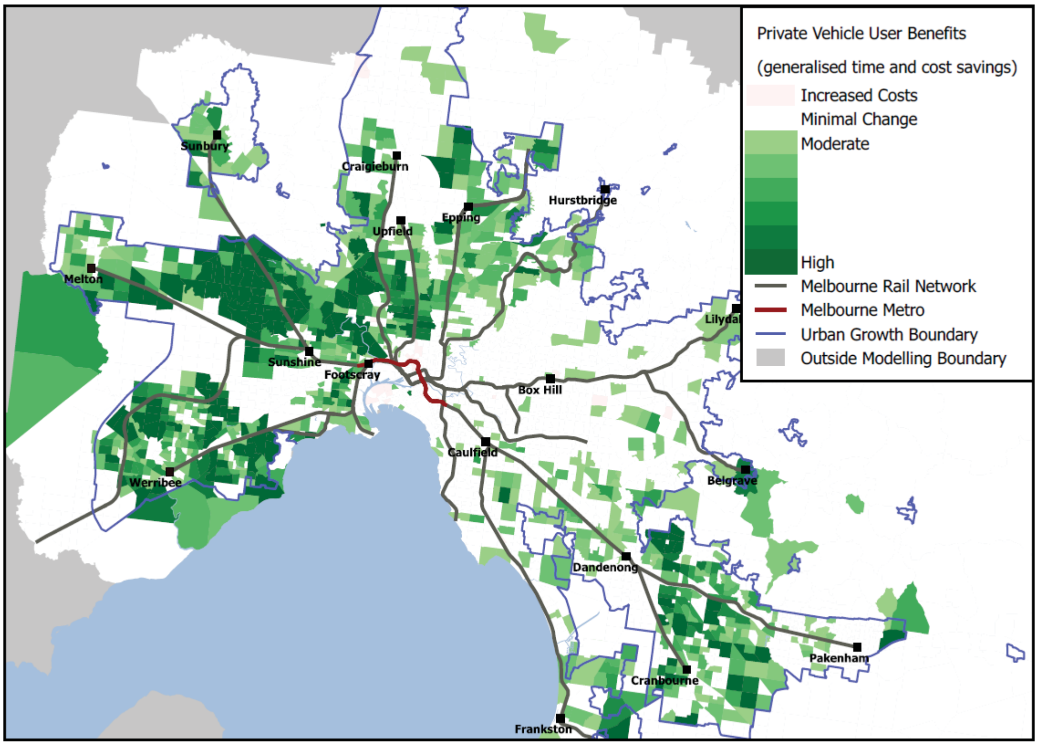
The residual value makes up between 1 and 3 per cent of the conventional benefits attributable to the Melbourne Metro Program and the Extended Program. The present value of residual asset values ranges from $0.2bn (discounting at 7 per cent) to $0.9bn (discounting at 4 per cent) for the Melbourne Metro Program and from $0.2bn to $1.2bn under the Extended Program Case (depending on the discount rate used). The central analysis uses the DTF-preferred method of taking the asset replacement cost as the residual value, with sensitivity tests undertaken using the alternative DTF future net benefits method, and straight-line depreciation (favoured by IA).

Figure 8 – Distribution of road user benefits by origin of trip, AM peak period 2031, Melbourne Metro Program



Source: PTV

Figure 9 – Distribution of road user benefits by origin of trip, AM peak period 2031, Extended Program



Source: PTV

6. Wider economic benefits

6.1. Overview

The conventional CBA discussed in Section 5 is based on the assumption of perfect competition and lack of market imperfections. The presence of additional market imperfections (beyond those externalities typically identified in a conventional CBA), means that not all the impacts of changes in the marginal costs of travel are assessed in a conventional CBA. In addition, the cost of travel does not equate to the marginal social cost of transport supply. This divergence between price and marginal social cost gives rise to potential for additional impacts (benefits or costs) that are not captured in the conventional CBA.

These impacts, which have been traditionally excluded from 'conventional' CBA in the past, are now commonly referred to as **'wider economic benefits' (WEBs).** Over the last decade, WEBs have entered the project evaluation framework for significant transport projects.

The evaluation of WEBs for Melbourne Metro has been undertaken in accordance with the status of guidance being developed as part of the ongoing revision of the NGTSM as at early 2016, noting that this will not be finalised until late 2016.

The WEBs which have been included in the economic evaluation include:

- WB1: Agglomeration economies
- WB2: Labour market deepening
  - WB2a: Increased labour supply
  - WB2b: Move to more (or less) productive jobs
- WB3: Output increase in imperfectly competitive markets

As per the current NGTSM, the fourth type of WEB, namely WB4 – Increased competition, has not been included in the analysis as it is unlikely that Melbourne Metro will alter the level of industry competition significantly.

WEBs that have been captured in the analysis are shown in Table 12.

Table 12 – Wider economic benefits

Benefit type	Description
WB1 – Agglomeration economies	'Agglomeration economies' (WB1) refers to benefits which flow to firms and workers located in close proximity (or agglomerating). Agglomeration economies arise from economies of scale and scope. The three principal sources of agglomeration economies include input sharing (including labour market pooling), knowledge/technological spillovers and output sharing. By lowering travel costs and enabling land use densification, transport projects can have a significant impact on agglomeration/density (i.e. effective density). Lower generalised costs or greater physical density of employment result in enhanced accessibility/connectivity which facilitates increased formal and informal interaction. This in turn enables increased input and output sharing and, more importantly, knowledge spillovers, the principal source of agglomeration economies in the modern economy. Agglomeration economies can be facilitated by either improving connectivity between employment dense areas (proximity effects), or enabling land use changes which lead to more jobs locating in areas that are already employment dense (cluster effects) or both.

Benefit type	Description
WB2 – Labour market deepening	Labour market deepening refers to two distinct impacts: • WB2a – Increased labour supply; and • WB2b – Move to more or less productive jobs. **WB2a – Increased labour supply** In deciding whether to work, a worker weighs, among other factors, travel costs associated with the job against the wage received from the job. Lowering of transport cost may encourage workers to work longer hours or encourage the under-engaged and disengaged workforce into active employment. This may result in an increase in overall labour supply in the economy. This increased labour supply in turn will result in increased value added or gross domestic or state product (GDP/GSP). The marginal change in tax receipts from changes in labour supply (i.e. WB2a) is then estimated for inclusion in the economic evaluation. **WB2b – Move to more or less productive jobs** 'Move to more or less productive jobs' (M2MPJ) (WB2b) refers to how improved transport accessibility may provide employers with access to a broader range of employees (to recruit the most suitable skills), and employees with access to a wider range of jobs better suited to their skills. Better skills matching/alignment, in turn, results in workers being more productive. Ultimately, this will lead to an increase in GSP and GDP. Similar to WB2a, the changes in tax receipts can then be estimated for inclusion in the analysis.
WB 3 – Output increase in imperfectly competitive markets	In an imperfectly competitive market, prices may exceed production costs and output may be less than optimal. 'Output change in imperfectly competitive markets' (WB3) arises from a reduction in transport costs allowing for an increase in production or output of goods or services that use transport. The existence of price-cost mark up under imperfect competition implies that some consumers are willing to pay more, i.e. there are additional consumer surpluses. This impact is not captured in conventional CBA as it assumes that markets are perfectly competitive.

The economic analysis for this project considers the impacts of land use changes, allowing WEBs to be fully captured. By contrast, many business cases ignore land use impacts of major transport infrastructure projects, instead assuming constant land use. If constant land use was assumed, there are two categories of WEBs that would not be properly captured in the economic analysis:

- WB1: Agglomeration economies. With a constant land use assumption only proximity effects would be able to be captured.
- WB2b: Move to more (or less productive jobs. With a constant land use assumption, WB2b is not able to be captured at all.

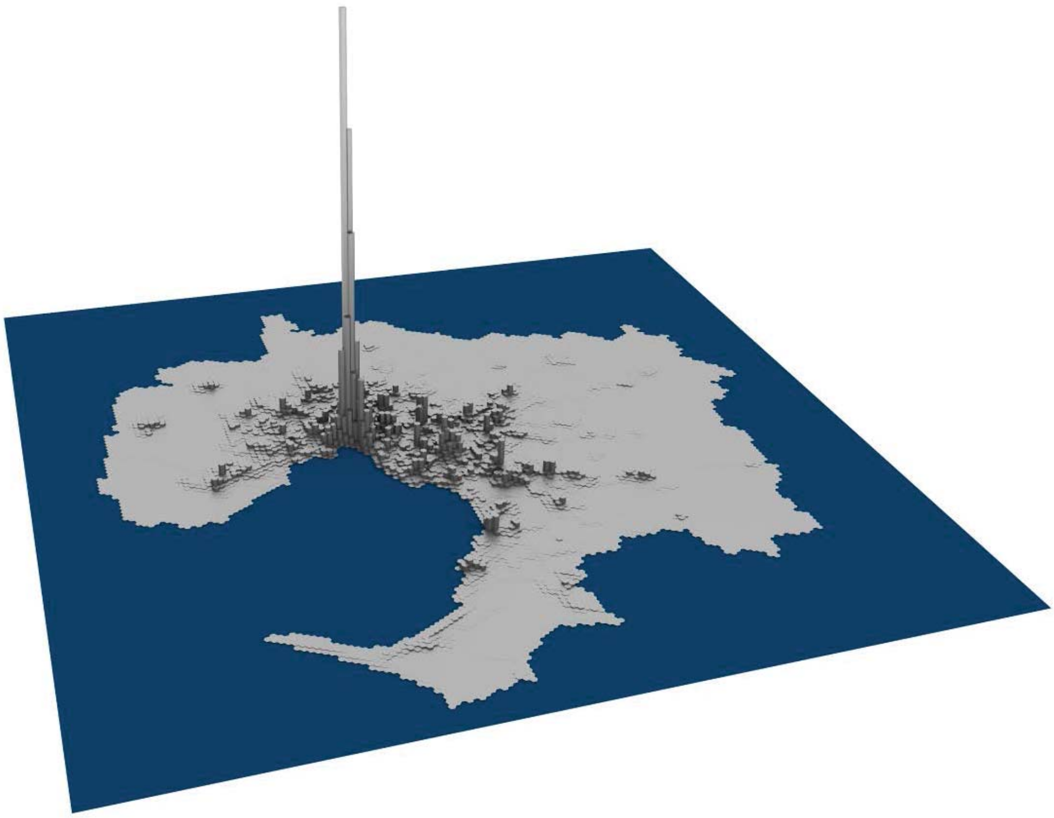
As discussed in Section 2.1, Melbourne Metro increases commuter capacity into the Melbourne CBD, thereby allowing more employment to locate in Melbourne CBD than would otherwise be the case.

6.2. WB1 – Agglomeration economies

6.2.1. Overview

Agglomeration economies are positive externalities which arise from increases in the density of economic activity. The existence of agglomeration economies is one of the reasons that cities exist, as inner city offices continue to attract tenants despite higher and increasing rents and congested transport networks. Figure 10 demonstrates the extremely high concentration of employment in Melbourne's CBD, with a peak employment density of 110,000 jobs per square kilometre in the Hoddle Grid. This concentration has increased over time, as agglomeration economies have created a positive feedback loop, continually encouraging more firms to locate centrally. This same dynamic is apparent in other major cities in developed economies. In New York and London, peak employment density has reached around 150,000 jobs per square kilometre[22]. High employment density leads to increased economic interactions between firms, and also between firms and customers. This leads to benefits as firms are able to enhance their productivity through reaching wider markets, gaining scale economies and developing more specialised skills.

Figure 10 – Employment density in Melbourne, 2011



Source: ABS 2011 Census; KPMG Analysis.

[22] Smith, Duncan. *World City Living and Working Densities: Poles Apart?* (2012).

6.2.2. Approach

Agglomeration economies were estimated using the 'Wage Function Framework' methodology specified in guidance being developed as part of the NGTSM as at early 2016. As per the conventional analysis, demand data from two different transport models were used: the Victorian Integrated Transport Model (VITM) and the Zenith transport model.

Agglomeration economies can be divided into two categories;

- **Proximity effects** due to firms being able to interact more easily with each other through improved transport connectivity. Proximity effects are due to improvements in transport network performance, independent of any changes in land use.

  The Melbourne Metro Program and Extended Program enhance the proximity between firms (in an effective sense) by lowering the cost of travel. Lower cost of travel enables firms to interact more easily with each other, in turn facilitating increased input and output sharing and knowledge spill-over, in turn improving firms' productivity.

- **Cluster effects** due to more firms being able to locate in employment-dense areas (i.e. the CBD) than would otherwise be the case. Transport improvements can facilitate this if commuter capacity constraints are apparent in the base case. If the transport improvement allows more workers to access areas with high employment density, this may then enable further increases in employment density, and therefore additional agglomeration economies.

By alleviating commuting capacity constraints to Melbourne's CBD, the Melbourne Metro Program and the Extended Program enables additional employment to locate in Melbourne's CBD. As noted in Section 2.2 and 2.3, the Melbourne Metro Program enables an additional 28,000 jobs and the Extended Program enables an additional 47,000 jobs (inclusive of the 28,000 jobs attributed to the Melbourne Metro Program) to locate in the CBD by 2046. Facilitating additional jobs to locate in the already dense core of metropolitan Melbourne enables increased interaction between firms and between workers. This further improves input and output sharing and knowledge spill-over, making CBD based firms more productive. The approach of considering changes in geographical distribution of employment in the inner city for WEBs analysis is consistent with the approach used in the Crossrail business case in the UK in 2007.

A key assumption in the approach is that jobs are only redistributed elsewhere in Melbourne, and not interstate or overseas, a conservative assumption. This results in no net change in jobs across the metropolitan area (overall employment forecasts are constant between the scenarios). Jobs are relocated to other Local Government Areas, and largely follow the forecast distribution of employment across Melbourne. The redistribution mainly occurs in the inner municipalities such as the Cities of Yarra, Port Phillip, Boroondara and Stonnington, and in major activity centres located in the Cities of Hume, Monash, Greater Dandenong and Whitehorse. It is worth noting that the redistributed jobs are white collar jobs that are often highly mobile. Given that Melbourne operates in national and international employment markets it is possible that if the opportunity to grow employment in central Melbourne is not available, jobs may be lost from Victoria altogether and move interstate or overseas. This effect has not been included in the economic analysis, however it was included in the UK Crossrail business case.

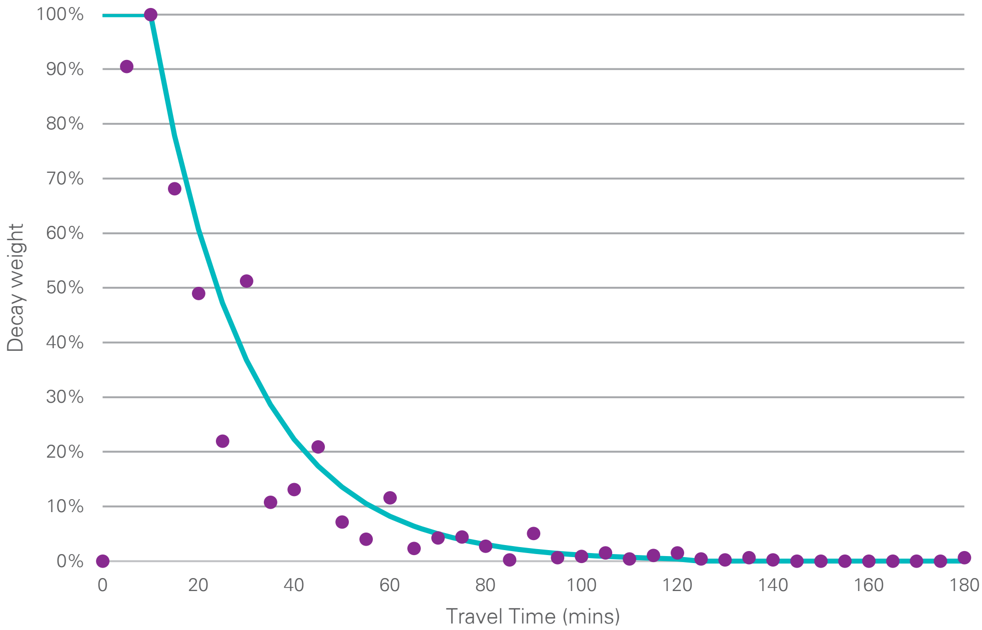
Quantification of agglomeration economies relies on the concept of business to business effective density (B2BEd):

- **Physical density** is the number of jobs **within a given unit of area** (i.e. jobs per square kilometre, shown in Figure 10 for Melbourne).
- **Effective density is** the (weighted) number of jobs accessible **within a given travel time**.

A decay function needs to be applied to assign high weights to 'near' jobs and low weights to 'far' jobs. The form of the decay function was calibrated to travel survey data from the Victorian

Integrated Survey of Travel and Activity (VISTA) for business to business trips. The shape of the decay function is shown in Figure 11. The decay factor represents the weighting of a job i.e. if a job is 20 minutes away from a given origin, it is assigned a weight of 60 per cent. If a job is 5 minutes away, it is assigned a weight of 100 per cent. The calibrated decay curve has a weighting of 100 per cent for jobs less than ten minutes away, a weighting of 0 per cent for jobs more than 120 minutes away, and decays according to a negative exponential curve with a scale parameter of -0.05. The equation for the negative exponential part of the curve is $e^{-0.05 \times (TT-10)}$ where TT is travel time from a given origin.

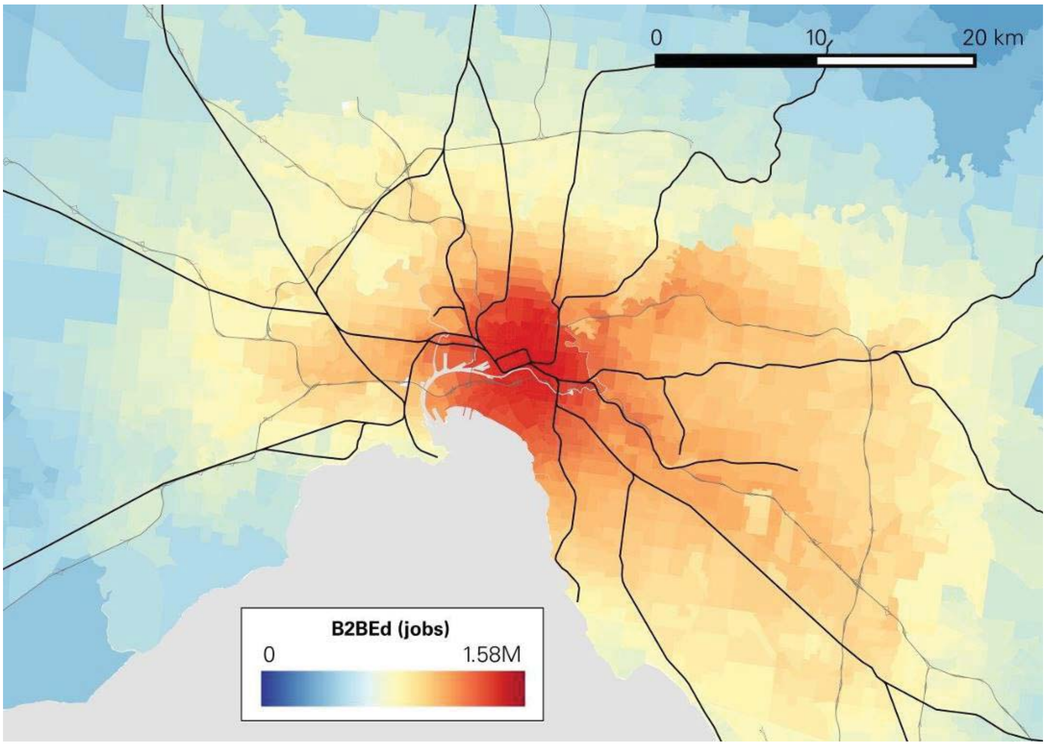
Figure 11 – Decay curve, business to business travel



Source: VISTA 09-10; KPMG Analysis.

Using the inputs of employment density, transport network performance (i.e. travel times for all origin-destination pairs) and the decay function, B2BEd can be estimated. Figure 12 shows B2BEd for Melbourne using the employment density and decay functions (given in Figure 10 and Figure 11 respectively) and travel times from the base case VITM transport model for the 2031 Base Case.

Figure 12 – Business to business effective density (B2BEd), Melbourne 2031 Base Case



Source: ABS 2011 Census; VISTA 07-08 & 09-10 (combined); VITM transport model; KPMG Analysis.

Agglomeration economies are quantified by estimating the change in B2BEd between the Base Case and each of the Melbourne Metro Program Case and Extended Program Case. The percentage change in B2BEd due to the Extended Program is then used to estimate the percentage change in labour productivity (and therefore increased economic output) using a set of elasticities of productivity with respect to effective density. These elasticities were estimated for metropolitan Melbourne using a regression analysis on existing effective density and labour productivity data for each industry, controlling for other variables such as occupation and experience of workers. The results of this analysis is shown in Table 13.

Table 13 – Elasticities of productivity with respect to effective density, Melbourne 2011

Industry	Elasticity
A – Agriculture, Forestry and Fishing	0.09
B – Mining	0.09
C – Manufacturing	0.09
D – Electricity, Gas, Water and Waste Services	0.00
E – Construction	0.08
F – Wholesale Trade	0.05
G – Retail Trade	0.12
H – Accommodation and Food Services	0.05
I – Transport, Postal and Warehousing	0.02
J – Information Media and Telecommunications	0.07
K – Financial and Insurance Services	0.05
L – Rental, Hiring and Real Estate Services	0.07
M – Professional, Scientific and Technical Services	0.08
N – Administrative and Support Services	0.09
O – Public Administration and Safety	0.04
P – Education and Training	0.05
Q – Health Care and Social Assistance	0.10
R – Arts and Recreation Services	0.06
S – Other Services	0.12
T – Total	0.09

Source: KPMG analysis.

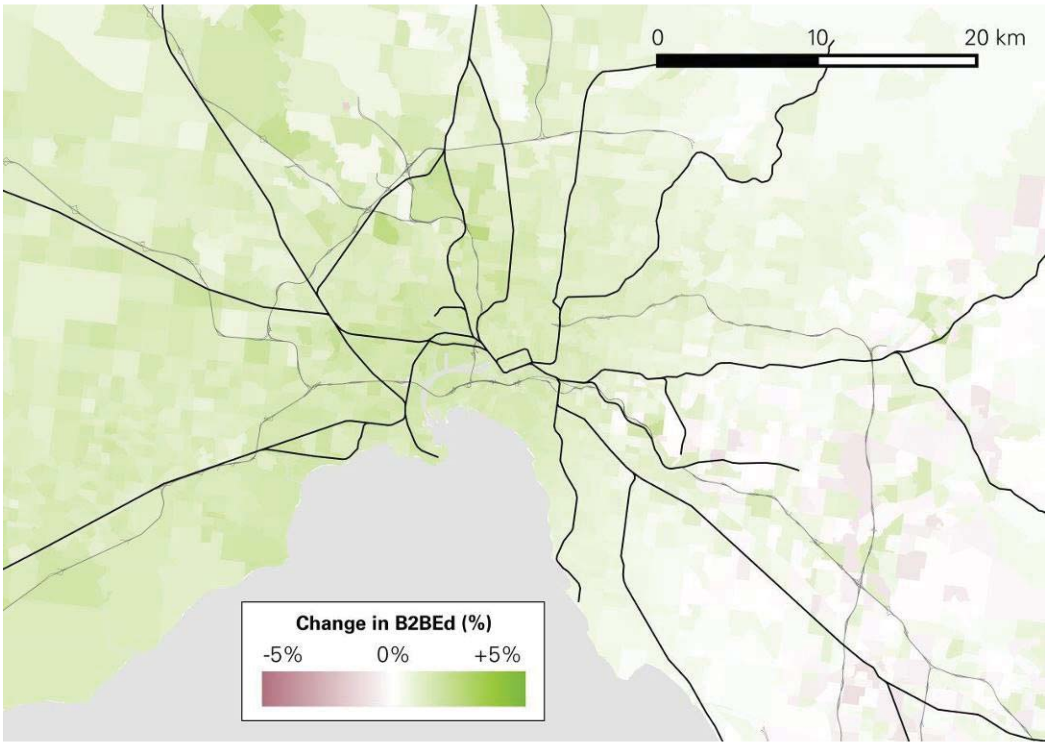
6.2.3. Key findings

Figure 13 and Figure 14 show the estimated change in B2BEd attributable to the Melbourne Metro Program and the Extended Program in the year 2031. The Melbourne Metro Program leads to improvements in B2BEd across majority of metropolitan Melbourne (including the CBD) as a proportion of users shift from road to rail, thereby reducing road congestion and improving the performance of the entire transport network. B2BEd of the CBD is also enhanced as more jobs are facilitated to locate within the CBD.

Under the Extended Program, larger improvements in B2BEd are apparent along the Melton line corridor, and to a lesser extent along the Werribee and Pakenham lines.

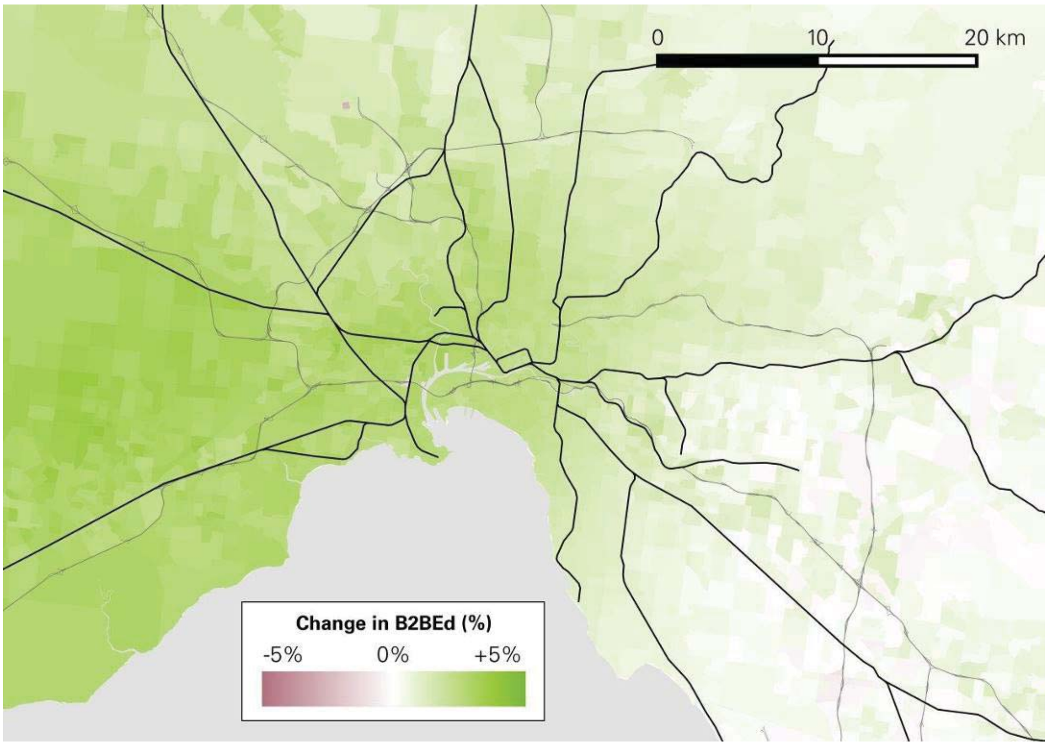
While increases in B2BEd are apparent across Melbourne, only increases in the inner city are significant, due to the high concentration of employment in that area. Figure 15 and Figure 16 show the estimated concentration of agglomeration benefits (dollars per hectare) attributable to the Melbourne Metro Program and the Extended Program in the year 2031.

Figure 13 – Change in effective density in 2031 attributable to Melbourne Metro Program



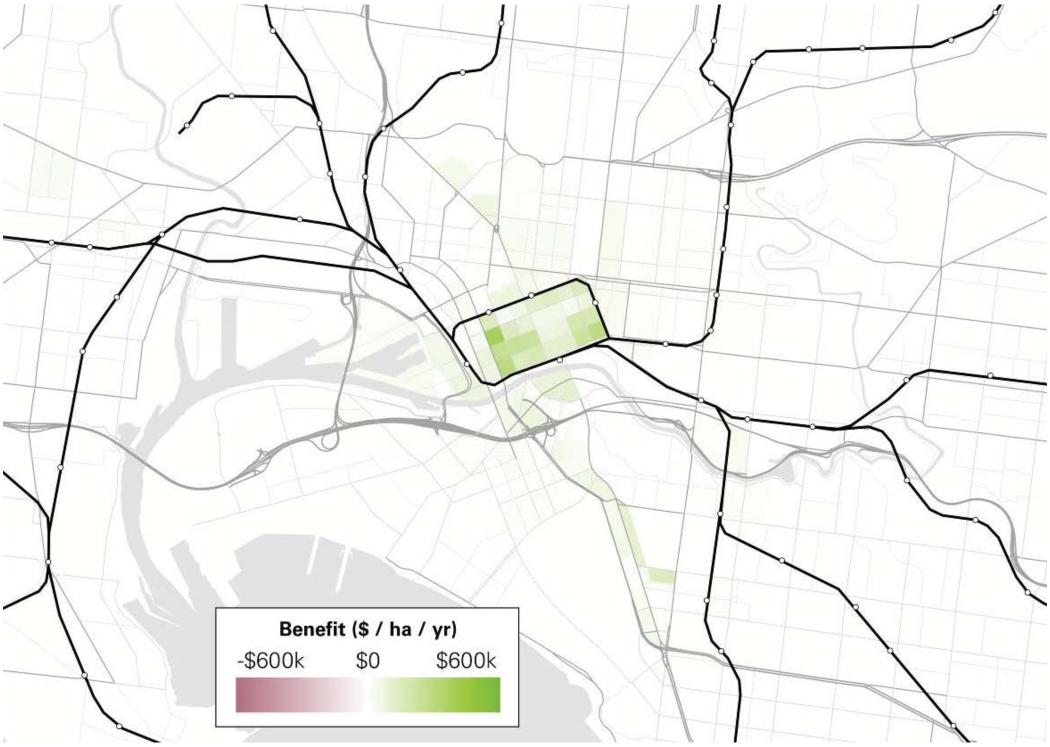
Source: VITM; KPMG analysis.

Figure 14 – Change in effective density in 2031 attributable to Extended Program



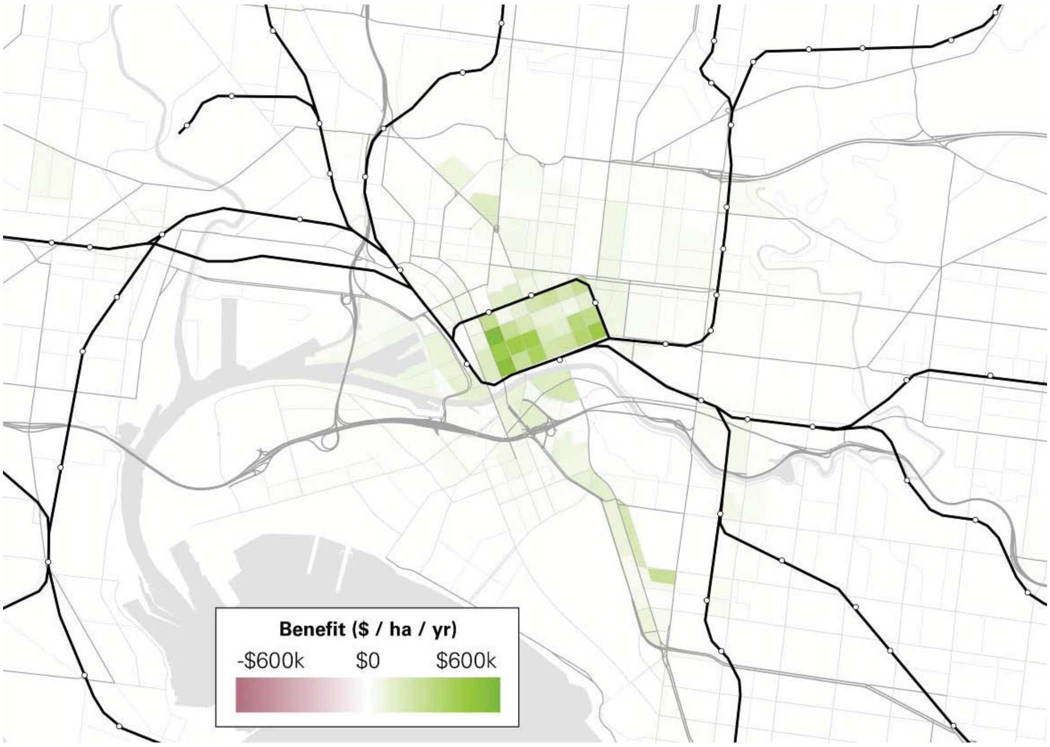
Source: VITM; KPMG analysis.

Figure 15 – Concentration of agglomeration benefits in 2031 attributable to Melbourne Metro Program



Source: VITM; KPMG analysis.

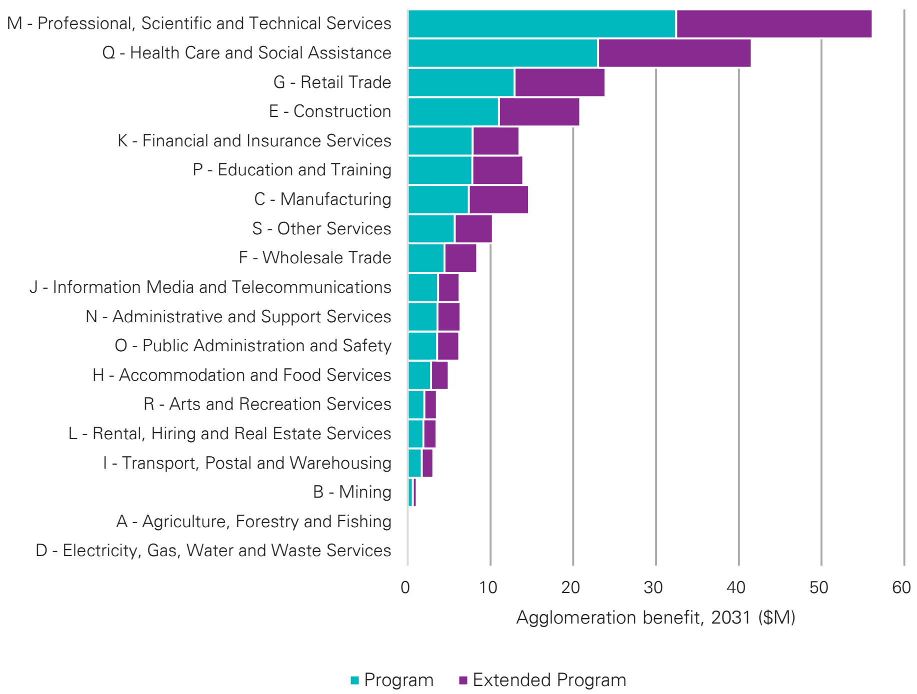
Figure 16 – Concentration of agglomeration benefits in 2031 attributable to Extended Program



Source: VITM; KPMG analysis.

Figure 17 shows the agglomeration benefits by industry for the year 2031. Industries that benefit most from the Melbourne Metro Program and the Extended Program include Professional, Scientific and Technical services and Health Care and Social Assistance. These industries benefit the most due to their spatial locations in Melbourne as well as having relatively higher elasticities of productivity with respect to effective density.

Figure 17 – Agglomeration benefits by industry in 2031 attributable to Melbourne Metro



Source: VITM; KPMG analysis.

Agglomeration economies make up the largest component of WEBs attributable to the Melbourne Metro Program and the Extended Program. Using the VITM model, the present value of agglomeration economies ranges from $1.5bn (discounting at 7 per cent) to $3.8bn (discounting at 4 per cent) under the Melbourne Metro Program Case and from $2.4bn to $6.1bn under the Extended Program Case (depending on the discount rate used).

6.3. WB2 – Labour market deepening

6.3.1. Overview

Transport projects can enable labour market benefits by reducing the generalised cost of commuting. Lower generalised cost of commuting reduces barriers to people taking up work/ working longer hours or switching to jobs that better match their skills and areas of interest (i.e. moving to more productive jobs). Conventional economic analysis captures the benefits of transport infrastructure to new users through time and operating cost savings, but it does not capture the benefit of additional tax revenue due to increased labour force participation or increased productivity of workers. Therefore, labour market deepening benefits arise from the market imperfection created by taxation, in which the Government realises a proportion of the benefits of increased economic activity.

Labour market deepening benefits arise from increased participation in the labour market (WB2a: increased labour supply) and from existing workers switching to more productive jobs (WB2b: move to more productive jobs).

6.3.2. Approach

Increased labour supply benefits (WB2a) are based on the assumption that in choosing whether to take up work, individuals trade off the perceived benefit of the potential wages with the perceived disbenefit of commuting. Increased labour supply benefits are quantified by estimating the change in the average daily generalised cost of commuting due to the initiative for different areas of the city. The perceived benefit of working (measured in dollars) for each area is defined as the average daily wage minus the average daily generalised cost of commuting. A reduction in generalised cost of commuting translates to an increase in the perceived benefit of working. The percentage increase in this perceived benefit is then multiplied by an elasticity of labour supply of 5 per cent[23] to estimate the total increase in labour supply attributable to the Melbourne Metro Program and the Extended Program. Finally, the overall change in economic output is estimated due to the increased participation in the labour market and the increased tax revenue estimated by applying the average tax rate of 21 per cent[24] to estimate the additional tax revenue attributable to the Melbourne Metro Program and the Extended Program.

Move to more productive jobs benefits are quantified by estimating the total number of jobs (by industry classification) that move from lower productivity areas (i.e. the suburbs) to higher productivity areas (i.e. the CBD). The overall change in economic output is estimated due to the increased productivity of these jobs (after controlling for the industry mix) and the increased tax revenue is estimated by applying the marginal tax rate of 32.5 per cent[25] to estimate the additional tax revenue attributable to the Melbourne Metro Program and the Extended Program.

The highly productive knowledge based and advanced professional jobs are located and are expected to continue to be concentrated in central Melbourne. By removing barriers associated with commuting capacity, Melbourne Metro provides employers with access to workers and residents in suburban areas with access to these jobs. This enables Victorians to move to the jobs in central Melbourne, taking higher wages and higher productivity jobs.

The rationale for the move to more productive jobs is very similar to that presented in the business case for the UK's Crossrail. The Melbourne CBD attracts successful firms and industries, which employ workers who would otherwise be employed in less productive jobs. As a result of this, enabling more jobs to locate in the Melbourne CBD leads to a change in the overall employment profile of Melbourne, with the jobs being of a different type (not different industry, but rather different type of jobs in the same industry. For instance, an accounting job located in the suburbs might be catering for individual tax returns or tax advice for sole-traders, whilst an accounting job based in the CBD may specialise in delivering services to small and medium sized firms) than would otherwise be the case.

6.3.3. Key findings

Using the VITM model, the present value of benefits from increased labour supply (WB2a) and from people moving to more productive jobs (WB2b) ranges from $1.5bn (discounting at 7 per cent) to $3.4bn (discounting at 4 per cent) under the Melbourne Metro Program Case and from $2.4bn to $5.6bn under the Extended Program Case (depending on the discount rate used).

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[23] Legaspi, J, Hensher, D, Wang, B. *Estimating the wider economic benefits of transport investments: The case of the Sydney North West Rail Link project* (2015), 5.
[24] Legaspi, J, Hensher, D, Wang, B. *Estimating the wider economic benefits of transport investments: The case of the Sydney North West Rail Link project* (2015), 5.
[25] Legaspi, J, Hensher, D, Wang, B. *Estimating the wider economic benefits of transport investments: The case of the Sydney North West Rail Link project* (2015), 5.

6.4. WB3 – Output increase in imperfectly competitive markets

6.4.1. Overview

Transport costs act as a barrier to competition and therefore help to maintain imperfect competition. Imperfectly competitive markets mean firms are incentivised to sell less output at higher prices than they would in a perfectly competitive market in order to maximise their profit. Projects that reduce transport costs can enhance the ability for the firms to produce goods at a lower cost; therefore generating additional consumer surplus due to the existence of price-cost mark-up which is not captured in the conventional economic analysis. The welfare impact of a transport improvement depends on the increase in output attributable to the transport improvement and the price-cost margin applicable to the industry sector. The welfare gain is the product of the two.

6.4.2. Approach

To assess this benefit, and as per the status of the NGTSM guidance at the time of the analysis, a 10 per cent uplift on business user benefits was applied to estimate this benefit.[26]

6.4.3. Key findings

Using the VITM model outputs, the present value of WB3 ranges from $0.1bn to $0.2bn under the Melbourne Metro Program Case and from $0.2bn to $0.4bn under the Extended Program Case (depending on the discount rate used).

7. Economy-wide CGE modelling methodology

7.1. Overview

To assess the net, total (including flow-on) impact on labour market as well as to understand the impact on other key economic variables, Victoria University Centre of Policy Studies (VU-COPS) undertook a computable general equilibrium (CGE) modelling. The study estimated the economy-wide effects of Melbourne Metro Program and the Extended Program at the state and national levels.

The analysis is complementary to the financial analysis and cost benefit analysis (CBA). The CGE model used is a customised version of 'The Enormous Regional Model' of Victoria University (VU-TERM). A key feature and the benefit of using VU-TERM is the dynamic approach in which the shocks to capital and labour flow through the economy. This is particularly relevant for assessing the Melbourne Metro Program and the Extended Program which will have a significant impact on the capital stock of Victoria as well as on the employment over an extended period.

VU-TERM assessed the accumulation of sector-specific capital in response to expected relative rates of return, which in turn depends on the rates of growth in capital stock. Consequently, as a sector grows faster, investors demand higher rates of return. The labour markets in VU-TERM are characterised by mobility of workers between regions in response to changes in real wage relativities and temporary changes in unemployment rates linked to real wage changes. The key point here is that the adjustment to industry- and / region-specific economic shocks takes place over a period of years, with the economy demonstrating much greater flexibility in the long run than in the short run.

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[26] Legaspi, J, Hensher, D, Wang, B. *Estimating the wider economic benefits of transport investments: The case of the Sydney North West Rail Link project* (2015), 4.

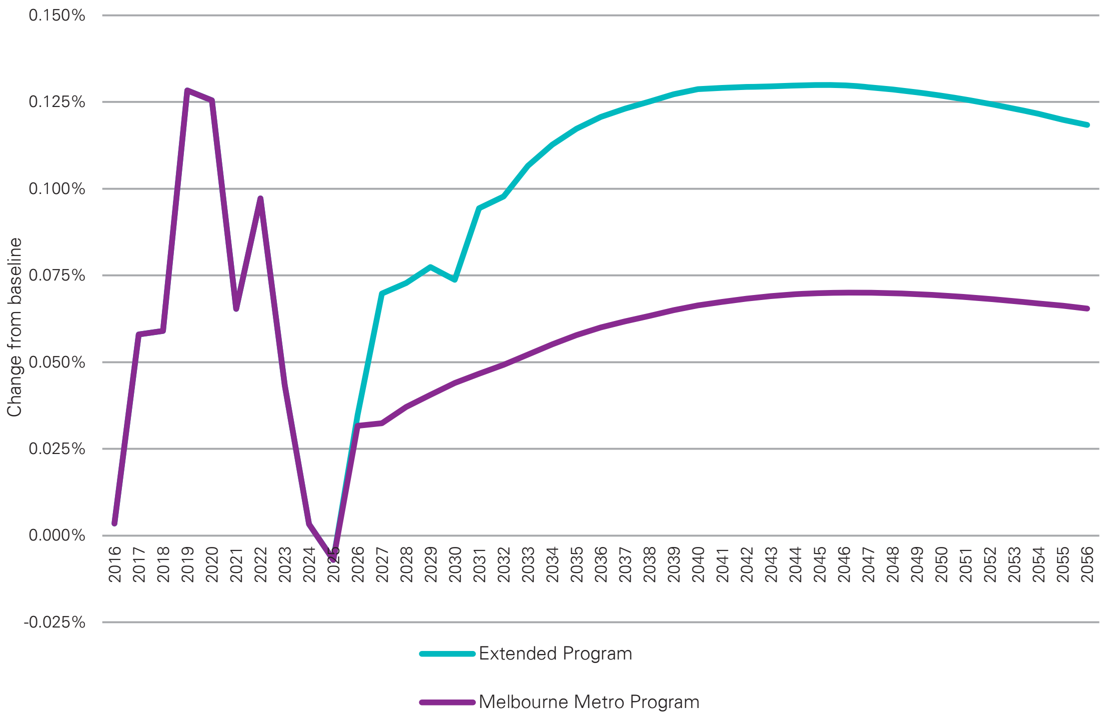
In order to assess the economy-wide impact, VU-COPS took the direct effects of Melbourne Metro Program and the Extended Program from the financial analysis and CBA and inputted these as economic shocks in the VU-TERM model.

Simulations of the economy-wide impacts of the investment and operational phases (to 2056) of the Melbourne Metro Program and Extended Program were undertaken.

7.2. Key findings

Figure 18 to Figure 20 show the output of the CGE analysis, showing the effect of the Melbourne Metro Program and the Extended Program on GDP/GSP, real wages and on employment in Victoria.

Figure 18 – Effect of Melbourne Metro on Victorian GSP, % deviation from baseline



Source: Victoria University Centre of Policy Studies, 2016

Figure 19 – Effect of Melbourne Metro on Victorian real wages, % deviation from baseline

Source: Victoria University Centre of Policy Studies, 2016

Figure 20 – Effect of Melbourne Metro on Victorian employment, % deviation from baseline

Source: Victoria University Centre of Policy Studies, 2016

Table 14 and Table 15 show the economy wide impact on employment and Gross State Product (GSP) and Gross Domestic Product (GDP) using 7 and 4 per cent discount rates respectively.

Table 14 – Economy wide impact using 7 per cent discount rate

Macro-economic impact		Construction period	Operating period	Total
Melbourne Metro Program		**(2016 to 2025)**	**(2026 to 2056)**	**(2016 to 2056)**
Gross State Product/ Gross Domestic Product	Victoria	$1.9bn	$5.3bn	$7.2bn
	Australia	$3.0bn	$4.2bn	$7.2bn
Jobs, number in peak year	Victoria	3,900	470	n/a
	Australia	4,700	410	n/a
Extended Program		**(2016 to 2030)**	**(2031 to 2056)**	**(2016 to 2056)**
Gross State Product/ Gross Domestic Product	Victoria	$2.9bn	$9.2bn	$12.1bn
	Australia	$3.8bn	$8.4bn	$12.2bn
Jobs, number in peak year	Victoria	3,900	740	n/a
	Australia	4,700	600	n/a

Source: Based on Victoria University Centre of Policy Studies, 2016. GSP/ GDP figures are presented in $2015, real, present value terms discounted at 7 per cent

Table 15 – Economy wide impact using 4 per cent discount rate

Macro-economic impact		Construction period	Operating period	Total
Melbourne Metro Program		**(2016 to 2025)**	**(2026 to 2056)**	**(2016 to 2056)**
Gross State Product/ Gross Domestic Product	Victoria	$2.2bn	$11.7bn	$13.9bn
	Australia	$3.4bn	$9.8bn	$13.2bn
Jobs, number in peak year	Victoria	3,900	470	n/a
	Australia	4,700	410	n/a
Extended Program		**(2016 to 2030)**	**(2031 to 2056)**	**(2016 to 2056)**
Gross State Product/ Gross Domestic Product	Victoria	$3.7bn	$21.1bn	$24.7bn
	Australia	$4.7bn	$19.4bn	$24.0bn
Jobs, number in peak year	Victoria	3,900	740	n/a
	Australia	4,700	600	n/a

Source: Based on Victoria University Centre of Policy Studies, 2016. GSP/ GDP figures are presented in $2015, real, present value terms discounted at 4 per cent

The analysis demonstrates that the largest economic impacts of Melbourne Metro on employment occur during the construction phase. These are positive as investment ramps up, with increases in the terms of trade leading to gains in both real wages and aggregate employment. In Victoria, net job creation peaks at 3,900 while nationally, 4,700 jobs are created at the peak of construction.

Operational impacts increase gradually from 2026, although with a step change in 2031 in the case of the Extended Program. Economic output grow through to 2056, but jobs peak in 2019. During the operation period, employment in Victoria is expected to be higher by around 470 jobs under the Melbourne Metro Program and by 740 jobs under the Extended Program.

Over the evaluation period, Victorian GSP is estimated to be $7.2bn higher with the Melbourne Metro Program and $12.1bn higher with the Extended Program using a 7 per cent discount rate. Discounting by 4 per cent suggests that the Victorian GSP is higher by around $13.9bn and $24.7bn for the Melbourne Metro Program and the Extended Program respectively.

For Australia as a whole, the corresponding impacts are slightly lower, reflecting the relocation of some economic activity from rest of Australia to Greater Melbourne in response to the relatively higher levels of productivity resulting from Melbourne Metro. Productivity benefits of Melbourne Metro are reflected in higher average real wage rates at both state and national levels. By the end of the operational phase, increases in wages are a much more important source of benefits than are increases in employment, especially at the national scale.

The two industries significantly impacted during the investment phase are Construction and Rail Equipment. Operation and renewal of associated rolling stock in the of the Melbourne Metro Program or the Extended Program significantly impact only the Urban Rail and Rail Equipment industries. Output of most other industries is slightly higher by 2056, although output of the Petroleum Products industry declines slightly due to decreased fuel demand for motor fuels.

8. Discussion of results

The following section details the results of the economic evaluation which compares and contrasts the costs and benefits over the evaluation period.

Benefits and operating costs are calculated over a 50-year period from project opening and discounted at a rate of 4 per cent and 7 per cent (real). Capital costs have been distributed across the construction and commissioning period and discounted at 4 per cent and 7 per cent (real).

8.1. Key economic indicators

The following economic performance measures were calculated to compare the economic viability of Melbourne Metro:

- The **Net Present Value** (NPV) gives an indication of the *magnitude* of net benefit to society, calculated by taking the difference between the present value of the total incremental benefits and the present value of the total incremental costs. Positive NPVs indicate an investment is desirable to society as a whole.
- The **Benefit Cost Ratio** (BCR) is a measure of *value for money* for government expenditure, calculated by dividing the present value of total incremental benefits by the present value of the investment and recurrent operating and maintenance costs. It is of principal value when Government is considering spending scarce funds. BCRs greater than one indicate that an investment is economically efficient.

8.2. Key findings – Melbourne Metro Program

Table 16 summarises the economic evaluation results for the Melbourne Metro Program.

Using VITM demand modelling data, the BCR for the Melbourne Metro Program ranges from 1.5 to 3.3 and NPV ranges from $3.7bn to $18.0bn (under an holistic assessment including WEBs) discounting at 7 and 4 per cent respectively at the P50 cost level. Under an assessment that considers conventional benefits only, the BCR ranges from 1.1 (discounting at 7 per cent) to 2.4 (discounting at 4 per cent).

Using Zenith demand modelling data, the BCR for the Melbourne Metro Program ranges from 1.9 to 3.9 and NPV ranges from $5.9bn to $22.5bn (under an holistic assessment including WEBs) discounting at 7 and 4 per cent respectively at the P50 cost level. Under an assessment that considers conventional benefits only, the BCR ranges from 1.4 (discounting at 7 per cent) to 3.0 (discounting at 4 per cent).

8.3. Key findings – Extended Program

Table 17 summarises the economic evaluation results for the Extended Program.

Using VITM demand modelling data, the BCR for the Extended Program ranges from 2.1 to 4.5 and NPV ranges from $8.7bn to $32.5bn (under an holistic assessment including WEBs) discounting at 7 and 4 per cent respectively at the P50 cost level. Under an assessment that considers conventional benefits only, the BCR ranges from 1.5 (discounting at 7 per cent) to 3.2 (discounting at 4 per cent).

Using Zenith demand modelling data, the BCR for the Extended Program ranges from 2.7 to 5.8 and NPV ranges from $13.3bn to $45.4bn (under an holistic assessment including WEBs) discounting at 7 and 4 per cent respectively at the P50 cost level. Under an assessment that considers conventional benefits only, the BCR ranges from 2.1 (discounting at 7 per cent) to 4.6 (discounting at 4 per cent).

Table 16 – Economic evaluation results of Melbourne Metro Program

	Model	VITM	VITM	Zenith	Zenith
	Discount rate	**7%**	**4%**	**7%**	**4%**
	COSTS (P50)				
1	Capital costs	$6.7bn	$7.7bn	$6.7bn	$7.7bn
2	Operation & maintenance costs	$0.6bn	$1.3bn	$0.6bn	$1.3bn
3=1+2	**TOTAL COSTS**	**$7.3bn**	**$9.1bn**	**$7.3bn**	**$9.1bn**
	BENEFITS				
	Conventional economic benefits				
4	Public transport user benefits	$4.7bn	$11.2bn	$5.7bn	$13.5bn
5	Road user benefits	$2.3bn	$5.8bn	$2.7bn	$6.4bn
6	Non-user benefits	$0.8bn	$1.8bn	$1.7bn	$3.8bn
7	Residual value of assets	$0.2bn	$0.9bn	$0.2bn	$0.9bn
8=4+5+6+7	**Total conventional economic benefits**	**$7.9bn**	**$19.7bn**	**$10.3bn**	**$24.6bn**
	Wider Economic Benefits				
9	WB1 – Agglomeration economies	$1.5bn	$3.8bn	$1.3bn	$3.2bn
10	WB2 – Labour market deepening	$1.5bn	$3.4bn	$1.6bn	$3.5bn
11	WB3 – Increased output under imperfectly competitive markets	$0.1bn	$0.2bn	$0.1bn	$0.2bn
12=9+10+11	**Total Wider Economic Benefits**	**$3.1bn**	**$7.4bn**	**$3.0bn**	**$6.9bn**
13=8+12	**TOTAL BENEFITS**	**$11.0bn**	**$27.0bn**	**$13.2bn**	**$31.5bn**
	ECONOMIC INDICATORS				
14=8-3	Net Present Value excluding WEBs	$0.6bn	$10.6bn	$2.9bn	$15.6bn
15=(8-2)/1	**Benefit cost ratio excluding WEBs**	**1.1**	**2.4**	**1.4**	**3.0**
16=8+12-3	Net Present Value including WEBs	$3.7bn	$18.0bn	$5.9bn	$22.5bn
17=(13-2)/1	**Benefit cost ratio including WEBs**	**1.5**	**3.3**	**1.9**	**3.9**

Source: PTV. Monetary values presented in Q2 $2015. Costs and benefits discounted to $2015

Table 17 – Economic evaluation results of Extended Program

	Model	VITM	VITM	Zenith	Zenith
	Discount rate	**7%**	**4%**	**7%**	**4%**
	COSTS (P50)				
1	Capital costs	$7.8bn	$9.4bn	$7.8bn	$9.4bn
2	Operation & maintenance costs	$0.8bn	$1.9bn	$0.8bn	$1.9bn
3=1+2	**TOTAL COSTS**	**$8.7bn**	**$11.3bn**	**$8.7bn**	**$11.3bn**
	BENEFITS				
	Conventional economic benefits				
4	Public transport user benefits	$6.6bn	$16.4bn	$9.4bn	$25.7bn
5	Road user benefits	$4.4bn	$11.3bn	$4.8bn	$11.8bn
6	Non-user benefits	$1.2bn	$2.9bn	$2.6bn	$6.3bn
7	Residual value of assets	$0.2bn	$1.2bn	$0.2bn	$1.2bn
8=4+5+6+7	**Total conventional economic benefits**	**$12.4bn**	**$31.8bn**	**$17.1bn**	**$45.0bn**
	Wider Economic Benefits				
9	WB1 – Agglomeration economies	$2.4bn	$6.1bn	$2.2bn	$5.4bn
10	WB2 – Labour market deepening	$2.4bn	$5.6bn	$2.5bn	$5.9bn
11	WB3 – Increased output under imperfectly competitive markets	$0.2bn	$0.4bn	$0.2bn	$0.4bn
12=9+10+11	**Total Wider Economic Benefits**	**$5.0bn**	**$12.0bn**	**$4.9bn**	**$11.8bn**
13=8+12	**TOTAL BENEFITS**	**$17.4bn**	**$43.8bn**	**$22.0bn**	**$56.8bn**
	ECONOMIC INDICATORS				
14=8-3	Net Present Value excluding WEBs	$3.7bn	$20.5bn	$8.4bn	$33.7bn
15=(8-2)/1	**Benefit cost ratio excluding WEBs**	**1.5**	**3.2**	**2.1**	**4.6**
16=8+12-3	Net Present Value including WEBs	$8.7bn	$32.5bn	$13.3bn	$45.4bn
17=(13-2)/1	**Benefit cost ratio including WEBs**	**2.1**	**4.5**	**2.7**	**5.8**

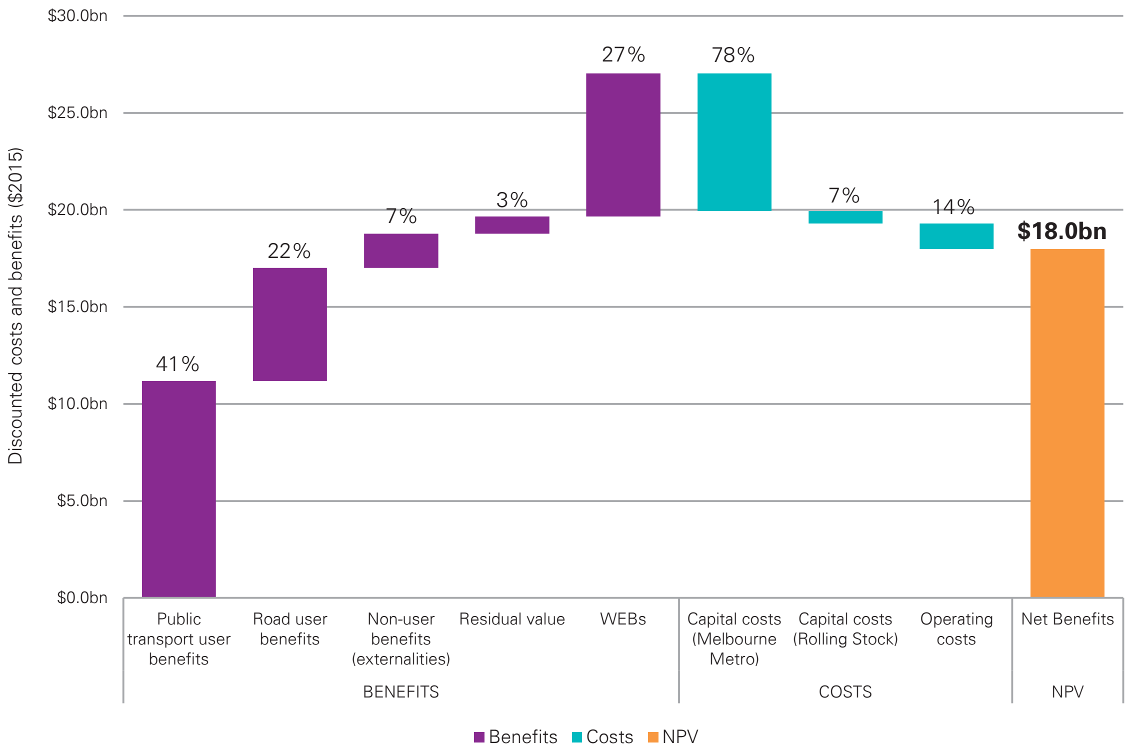
Source: PTV. Monetary values presented in Q2 $2015. Costs and benefits discounted to $2015

Figure 21 to Figure 24 show the cumulative benefits and costs for the Melbourne Metro Program Case and Extended Program Case.

For the Melbourne Metro Program, the largest contributing category of benefit is public transport user benefits accounting for 41 to 43 per cent of the total benefits. Road user benefits arising from decongestion comprise the second largest component of benefits of approximately 21 to 22 per cent. Other benefits including externalities and the residual value of assets, comprise approximately 9 to 10 percent of the benefits. Wider Economic Benefits comprise 27 to 28 per cent of the total.

The composition of benefits for the Extended Program is similar to that of the Melbourne Metro Program.

Figure 21 – Cumulative benefits and costs, Melbourne Metro Program, VITM, 4 per cent discount rate

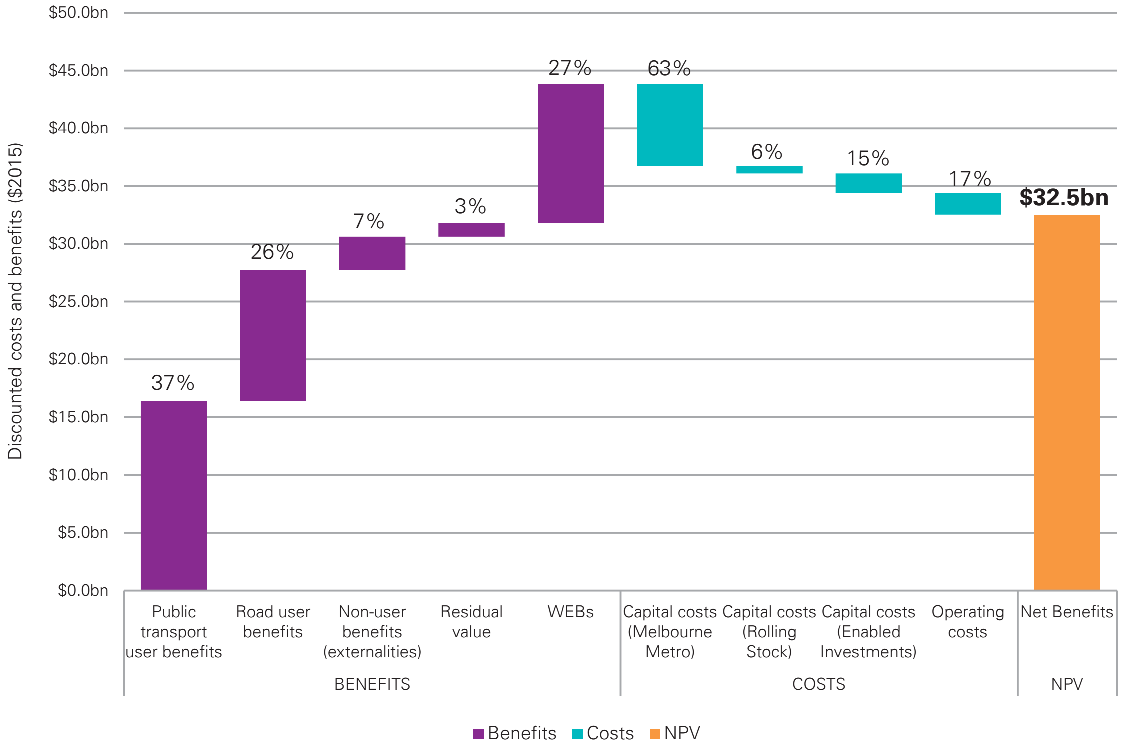


Source: PTV

Figure 22 – Cumulative benefits and costs, Melbourne Metro Program, VITM, 7 per cent discount rate

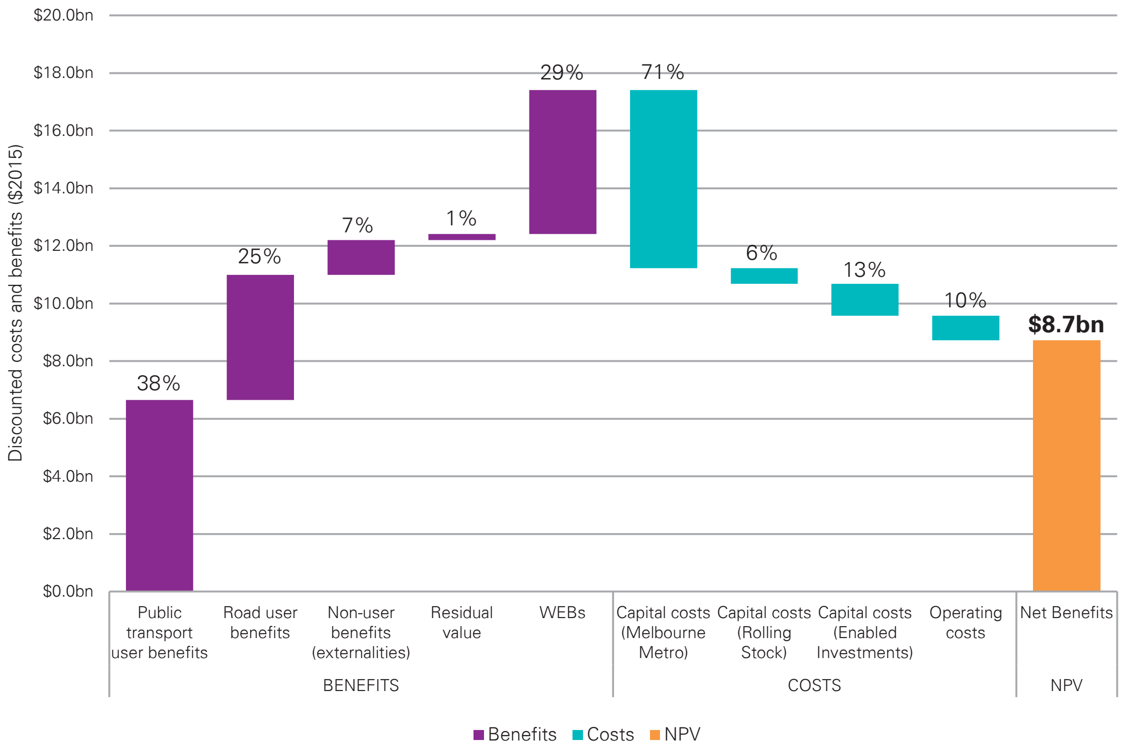
Source: PTV

Figure 23 – Cumulative benefits and costs, Extended Program, VITM, 4 per cent discount rate



Source: PTV

Figure 24 – Cumulative benefits and costs, Extended Program, VITM, 7 per cent discount rate



Source: PTV

9. Sensitivity analysis

With economic analysis depending heavily on cost planning, transport modelling and a range of other assumptions, including land use forecasts and expected transport network in future, it is important to assess the impact of changes in major inputs and assumptions to the economic viability of the Melbourne Metro.

Sensitivity tests were constructed to test the most crucial assumptions in the modelling and were undertaken on the 4 per cent and 7 per cent discount rates. The sensitivity test results are presented in Table 18 (VITM, 4 per cent discount rate) and Table 19 (VITM, 7 per cent discount rate) for the Melbourne Metro Program. Table 20 and Table 21 provide the sensitivity test results for the Extended Program.

The sensitivity tests demonstrate that the economic evaluation is resilient to major changes in key assumptions.

- The "upside" results show that the Melbourne Metro Program could deliver a more positive economic result than the core evaluation result suggests, with some tests showing the BCR (including WEBs) exceeding 4.0 and the NPV exceeding $23.4bn.
- The "upside" results are significantly more positive with the delivery of the Extended Program with some tests showing the BCR (including WEBs) exceeding 5.4 and the NPV exceeding $41.3bn.
- The "downside" results demonstrate that the Melbourne Metro Program, which produces a positive economic outcome under the majority of tests, with the most conservative scenario where benefits decrease by 20 per cent generating a BCR of 0.8 excluding WEBs (discount rate of 7 per cent only). Even under this highly conservative scenario, in a more holistic analysis that includes WEBs the BCR is estimated to be around 1.2.
- The "downside" results show that the Extended Program could deliver a positive economic result with even the most conservative scenario showing the BCR (excluding WEBs) of 1.2 and the NPV exceeding $1.3bn.

Table 18 – Summary of sensitivity test results (VITM, 4 per cent discount rate) – Melbourne Metro Program

	PV capital costs	PV op. costs	PV conv. benefits	PV WEBs	NPV (exc. WEBs)	BCR (exc. WEBs)	NPV (inc. WEBs)	BCR (inc. WEBs)
S0. Central scenario	$7.7bn	$1.3bn	$19.7bn	$7.4bn	$10.6bn	2.4	$18.0bn	3.3
1. Modelling scenarios								
S1a. MM Program modelled using Zenith model	$7.7bn	$1.3bn	$24.6bn	$6.9bn	$15.6bn	3.0	$22.5bn	3.9
S1b. MM Program with no land use change	$7.7bn	$1.3bn	$19.3bn	$2.7bn	$10.2bn	2.3	$12.9bn	2.7
S1c. MM Program with no growth in real income	$7.6bn	$1.1bn	$16.4bn	$4.4bn	$7.7bn	2.0	$12.1bn	2.6
2. Costs								
S2a. P90 Costs	$8.3bn	$1.3bn	$19.7bn	$7.4bn	$10.1bn	2.2	$17.5bn	3.1
3. Benefits								
S3a. Total benefits +20%	$7.7bn	$1.3bn	$23.6bn	$8.8bn	$14.5bn	2.9	$23.4bn	4.0
S3b. Total benefits -20%	$7.7bn	$1.3bn	$15.7bn	$5.9bn	$6.7bn	1.9	$12.6bn	2.6
S3c. WEBs +50%	$7.7bn	$1.3bn	$19.7bn	$11.1bn	$10.6bn	2.4	$21.7bn	3.8
S3d. WEBs -50%	$7.7bn	$1.3bn	$19.7bn	$3.7bn	$10.6bn	2.4	$14.3bn	2.8
4. Public transport benefits								
S4a. Crowding benefits +20%	$7.7bn	$1.3bn	$20.6bn	$7.4bn	$11.6bn	2.5	$18.9bn	3.4
S4b. Crowding benefits -20%	$7.7bn	$1.3bn	$18.7bn	$7.4bn	$9.7bn	2.2	$17.0bn	3.2
6. Highway benefits								
S5a. VOC benefits +20%	$7.7bn	$1.3bn	$20.1bn	$7.4bn	$11.1bn	2.4	$18.4bn	3.4
S5b. VOC benefits -20%	$7.7bn	$1.3bn	$19.2bn	$7.4bn	$10.2bn	2.3	$17.5bn	3.3
S5c. Travel time savings +20%	$7.7bn	$1.3bn	$20.2bn	$7.4bn	$11.2bn	2.4	$18.6bn	3.4
S5d. Travel time savings -20%	$7.7bn	$1.3bn	$19.1bn	$7.4bn	$10.0bn	2.3	$17.4bn	3.2
6. Expansion factors								
S6a. PT daily to annual expansion factors +10%	$7.7bn	$1.3bn	$20.9bn	$7.4bn	$11.8bn	2.5	$19.2bn	3.5
S6b. PT daily to annual expansion factors -10%	$7.7bn	$1.3bn	$18.5bn	$7.4bn	$9.4bn	2.2	$16.8bn	3.2
S6c. Highway daily to annual expansion factors +10%	$7.7bn	$1.3bn	$20.3bn	$7.4bn	$11.3bn	2.5	$18.7bn	3.4
S6d. PT daily to annual expansion factors -10%	$7.7bn	$1.3bn	$19.0bn	$7.4bn	$10.0bn	2.3	$17.3bn	3.2
7. Extrapolation method								
S7a. Plateau (no growth in benefits post-2046)	$7.7bn	$1.3bn	$17.6bn	$6.7bn	$8.6bn	2.1	$15.2bn	3.0
S7b. Straight-line extrapolation	$7.7bn	$1.3bn	$20.9bn	$7.8bn	$11.9bn	2.5	$19.7bn	3.5
8. Residual value method								
S8a. Future net benefits	$7.7bn	$1.3bn	$23.7bn	$7.4bn	$14.7bn	2.9	$22.0bn	3.8
S8b. Straight line depreciation	$7.7bn	$1.3bn	$19.2bn	$7.4bn	$10.2bn	2.3	$17.5bn	3.3

Table 19 – Summary of sensitivity test results (VITM, 7 per cent discount rate) – Melbourne Metro Program

	PV capital costs	PV op. costs	PV conv. benefits	PV WEBs	NPV (exc. WEBs)	BCR (exc. WEBs)	NPV (inc. WEBs)	BCR (inc. WEBs)
S0. Central scenario	$6.7bn	$0.6bn	$7.9bn	$3.1bn	$0.6bn	1.1	$3.7bn	1.5
1. Modelling scenarios								
S1a. MM Program modelled using Zenith model	$6.7bn	$0.6bn	$10.3bn	$3.0bn	$2.9bn	1.4	$5.9bn	1.9
S1b. MM Program with no land use change	$6.7bn	$0.6bn	$7.7bn	$1.0bn	$0.4bn	1.1	$1.4bn	1.2
S1c. MM Program with no growth in real income	$6.5bn	$0.5bn	$6.7bn	$1.9bn	-$0.4bn	0.9	$1.6bn	1.2
2. Costs								
S2a. P90 Costs	$7.2bn	$0.6bn	$7.9bn	$3.1bn	$0.1bn	1.0	$3.2bn	1.4
3. Benefits								
S3a. Total benefits +20%	$6.7bn	$0.6bn	$9.5bn	$3.7bn	$2.1bn	1.3	$5.9bn	1.9
S3b. Total benefits -20%	$6.7bn	$0.6bn	$6.3bn	$2.5bn	-$1.0bn	0.8	$1.5bn	1.2
S3c. WEBs +50%	$6.7bn	$0.6bn	$7.9bn	$4.7bn	$0.6bn	1.1	$5.3bn	1.8
S3d. WEBs -50%	$6.7bn	$0.6bn	$7.9bn	$1.6bn	$0.6bn	1.1	$2.1bn	1.3
4. Public transport benefits								
S4a. Crowding benefits +20%	$6.7bn	$0.6bn	$8.3bn	$3.1bn	$0.9bn	1.1	$4.1bn	1.6
S4b. Crowding benefits -20%	$6.7bn	$0.6bn	$7.5bn	$3.1bn	$0.2bn	1.0	$3.3bn	1.5
6. Highway benefits								
S5a. VOC benefits +20%	$6.7bn	$0.6bn	$8.1bn	$3.1bn	$0.8bn	1.1	$3.9bn	1.6
S5b. VOC benefits -20%	$6.7bn	$0.6bn	$7.7bn	$3.1bn	$0.4bn	1.1	$3.5bn	1.5
S5c. Travel time savings +20%	$6.7bn	$0.6bn	$8.1bn	$3.1bn	$0.8bn	1.1	$3.9bn	1.6
S5d. Travel time savings -20%	$6.7bn	$0.6bn	$7.7bn	$3.1bn	$0.4bn	1.1	$3.5bn	1.5
6. Expansion factors								
S6a. PT daily to annual expansion factors +10%	$6.7bn	$0.6bn	$8.4bn	$3.1bn	$1.1bn	1.2	$4.2bn	1.6
S6b. PT daily to annual expansion factors -10%	$6.7bn	$0.6bn	$7.4bn	$3.1bn	$0.1bn	1.0	$3.2bn	1.5
S6c. Highway daily to annual expansion factors +10%	$6.7bn	$0.6bn	$8.1bn	$3.1bn	$0.8bn	1.1	$4.0bn	1.6
S6d. PT daily to annual expansion factors -10%	$6.7bn	$0.6bn	$7.6bn	$3.1bn	$0.3bn	1.0	$3.4bn	1.5
7. Extrapolation method								
S7a. Plateau (no growth in benefits post-2046)	$6.7bn	$0.6bn	$7.3bn	$2.9bn	$0.0bn	1.0	$2.9bn	1.4
S7b. Straight-line extrapolation	$6.7bn	$0.6bn	$8.2bn	$3.2bn	$0.8bn	1.1	$4.1bn	1.6
8. Residual value method								
S8a. Future net benefits	$6.7bn	$0.6bn	$8.3bn	$3.1bn	$1.0bn	1.1	$4.1bn	1.6
S8b. Straight line depreciation	$6.7bn	$0.6bn	$7.8bn	$3.1bn	$0.5bn	1.1	$3.6bn	1.5

Table 20 – Summary of sensitivity test results (VITM, 4 per cent discount rate) – Extended Program

	PV capital costs	PV op. costs	PV conv. benefits	PV WEBs	NPV (exc. WEBs)	BCR (exc. WEBs)	NPV (inc. WEBs)	BCR (inc. WEBs)
S0. Central scenario	$9.4bn	$1.9bn	$31.8bn	$12.0bn	$20.5bn	3.2	$32.5bn	4.5
1. Modelling scenarios								
S1a. Extended Program modelled using Zenith model	$9.4bn	$1.9bn	$45.0bn	$11.8bn	$33.7bn	4.6	$45.4bn	5.8
S1b. Extended Program with no land use change	$9.4bn	$1.9bn	$31.4bn	$4.5bn	$20.1bn	3.1	$24.7bn	3.6
S1c. Extended Program with no growth in real income	$9.1bn	$1.6bn	$26.2bn	$7.1bn	$15.5bn	2.7	$22.6bn	3.5
2. Costs								
S2a. P90 Costs	$10.1bn	$1.9bn	$31.9bn	$12.0bn	$19.9bn	3.0	$31.9bn	4.2
3. Benefits								
S3a. Total benefits +20%	$9.4bn	$1.9bn	$38.2bn	$14.5bn	$26.8bn	3.9	$41.3bn	5.4
S3b. Total benefits -20%	$9.4bn	$1.9bn	$25.4bn	$9.6bn	$14.1bn	2.5	$23.8bn	3.5
S3c. WEBs +50%	$9.4bn	$1.9bn	$31.8bn	$18.1bn	$20.5bn	3.2	$38.6bn	5.1
S3d. WEBs -50%	$9.4bn	$1.9bn	$31.8bn	$6.0bn	$20.5bn	3.2	$26.5bn	3.8
4. Public transport benefits								
S4a. Crowding benefits +20%	$9.4bn	$1.9bn	$33.5bn	$12.0bn	$22.2bn	3.4	$34.3bn	4.6
S4b. Crowding benefits -20%	$9.4bn	$1.9bn	$30.1bn	$12.0bn	$18.8bn	3.0	$30.8bn	4.3
6. Highway benefits								
S5a. VOC benefits +20%	$9.4bn	$1.9bn	$32.6bn	$12.0bn	$21.3bn	3.3	$33.4bn	4.5
S5b. VOC benefits -20%	$9.4bn	$1.9bn	$31.0bn	$12.0bn	$19.7bn	3.1	$31.7bn	4.4
S5c. Travel time savings +20%	$9.4bn	$1.9bn	$32.9bn	$12.0bn	$21.6bn	3.3	$33.7bn	4.6
S5d. Travel time savings -20%	$9.4bn	$1.9bn	$30.7bn	$12.0bn	$19.4bn	3.1	$31.4bn	4.3
6. Expansion factors								
S6a. PT daily to annual expansion factors +10%	$9.4bn	$1.9bn	$33.6bn	$12.0bn	$22.3bn	3.4	$34.3bn	4.6
S6b. PT daily to annual expansion factors -10%	$9.4bn	$1.9bn	$30.0bn	$12.0bn	$18.7bn	3.0	$30.8bn	4.3
S6c. Highway daily to annual expansion factors +10%	$9.4bn	$1.9bn	$33.1bn	$12.1bn	$21.8bn	3.3	$33.8bn	4.6
S6d. PT daily to annual expansion factors -10%	$9.4bn	$1.9bn	$30.5bn	$12.0bn	$19.2bn	3.0	$31.2bn	4.3
7. Extrapolation method								
S7a. Plateau (no growth in benefits post-2046)	$9.4bn	$1.9bn	$28.2bn	$10.9bn	$16.9bn	2.8	$27.8bn	4.0
S7b. Straight-line extrapolation	$9.4bn	$1.9bn	$34.0bn	$12.7bn	$22.7bn	3.4	$35.4bn	4.8
8. Residual value method								
S8a. Future net benefits	$9.4bn	$1.9bn	$39.0bn	$12.0bn	$27.7bn	3.9	$39.8bn	5.2
S8b. Straight line depreciation	$9.4bn	$1.9bn	$31.2bn	$12.0bn	$19.9bn	3.1	$31.9bn	4.4

Table 21 – Summary of sensitivity test results (VITM, 7 per cent discount rate) – Extended Program

	PV capital costs	PV op. costs	PV conv. benefits	PV WEBs	NPV (exc. WEBs)	BCR (exc. WEBs)	NPV (inc. WEBs)	BCR (inc. WEBs)
S0. Central scenario	$7.8bn	$0.8bn	$12.4bn	$5.0bn	$3.7bn	1.5	$8.7bn	2.1
1. Modelling scenarios								
S1a. Extended Program modelled using Zenith model	$7.8bn	$0.8bn	$17.1bn	$4.9bn	$8.4bn	2.1	$13.3bn	2.7
S1b. Extended Program with no land use change	$7.8bn	$0.8bn	$12.2bn	$1.7bn	$3.6bn	1.5	$5.3bn	1.7
S1c. Extended Program with no growth in real income	$7.6bn	$0.7bn	$10.5bn	$3.1bn	$2.2bn	1.3	$5.2bn	1.7
2. Costs								
S2a. P90 Costs	$8.4bn	$0.8bn	$12.4bn	$5.0bn	$3.2bn	1.4	$8.2bn	2.0
3. Benefits								
S3a. Total benefits +20%	$7.8bn	$0.8bn	$14.9bn	$6.0bn	$6.2bn	1.8	$12.2bn	2.6
S3b. Total benefits -20%	$7.8bn	$0.8bn	$9.9bn	$4.0bn	$1.3bn	1.2	$5.2bn	1.7
S3c. WEBs +50%	$7.8bn	$0.8bn	$12.4bn	$7.5bn	$3.7bn	1.5	$11.2bn	2.4
S3d. WEBs -50%	$7.8bn	$0.8bn	$12.4bn	$2.5bn	$3.7bn	1.5	$6.2bn	1.8
4. Public transport benefits								
S4a. Crowding benefits +20%	$7.8bn	$0.8bn	$13.1bn	$5.0bn	$4.4bn	1.6	$9.4bn	2.2
S4b. Crowding benefits -20%	$7.8bn	$0.8bn	$11.8bn	$5.0bn	$3.1bn	1.4	$8.1bn	2.0
6. Highway benefits								
S5a. VOC benefits +20%	$7.8bn	$0.8bn	$12.7bn	$5.0bn	$4.1bn	1.5	$9.1bn	2.2
S5b. VOC benefits -20%	$7.8bn	$0.8bn	$12.1bn	$5.0bn	$3.4bn	1.4	$8.4bn	2.1
S5c. Travel time savings +20%	$7.8bn	$0.8bn	$12.8bn	$5.0bn	$4.2bn	1.5	$9.2bn	2.2
S5d. Travel time savings -20%	$7.8bn	$0.8bn	$12.0bn	$5.0bn	$3.3bn	1.4	$8.3bn	2.1
6. Expansion factors								
S6a. PT daily to annual expansion factors +10%	$7.8bn	$0.8bn	$13.1bn	$5.0bn	$4.5bn	1.6	$9.4bn	2.2
S6b. PT daily to annual expansion factors -10%	$7.8bn	$0.8bn	$11.7bn	$5.0bn	$3.0bn	1.4	$8.0bn	2.0
S6c. Highway daily to annual expansion factors +10%	$7.8bn	$0.8bn	$12.9bn	$5.0bn	$4.2bn	1.5	$9.2bn	2.2
S6d. PT daily to annual expansion factors -10%	$7.8bn	$0.8bn	$11.9bn	$5.0bn	$3.2bn	1.4	$8.2bn	2.0
7. Extrapolation method								
S7a. Plateau (no growth in benefits post-2046)	$7.8bn	$0.8bn	$11.4bn	$4.7bn	$2.8bn	1.4	$7.4bn	2.0
S7b. Straight-line extrapolation	$7.8bn	$0.8bn	$12.9bn	$5.1bn	$4.2bn	1.5	$9.4bn	2.2
8. Residual value method								
S8a. Future net benefits	$7.8bn	$0.8bn	$13.2bn	$5.0bn	$4.5bn	1.6	$9.5bn	2.2
S8b. Straight line depreciation	$7.8bn	$0.8bn	$12.3bn	$5.0bn	$3.6bn	1.5	$8.6bn	2.1

10. Qualitative benefits excluded from assessment

A range of other economic effects have been identified but not quantified in the economic analysis. These range from some of the temporary effects of construction through to the potential for Melbourne Metro to enable urban consolidation in established areas. In addition, the benefits of facilitating electrification to Wallan and future rail links to Melbourne Airport and Rowville were not incorporated. Commentary on these qualitative benefits is provided in Table 22.

Table 22 – Qualitative economic effects of Melbourne Metro

Cost or Benefit	Description	Rating
Real Options	Melbourne Metro provides the capacity to expand the metropolitan rail network to Melbourne Airport, Rowville and Wallan. While the costs associated with delivering this capacity have been included in the economic evaluation, no benefits have been quantified.	Highly beneficial
Urban consolidation in established areas	Benefits associated with dwelling development in established areas which could otherwise have occurred on the fringe. The increased accessibility along train lines upgraded by Melbourne Metro could stimulate and support additional dwellings (transit oriented development). In particular, Melbourne Metro also enables the Arden urban renewal area.	Moderately beneficial
Option Value	The value people place on having available to them the option to use public transport, even if they do not currently use it. New stations and surrounding development will provide citizens with access to public transport they did not previously have. (Value uplift to properties around new stations is being assessed separately but will not be included in the economic evaluation, as a significant portion of the value uplift would potentially duplicate other economic benefits).	Moderately beneficial
Reduced roadway costs	Includes road maintenance, construction and land. These are affected by vehicle weight, size and speed. In urban areas with significant congestion problems and high land values, even a modest reduction in volumes can provide large savings. Melbourne Metro reduces car use, particularly in inner Melbourne.	Slightly beneficial
Biodiversity	Impacts on flora and fauna as a result of the construction and operation of Melbourne Metro.	Slightly detrimental
Construction disruption	While a range of construction related impacts are captured in the economic costs (including business disruption and costs to mitigate impacts), some have not had an economic value placed on them.	Moderately detrimental