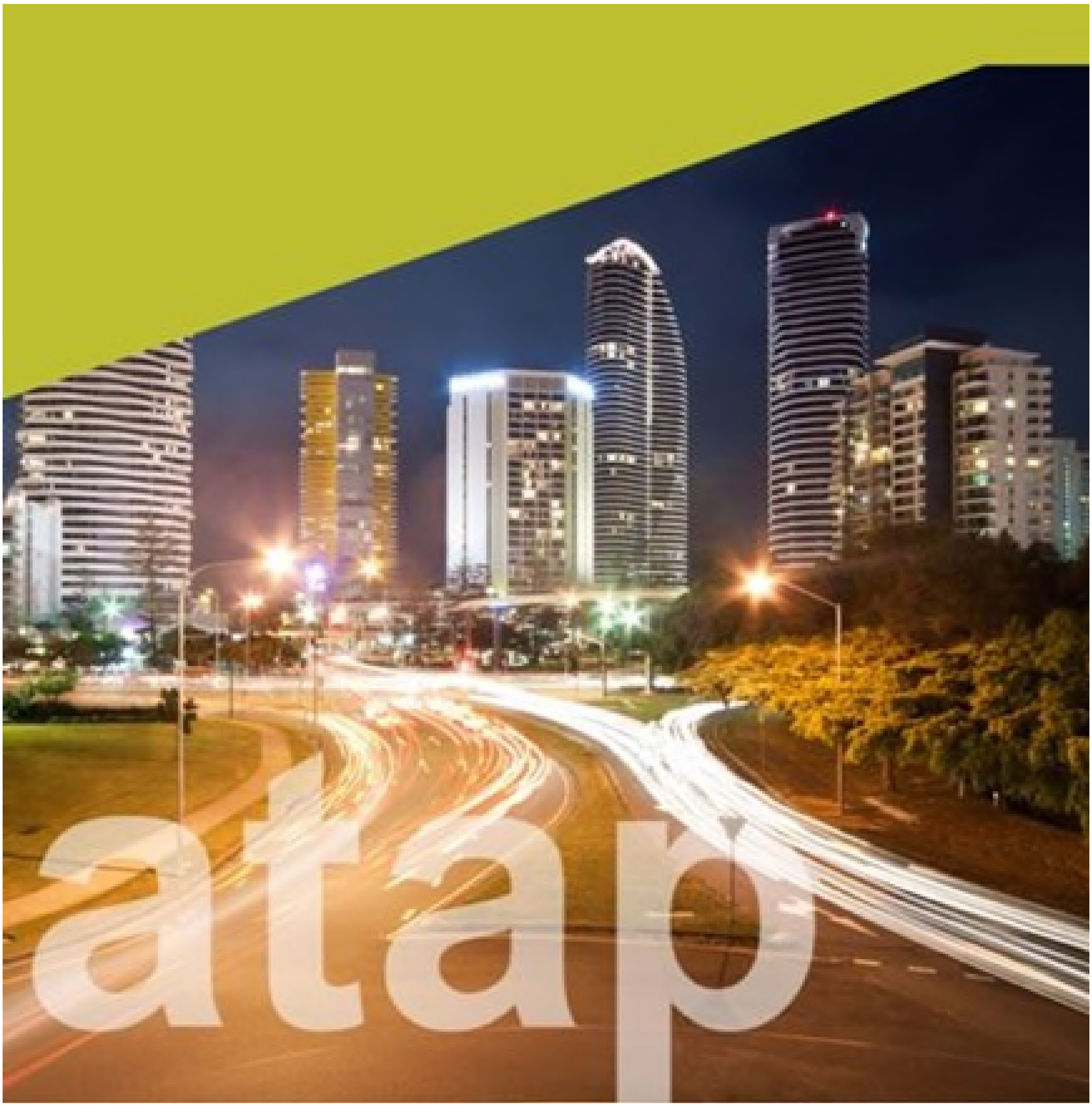
INFRASTRUCTURE AND TRANSPORT MINISTERS

Australian Transport Assessment and Planning Guidelines

T3 Wider economic benefits

January 2023



ISBN 978-1-925401-56-1 INFRA-2922

April 2022

The contributions of the following people in the development of this report are acknowledged.

KPMG: Praveen Thakur, Renan Grace

ATAP Guidelines project team: Mark Harvey, Atiqur Rahman, Robert Smith, Matthew Jones, Baojin Wang, Ed McGeehan, Kathy Goth, Justinieta Balberona

Reviewers of drafts

Members of the ATAP Steering Committee: Mark Harvey, Andreas Bleich, Belinda Sachse and Paula Stagg (Australian Government), Atiqur Rahman, Paul Stanley and David Tucker (Infrastructure Australia), Alban Pinz (QLD), Robert Smith and Matthew Jones (NSW), Justinieta Balberona (ACT), Ed McGeehan (VIC), Arun Kendall (TAS), Scott Cooper and Aaron Bell (SA), Des Lock (WA), Brett Clifford (NT), Sandy Fong (NZ), Richard Delplace (Austroads), Peter Tisato (Technical Coordinator).

Contact us

This publication was prepared by the Australian Transport Assessment and Planning (ATAP) Steering Committee and approved by the Transport and Infrastructure Senior Officials' Committee. The Committees cannot accept responsibility for any consequences arising from the use of this information. Readers should rely on their own skill and judgment when applying any information or analysis to particular issues or circumstances.

ATAP Steering Committee Secretariat
Australian Transport Assessment and Planning Guidelines
Department of Infrastructure, Transport, Regional Development and Communications
GPO Box 594
Canberra ACT 2601
Australia

Email: atap@infrastructure.gov.au

Website: atap.gov.au

Contents

Tables

Figures

At a glance

This part of the ATAP Guidelines provides guidance on the estimation the Wider Economic Benefits (WEBs) in appraisal of transport initiatives.

WEBs are improvements in economic welfare associated with changes in accessibility or land use that are not captured in traditional cost–benefit analysis (CBA). They arise from market imperfections, that is, prices of goods and services differing from costs to society as a whole. Reasons include economies of scale and scope, positive externalities, taxation and imperfect competition.

The international literature to date has concentrated on four types of WEBs that arise from major transport initiatives.

- WB1: Agglomeration economies — productivity gains from clustering by firms
  - Static clustering, which arises from improved access with land-use held constant
  - dynamic clustering, which arises from changed land use
- WB2: Labour market and tax impacts — productivity gains accruing to governments via the taxation system
  - WB2a: Change in labour supply — changes in transport costs encouraging more labour supply
  - WB2b: Move to more or less productive jobs — changes in jobs between locations with different productivity levels
- WB3: Output changes in imperfectly competitive markets — profit increases for firms
- WB4: Change in competition — gains to consumers and more efficient production.

These guidelines provide methodologies and parameter values for estimating WB1, WB2a and WB3. Estimation of WB2b is not supported at this stage because of inadequate understanding of productivity differentials between locations. No methodology is given for WB4 because it is not considered relevant for economies that already have a good base level of transport connectivity such as Australian cities.

Whether it is worthwhile to estimate WEBs for particular transport initiatives is a matter for judgement by proponents. The following guidance is relevant to making those judgements:

- WEBs are only likely to be significant, and so worth estimating, for sizeable transport initiatives located in or improving access to large urban areas
- Estimation will require much less effort where benefits have been estimated using a transport model
- The mix of industries in the area to which access is improved will be a consideration because agglomeration benefits are higher for business services industries (financial, insurance, legal)
- To have significant WEBs, the transport initiative should give rise to significant demand changes — generated and/or diverted.

WEBs estimates should be accompanied by a narrative describing how each type of WEB estimated arises. The narrative serves as a common-sense test for the reasonableness of the claim that an initiative will generate WEBs of the size estimated. Some suggestions are offered for developing narratives.

The guidelines for assessing WEBs should be used in conjunction with ATAP Part T2 Cost–Benefit Analysis.

1. Introduction

ATAP Part T3 sets out guidance for estimating Wider Economic Benefits (WEBs) of transport initiatives arising from agglomeration, taxes on labour markets and imperfectly competitive product markets. It features a detailed methodology with parameter values for each of the three types of WEB.

1.1 Links to other parts of the Guidelines

These guidelines should be used in conjunction with ATAP Part T2 Cost–benefit analysis (CBA), which gives a step-by-step approach to undertaking CBAs of transport initiatives.

Other closely related parts of the ATAP Guidelines are

- F3 Options Generation and Assessment
- T1 Travel demand modelling
- T4 Computable general equilibrium models in transport appraisal
- O8 Land-use benefits of transport initiatives
- Mode specific guidance: M1 Public transport, M2 Road transport, M4 Active travel, O9 Light rail transit /bus rapid transit.

1.2 What are WEBs?

Conventional CBA is, in effect, based on the assumption of perfect markets. The 'perfect' markets assumption implies that prices equal marginal social costs. Industries would have to be perfectly competitive and there would be no taxes, subsidies or externalities. Conventional transport CBAs allow for some market 'imperfections' such as the fuel excise, externalities of unpriced congestion, crash costs and environmental impacts. WEBs are intended to adjust for the understatement of benefits caused by other market imperfections that cause prices of goods and services to differ from marginal social costs. Sources of these imperfections include economies of scale and scope, external economies, taxation and imperfect competition. WEBs are additive to benefits estimated in conventional CBAs.

WEBs are sometimes referred to as 'Wider Economic Impacts' (WEIs). The use of the WEIs terminology acknowledges that not all transport initiatives generate positive benefits. Policymakers in Australia tend to use the WEBs terminology so the ATAP Guidelines adopts WEBs terminology noting that, as with all benefit categories, WEBs can be both positive and negative. Use of the WEBs terminology avoids possible confusion with secondary economic impacts of initiatives that are not legitimate inclusions in CBAs.

1.3 Types of WEBs

ATAP Part T3 covers the four types of WEBs identified in the early UK literature, for example, UK DfT (2005). Some authors group land-use benefits (see ATAP Part O8) with WEBs (Douglas and O'Keeffe 2016; Venables 2016). Others discuss further market imperfections that can give rise to additional benefits from transport initiatives and so can be termed WEBs (Laird and Mackie 2014; Venables 2016) but these other WEBs have yet to become widely accepted with standard estimation methodologies developed.

1.3.1 WB1 Agglomeration impacts

Agglomeration refers to the level of concentration of economic activity in an area. Transport interventions can alter the level of agglomeration by affecting:

- Transport network performance (static clustering), and
- The location choices of firms (dynamic clustering).

Firms benefit from access to greater numbers of other firms, workers and customers. These benefits arise from:

- Sharing of inputs and outputs
- Better matching of workers to employers, and suppliers or customers to firms, and
- Workers learning from one another.

1.3.2 WB2 Labour market and tax impacts

Labour market impacts arise from individuals changing their level of participation in the labour force or changing jobs in response to impacts of transport initiatives on commuting costs and land use. There are two distinct types of impact:

- WB2a — Change in labour supply; and
- WB2b — Move to more or less productive jobs.

Conventional CBA captures the benefits to individuals, from higher earnings but not the associated increases in income and payroll tax revenue. Both the increases in earnings and tax represent productivity improvements. Increases in earnings are revealed as savings in travel time and costs and are fully captured in the traditional benefits via the consumers' surplus gain. The value of the additional output paid as tax is omitted and therefore qualifies as a WEB, which needs to be estimated and added in separately.

1.3.3 WB3 Output change in imperfectly competitive markets

Firms in imperfectly competitive markets produce a level of output for which price exceeds the marginal cost of production. Price reflects consumers' willingness to pay, or marginal benefit, for additional output. So in imperfectly competitive markets, increasing output results in a marginal benefit greater than the marginal cost — a net gain, or welfare benefit, that accrues to the firm as additional profit. Transport interventions produce such a benefit because, by reducing the cost of production for firms, they lead to an increase in output in imperfectly competitive markets.

1.3.4 WB4 Change in competition

Transport costs can act as a barrier to trade giving rise to local monopolies in isolated regions. A new transport link, or greatly improved existing link to the rest of the economy can introduce competition from outside causing the monopolist to reduce prices, cut costs and improve service quality.

1.4 When to consider estimating WEBs

The Guidelines does not lay down any prerequisites for estimating WEBs in terms of the type, size or location of the initiative. However, deriving WEBs estimates will only be worthwhile and justified where sizeable WEBs can be realistically expected. The existence of WEBs arising from an initiative should be plausible, hence, the requirement for a 'narrative' to justify their realism and the effort of estimation.

1.4.1 Size of WEBs

The size of WEBs will be strongly related to the size of the transport initiative (as measured by either capital costs or conventional benefits), so it is not worth the effort of estimating WEBs for small projects. ATAP Guidelines Part T2 defines a 'small project' as one having investment costs below $15 million, but the threshold project size at which it might be worthwhile estimating WEBs would be far above this level.

WB1 is driven by employment density and access to areas of dense employment. Transport initiatives outside of large urban areas are unlikely to generate much agglomeration WEBs except possibly where the initiative greatly improves access between a small place and large place leading to a significant impact on the effective density of the small place.

Whether benefits have been estimated using a transport model is relevant to a decision to estimate WB1 because the transport model will have estimated the changes in generalised trip costs necessary to calculate WB1 and WB2 greatly reducing the amount of effort required.

The productivity elasticity used to estimate WB1 is considerably higher for business services industries (financial, insurance, legal), so the mix of industries in the area to which access is improved will be a consideration.

To have significant WEBs in reality (as distinct from the calculation method), the transport initiative would be expected to give rise to significant demand changes — generated and/or diverted. Important components of WEBs can only occur if there are increased physical interactions between economic entities, which means increased trip numbers between origin–destination pairs. These components are the sharing and learning sources of productivity gains from agglomeration (WB1), greater workforce participation (one source of WB2a), move to more productive jobs (WB2b), and increased output from imperfectly competitive industries (WB3). There are other components — WB1 from better matching of workers to employers and WB2a from people working longer hours (the other source of WB2a) — that do not require additional trip numbers. However, in practice, the quantity and quality of economic interactions that give rise to WEBs are strongly correlated.

WB3 can occur for all transport initiatives that benefit business travel and freight but the Guidelines recommends WB3 only be estimated in cases where WB1 and WB2 are estimated. The reasons are that WB3 tends to be the smallest of the three WEB types and the estimates are highly approximate. The simple calculation method for WB3 makes no distinction between locations and industries. The research into price–cost mark-ups of Australian firms needed to derive robust parameter values does not exist.

1.4.2 Need for a convincing narrative

The narrative requirement is a common-sense test for the reasonableness of the claim that an initiative will generate WEBs of the size estimated. A short narrative should be developed before any quantitative work is undertaken to ensure it is worth proceeding.

In the CBA report, WEBs estimates should be accompanied by an overarching narrative with supporting underlying individual narratives for WB1, WB2 and WB3 that describe how each type of WEB arises for the initiative being appraised. The narrative should seek to present a qualitative case that the WEBs attributed to the initiative are credible.

The narrative should not be a conceptual discussion of WEBs. It must be specific to the initiative and its context, addressing, in broad terms the causal channels through which the initiative is expected to have each impact. It should cover:

- The initiative's role in development of the city
- How the WEB impacts relate to the stated economic objectives of the initiative (which would be of interest to decision-makers in any case)
- The beneficiaries of the WEBs and any 'losers' by way of locations, industries or occupations.

Further suggestions for the narrative for each type of WEB are provided in subsequent chapters below.

1.5 Other considerations for assessing WEBs

1.5.1 Land-use impacts

Historically, most economic appraisals of transport interventions in Australia in major cities have assumed fixed land use. The spatial concentration of jobs and population is assumed to be the same in the Base and Project Cases. This simplifying assumption is appropriate for small and medium-size initiatives.

The fixed land-use assumption is, however, not appropriate for major, 'city-shaping' transport initiatives. By definition, city-shaping initiatives have a significant impact on land use because the changes to travel costs are large enough to affect the location decisions of households and businesses. WB1 from dynamic clustering and WB2b, tax impacts from moves to more or less productive jobs, arise from land-use changes.

As discussed in ATAP Part O8 Land use benefits of transport initiatives, Chapter 3, the land-use impacts of city-shaping initiatives can be assessed in a range of ways. Land-use change forecasting is challenging.

Note that if land-use transport interaction (LUTI) modelling is undertaken for an initiative, the results will inform not only WEBs estimation, but the conventional CBA as well, because land-use changes lead to changes in total demand and the distribution of demand in a transport network.

1.5.2 Spatial resolution of analysis

By their nature, WEBs tend to be greatest in small areas with high concentrations of households and firms (especially in the inner cores of major cities). As a result, a high spatial resolution of analysis is necessary for reasonable assessment of WEBs. In Australia, strategic transport models are often used for conventional CBA. These models typically divide a major city into travel zones (TZ) of between 2,000 to 4,000 zones. WEBs should be analysed at a similarly high spatial resolution in order to obtain a reasonable estimate.

1.5.3 Ramp-up periods

Benefits in conventional CBAs of transport initiatives during the first several years of operation ramp-up to forecast equilibrium levels in line with demand. ATAP Part M1 Public transport, Section 2.3, provides a detailed discussion of patronage ramp-up suggesting that the ramp-up period for new public transport initiatives can be up to five years. The same ramp-up profile as used for demand in the conventional CBA can be applied to non-land-use-change WEBs (static WB1, WB2a and WB3), factoring annual WEBs estimates down by the same proportions as for demand.

Since land-use changes occur more slowly over time, it is to be expected that estimates of dynamic WB1 and WB2b, move to more productive jobs, will have longer ramp-up periods. ATAP Part O8 Land-use benefits of transport initiatives (Chapter 5) suggests 5 to 10 years for smaller projects and longer for larger projects.

1.5.4 Presentation of WEBs

There is a higher level of uncertainty surrounding WEBs estimates compared with usual benefits estimated in conventional transport CBAs and size of WEBs can be large.[1] There is sufficient uncertainty surrounding WEBs estimates to recommend that they be presented in a way that clearly highlights the effect of adding WEBs.

Under the ATAP Guidelines, the core CBA results table should be presented in two parts — without and with land-use benefits and WEBs. Where WEBs have been estimated, they should be reported as follows:

In the core appraisal results table as shown in Table 1:

- First present the CBA results (NPV, BCR etc.) *without* land-use benefits and WEBs
- Then show the land-use benefits by category (higher value land use, second-round, other)
- Then show the CBA results (NPV, BCR, etc.) with land-use benefits included
- Then show the WEBs by category (WB1, WB2 and WB3)
- Then show the CBA results (NPV, BCR, etc.) *with* land-use benefits and WEBs included.

If WEBs from moves to more or less productive jobs associated with land use change (WB2b) are calculated, present them separately as a sensitivity test later in the report. This type of WEBs has an even higher level of uncertainty attached to it because of the estimation difficulties discussed below in Section 3.3.1

The amounts of each of the three types of WEBs are shown in Table 1 split into components, consistent with way benefits in the conventional CBA are split into components. If the amounts of each of WB1, WB2 and WB3 are not shown in the core appraisal results table, they should be provided somewhere in the report to ensure transparency and help reviewers assess the realism of the estimates.

The above-stated position on reporting WEBs, that is, outside of the core CBA results provides a consistent national approach for presenting benefits, however we note that individual state and territory jurisdictions may use alternative results as the decision criteria for projects fully funded within their jurisdiction. It is recommended that reasons for using alternative results be clearly explained in application reports for consideration by state and / or territory treasury departments andcentralised Infrastructure Agencies.

1.5.5 Calculation methods

These guidelines provide detailed methods and parameters for calculation of WEBs estimates. The parameters are intended to suit the particular methods shown. If the parameters are used with other methods, the resultant WEBs estimates cannot be considered consistent with the ATAP Guidelines.

[1] Several factors contribute to the uncertainty around WEBs estimates. The inability to obtain reliable, up-to-date productivity elasticities and decay curve parameters for Australian cities is discussed in Appendix B below. Data with which to estimate WEBs parameters in general, and to apply them in detail to specific initiatives, is limited. Ex-post evaluations are difficult to undertake because WEBs are aggregates of very small impacts spread over large numbers of economic entities and it is difficult to separate the WEBs impacts of a past transport initiative from other factors. The trend towards greater working from home and reliance on electronic communication instead of physical travel, noted in Section 1.6 below, adds to the uncertainty around WEBs estimates.

Table 1 Example of core appraisal results table

Costs and benefits	Present value ($ millions 202X)
Benefit 1	
Benefit 2	
Benefit 3	
[Insert rows as required, e.g. to separate existing and new user benefits]	
Total transport benefits	
Capital investment costs	
Operating costs	
Maintenance costs	
Total costs	
NPV	
BCR1	
BCR2	
FYRR	
Higher value land-use benefits	
Second-round transport benefits from land-use change	
Other land-use benefits (e.g. sustainability, public health)	
Total land-use benefits	
NPV with land-use benefits	
BCR1 with land-use benefits	
BCR2 with land-use benefits	
FYRR with land-use benefits	
Agglomeration WEBs	
Labour market tax WEBs	
Imperfect competition WEBs	
Total WEBs	
NPV with land-use benefits and WEBs	
BCR1 with land-use benefits and WEBs	
BCR2 with land-use benefits and WEBs	
FYRR with land-use benefits and WEBs	

Notes: WEBs arising from moves to more or less productive jobs associated with land-use changes, WB2b, if calculated, should be presented as a separate sensitivity test.

The first year rate of return (FYRR) with land-use change benefits and WEBs need not be presented if, due to ramp-up, the value is little different from the FYRR without land-use change benefits and WEBs.

Analysts may prefer alternative methods and parameter values from those presented in this guideline, whether changing small details or quite different approaches such as using a computable general equilibrium model (see ATAP Part T4 Computable general equilibrium models in transport appraisal). This introduces two issues for governments. First, it is difficult for government agencies to compare WEBs estimates for different project proposals obtained in different ways, and to have confidence in the estimates where the derivation is not transparent. Second, there are advantages in having a national standard methodology and set of parameters. Therefore, the Guidelines recommends that, where analysts make departures from the methods and parameter values set out in this guideline, they also make a WEBs calculation in strict conformance to this guideline for presentation in the core results table and present the other as a sensitivity test. When presenting alternative WEBs estimates, parameter values employed should be clearly presented, including parameters assumed within computable general equilibrium models that significantly affect WEB estimates such as productivity elasticities and decay curve parameters.

Under no circumstances should WEBs be estimated by taking a simple percentage of conventional benefits. Such an approach is considered unreliable and potentially highly misleading.

The calculation methods are symmetrical in that negative benefits will result where generalised costs increase or employment density falls. It is to be expected that a total WEB estimate will be a sum of positive and negative amounts, not all positive.

1.6 Working from home

The methods and parameters in this guideline all predate the COVID-19 pandemic and the trend it started towards greater working from home and reliance on electronic communication instead physical travel. If the trend continues, location in physical space will become less important, reducing the agglomeration and labour market impacts of transport initiatives. It will take some years before it becomes apparent just what the ‘new normal’ looks like and data become available to estimate new WEBs parameters. The methods and parameters recommended here for use in the interim are intentionally on the conservative side.

2. Wider Economic Benefit 1 — Agglomeration impacts

2.1 What are agglomeration impacts?

WB1 Agglomeration impacts refers to benefits that flow to firms and workers from locating in close proximity to one another (or agglomerating). Agglomeration economies can be used to explain the very reason for the existence of cities. The productivity and other benefits of clustering together outweigh the disadvantages of congestion and pollution. Agglomeration is driven by firms (and public sector entities) choosing to cluster together out of their own self-interest. Sources of agglomeration economies can be categorised into three groups:

1) **Sharing** — specialisation, economies of scale and scope, sharing indivisible goods and facilities, sharing risks
2) **Matching** — workers better matched to job requirements, suppliers and customers better matched to each other in product markets
3) **Learning** — knowledge generation, diffusion and accumulation (Duranton and Puga 2004).

The literature draws a distinction between urbanisation and localisation agglomeration economies.

- **Urbanisation economies** are external to the firm and industry. They arise from a firm's proximity to the overall economic mass of an urban area where there are large diverse markets for inputs and outputs, and good infrastructure and public service provision.
- **Localisation economies** are external to the firm but internal to the industry. They arise from proximity of a firm to other firms in the same industry caused by better matching with input suppliers and customers and knowledge sharing. (UK DfT 2020)

Urbanisation and localisation economies coexist together and it is not possible to separate them out for the purpose of estimating WB1. They might however be discussed separately in a narrative.

A further distinction is drawn between static and dynamic clustering as the source of agglomeration benefits:

- **Static agglomeration** benefits from a transport initiative arise from individuals and firms in the cluster having easier access to one another, facilitating economic interactions. The locations of firms and workers (land use) are held constant.
- **Dynamic agglomeration** benefits arise when the transport initiative causes changes in the location of economic activity (land-use) altering zonal employment densities.

Following UK DfT (2020, pp. 7-8), WB1 for dynamic agglomeration is defined as incorporating static agglomeration. It combines the effects of

- Changes to generalised costs with land use held constant (static WB1)
- Changes in the location of employment (land use)
- Second round changes to generalised costs caused by demand changes following on from land use changes.

2.2 Effective density

For the purpose of estimating WB1, access to economic opportunities is measured by 'effective density' (ED). The area over which agglomeration occurs is divided into zones. Each zone has an ED defined as the sum of economic mass in all zones in the area, with the mass for each zone weighted by a factor related to transport impedance between it and the zone for which ED is being measured. Static WB1 relates to changes in impedance between zones, and dynamic WB1 to changes in employment in zones. Economic mass can be measured by population, gross value added or employment. Transport impedance can be measured by distance, time or generalised cost of travel. Following widespread practice, including UK and New Zealand guidelines, the ATAP Guidelines recommends employment as the measure of economic mass and generalised cost for impedance.

As with the gravity model, where trip attraction between zones declines with transport impedance, the productivity enhancing impact of economic mass declines with impedance. Employment in each zone is multiplied by a decay weight or factor obtained from a function that declines with generalised cost. Standard practice is to use an inverse function with the decay factor given by $1/g^{\alpha}$ where g is impedance and α is a parameter that controls the rate of distance decay with respect of impedance (minus α is the elasticity of the decay factor with respect to impedance). It means that jobs within a shorter distance or travel time are assigned a higher weight than jobs that require a longer distance or travel time to access.

2.3 Recommended parameter values

In addition to the decay curve parameter, WB1 estimation requires a productivity or agglomeration elasticity parameter. It measures the percentage increase in productivity in a zone from a one percent increase in ED for the zone. The methodology for estimating WB1 involves computing the proportional increase in ED for each zone, then applying the productivity elasticity to obtain the proportional increase in productivity, and multiplying this by the Base Case value of production in the zone.

Table 2 sets out the recommended ATAP Guidelines productivity elasticities and decay curve parameters by industry, divided into three groups. The values are a simplified version of those in the UK guidance (UK DfT 2020). Appendix B explains the reasons for adopting UK rather than Australian elasticity estimates.

Group 1, which includes primary production and manufacturing, and group 2, comprised of construction and consumers services industries, have low productivity elasticities. The empirical evidence overwhelmingly shows that the business services industries in group 3 benefit most from agglomeration and so have a much higher productivity elasticity. Agglomeration benefits decay with transport impedance at a faster rate for the services and construction industries in groups 2 and 3 than for the group 1 industries.

2.4 Calculating WB1 Agglomeration

The steps to calculating WB1 are to estimate:

1. Average generalised costs between zones under the Base and Project Cases using a strategic transport model
2. Effective densities for the Base and Project Cases
3. The change in productivity between the Base and Project Cases
4. The change in gross value added between the Base and Project Cases
5. WB1: agglomeration impacts
6. (Optional): static and dynamic effects

The following notation is used:

- The subscripts *i* and *j* refer to origin and destination zone respectively and *ij* to trip numbers or travel costs from zone *i* to zone *j*. Effective density formulas are given for origin zones, *i*.

Table 2 Recommended productivity elasticities and decay curve parameters

ANZSIC	Industry group	Group	Productivity elasticity	Decay curve parameter
A B C D	Agriculture, forestry and fishing Mining Manufacturing Electricity, gas, water and waste services	1. low productivity elasticity, low distance decay rate	0.021	1.1
E F G H I O P Q R S	Construction Wholesale trade Retail trade Accommodation and food services Transport, postal and warehousing Public administration and safety Education and training Health care and social assistance Arts and recreation services Other services	2. low productivity elasticity, high distance decay rate	0.024	1.8
J K L M N	Information media and telecommunications Finance and insurance services Rental, hiring and real estate services Professional, scientific and technical services Administrative and support services	3. high productivity elasticity, high distance decay rate	0.083	1.8

- superscripts
  - *m* = transport mode — car, bus, train, light rail, ferry, and if the data is available, walking and cycling.
  - *p* = trip purpose — business, commuting, and, if desired for a sensitivity test, freight. Non-work or leisure trips are excluded.
  - *t* = time period — AM peak, inter-peak, PM peak, evening
  - *B* = Base Case
  - *P* = Project Case. There are likely to be multiple Project Cases, one for each option.
  - *f* = fixed land use
  - *v* = variable land use
- *ED* = effective density
- *T* = number of trips
- *g* = generalised cost of travel between zones
- *AGC* = average generalised cost
- *M* = employment
- *GVA* = Gross Value Added. The contribution of labour and capital to the production process. It equals the value of output minus the value of intermediate goods and equals GDP net of taxes and subsidies.
- *GVApw* = Gross Value Added per worker
- α = decay curve parameter
- ρ = productivity elasticity.

The inputs required for WB1 estimation are listed in Table 3.

Table 3 Inputs for estimation of WB1: Agglomeration impacts

Input	Variable name	Cases	Spatial resolution	Modes	Time period	Source
Generalised cost	$g_{ij}^{m,p,t}$	Base and project	By origin–destination travel zone pair	Car, Public transport (bus, train, light rail, ferry), Active travel (cycle, walk)	AM peak, inter-peak, PM peak, evening	Strategic transport model
Trip numbers	$T_{ij}^{m,p,t}$	Base and project	By origin–destination travel zone pair	Car, public transport (bus, train, light rail, ferry), Active travel (cycle, walk)	AM peak, inter-peak, PM peak, evening	Strategic transport model
Small area gross value added per worker by industry	$GVApw_i$	Base only	By travel zone	N/A	N/A	Small Area Gross Value Added estimates as provided on the ATAP website
Employment	M_j^B, M_j^P	Static WB1: base only Dynamic WB1: Base and Project	By travel zone	N/A	N/A	Land-use projections as used in strategic transport model

Notes: All inputs are required for the forecast year.

Non-work or leisure generalised costs and trip numbers are excluded. Inclusion of active travel generalised costs and trip numbers is optional depending on data availability.

Small area gross outputs and employment for 2014-15 by destination zone are provided in the Excel workbook 'Small area gross outputs and employment.xlsx' in the Technical Support Library. For a description of the derivation of the estimates, see Appendix C. In situations where the travel zones in transport models are larger than destination zones, it will be necessary to aggregate up. Taking the employment weighted average GVA for the component destination zones within a travel zone is an option. Section C.5.1 of Appendix C provides a method for transforming data between zone systems.

2.4.1 Calculation steps

Step 1: Estimate average generalised costs in the Base and Project Cases

The average generalised cost between an origin–destination pair is an average across transport modes, trip purposes and time of day using trip numbers as weights. Most strategic transport models across Australia use four time periods — AM peak, inter-peak, PM peak and off-peak. All four time periods should be included in the average generalised cost calculation. If the transport model is unable to provide generalised costs and trip numbers for all four periods, approximations for the missing periods should be made by taking proportions of the value of one of the available periods. If the off-peak period or both the off-peak and inter-peak periods are omitted, the WB1 estimate will be biased upward because generalised costs reductions from transport initiatives will be smaller in these less-congested periods. The mode coverage can extend to active travel if data permits.

Trip purposes should include business and commuter travel but not non-work or leisure travel.

Freight generalised costs and trips should be excluded from the core averaged generalised cost calculation. If the transport model forecasts changes to freight trip numbers as a result of the initiative, then WB1 estimates with freight trips included can be presented as a sensitivity test with a narrative about how transport access changes for freight contribute to agglomeration.[2] The justification for freight contributing to agglomeration economies relates to input or output sharing — economies of scale and scope in production or consumption of physical commodities.

Generalised costs for different modes, trip purposes and time periods need to be combined to arrive at a single average generalised cost between each origin–destination pair. A weighted average is taken using the sum of Base Case and Project Case trip numbers as weights. In effect, this is averaging the trips between the Base and Project Cases. The weights are identical for the Base and Project Cases. The formulas for Base Case and project average generalised costs are given in equations 1a and 1b, with the *B* and *P* superscripts bolded where they differ between the two formulas. Where multiple Project Case options are assessed, it will be necessary to recalculate Base Case average generalised costs for each option because equation 1a features Project Case trip numbers. For each project option, there will be two average generalised costs (Base Case and Project Case) for each origin–destination pair.[3]

$$AGC_{ij}^{\boldsymbol{B}} = \frac{\sum_{m,p,t}\left(T_{ij}^{B,m,p,t} + T_{ij}^{P,m,p,t}\right) g_{ij}^{\boldsymbol{B},m,p,t}}{\sum_{m,p,t} T_{ij}^{B,m,p,t} + \sum_{m,p,t} T_{ij}^{P,m,p,t}} \tag{1a}$$

$$AGC_{ij}^{\boldsymbol{P}} = \frac{\sum_{m,p,t}\left(T_{ij}^{B,m,p,t} + T_{ij}^{P,m,p,t}\right) g_{ij}^{\boldsymbol{P},m,p,t}}{\sum_{m,p,t} T_{ij}^{B,m,p,t} + \sum_{m,p,t} T_{ij}^{P,m,p,t}} \tag{1b}$$

2 The recommendations here for the non-work and freight trip purposes follow UK DfT (2020, pp. 13 and 15).

3 The approach to combining generalised costs in the ATAP Guidelines using identical weights in the Base and Project Cases follows the New Zealand guidelines (NZTA 2020, p. 77). If Base Case trip weights were used for the Base Case and Project Case trip weights for the Project Case, then, when a mode with a higher generalised cost experiences a cost reduction together with a consequent increase in mode share, the trip-weighted average generalised cost across all modes could be higher in the Project Case compared with Base Case. The cost reduction would then increase transport impedance. One solution is to use a logsum formula (related to the logit model) to combine generalised costs for different modes.

Suggested solutions for difficulties that may arise are as follows:

- If an ‘alternative specific constant’ (see ATAP Part 2, Appendix C) leads to a negative generalised cost, set it to zero.
- If there are no trips at all between an origin–destination pair, default to the car cost as car would be the most likely choice of mode.
- If the transport initiative introduces a new mode, assuming it has zero cost in the Base Case will distort the average generalised cost. The suggested approach is to condense the number of modes so there is a consistent set of modes between the Base and Project Cases. For example, if light rail is introduced in addition to car and bus, make the modes car and public transport.

Step 2: Estimate effective densities for the Base and Project Cases

The study area zone system should be selected to avoid any significant ‘boundary effects’ that would materially impact on the WEBs for a given initiative. In other words, the WB1 estimate should not be very sensitive to a change in the boundary between the zones included in ED calculations and the zones excluded. An initiative located within a metropolitan area but close to the boundary may have to be considered not to have any significant WEBs.

Effective densities for the Base Case and Project Case should be calculated using equation 2 for each zone i for each of the two decay curve parameters in Table 1. For each project option, each zone will have four effective densities — Base Case and Project Case for the two decay curve parameters, α = 1.1 for industry group 1 with low distance decay and α = 1.8 for industry groups 2 and 3 with high distance decay. Base case EDs will differ between options because Base Case average generalised costs differ.

$$ED_i = \sum_j \frac{M_j}{\left(AGC_{ij}\right)^{\alpha}} \tag{2}$$

Note that the summation over destination zones includes the case where $i = j$, that is, travel within the origin zone. If the transport model sets intra-zonal travel costs to zero, the average generalised cost within each origin zone can be taken as a proportion of the lowest average generalised cost between the origin zone and neighbouring zones. The ATAP Guidelines recommends two-thirds.[4]

With an inverse decay curve as recommended here, the decay factor $1/\left(AGC_{ij}\right)^{\alpha}$, can become quite large for small values of *AGC* compared with the average for a city and very sensitive to changes in *AGC*. This can lead to implausibly high benefit estimates from changes in impedances in and around the CBDs of major cities where there are small zones and high employment densities. An example, is a change from three to two minutes of travel time between two zones. This could occur for a short distance project that reduces travel impedance in very dense employment areas. It can also arise from model ‘noise’ in origin–destination pair travel costs for nearby zones due to convergence difficulties for strategic transport models where there are high levels of congestion. In situations where this is a possibility, sensitivity tests might be undertaken with *AGC* in the ED calculation restricted to some minimum amount.

---

[4] There are differences of opinion about the proportion to use with 50% and 70% having been suggested. The two-thirds proportion recommended here is based on zones forming perfect squares of length and width *d*. The shortest distance from the centroid of one zone to the centroid of a neighbour would *d*. Assuming streets form a grid pattern, the expected Manhattan distance between two randomly selected points within the same square would be two-thirds of *d*. This is because the average distance between any two randomly selected points on a line segment of length one is one-third. For Manhattan distances within a square, there is one-third in north-south direction plus one-third in the east-west direction. The Euclidean distance between any two randomly selected points in a unit square is $\left[2 + \sqrt{2} + 5\,Ln(1 + \sqrt{2})\right]/15 \approx 0.5214$.

Step 3: Estimate the relative change in productivity by industry group between the Base and Project Cases

The relative change in ED between the Base and Project Cases can then be used to estimate the relative change in productivity from the initiative. Equation 3 gives the increase in productivity as a proportion of Base Case productivity. For each zone there will be three productivity change estimates — industry group 1 (α = 1.1 ρ = 0.021), industry group 2 (α = 1.8 ρ = 0.024) and industry group 3 (α = 1.8, ρ = 0.083).

$$\frac{\Delta Productivity_i}{Productivity_i} = \left(\frac{ED_i^P}{ED_i^B}\right)^{\rho} - 1 \qquad (3)$$

Step 4: Estimate the change in gross value added between the Base and Project Cases

The relative productivity change estimates are then turned into a dollar figures by industry group for each origin zone *i* using an estimate of industry Gross Value Added (GVA) for each small area or travel zone (TZ). The change in GVA for each origin zone and industry is calculated, for static WB1, by multiplying the Base Case industry GVA per worker with the Base Case employment and anticipated change in productivity, as shown in equation 4. There will be one GVA change for each zone for each industry.

$$\Delta GVA_i = \frac{\Delta Productivity_i}{Productivity_i} \cdot GVApw_i^B \cdot M_i^B \qquad (4)$$

Detailed estimates of GVA per worker by industry by destination zone (DZN) are available in the accompanying Excel workbook on the ATAP website[5]. Appendix C describes the methodology used to derive the estimates. The estimates were produced using data from 2014-15 at current prices. They need to be inflated to the price year for the CBA using the GDP deflator. When applying these values to estimate productivity impacts in future years, it may be desirable to adjust for changes in labour productivity over time over the appraisal period. GVA per worker can be adjusted to the current year using the labour productivity index from the ABS publication Estimates of Industry Multifactor Productivity (ABS Cat. No. 5260.0.55.002, Table 6). Productivity can be assumed to remain constant in the future or to grow. If the productivity growth scenario is assumed, an annual growth rate of 1.5% can be applied to subsequent years based on Commonwealth Government projections of long-term labour productivity growth published in the 2015 Intergenerational Report (Commonwealth of Australia 2015). Changes in hours worked per employee should be assumed to be negligible. When adopting a productivity growth assumption for estimating agglomeration economies, it is highly desirable that the conventional CBA for the same project also incorporates future growth in real wages due to productivity improvements for assessing value of travel time savings benefits for instance. In other words, to ensure the overall economic appraisal is internally consistent, the conventional CBA and the WEBs estimation should use consistent assumptions on productivity growth.

Step 5: Estimate WB1: Agglomeration impacts

An estimate for WB1 can be obtained by summing the changes in gross value added for all industries and all origins as shown in equation 5.

$$WB1 = \sum_{ind} \sum_{i} \Delta\, GVA_{ind,i} \qquad (5)$$

---

5 See the spreadsheet ‘Small area gross outputs and employment.xlsx’ in the Technical Support Library and explanation in Appendix C.

Step 6 (Optional): Distinguish between static and dynamic effects

This step is only relevant for appraisals that consider land-use change impacts, that is, they allow the spatial distribution of employment to vary between the Base and Project Cases. Section 2.1 introduced the distinction between static and dynamic WB1. Static WB1 arises from changes in generalised costs between zones holding employment in zones constant. Dynamic agglomeration benefits arise when the transport initiative causes land-use changes altering zonal employment densities.

The estimate of static WB1 can be obtained by following steps 1 to 5 for Base Case and Project Case generalised costs, using Base Case employment estimates (M_j^B) in equation 2 to calculate Project Case effective densities — $ED_i^{\boldsymbol{B}} = \sum_j M_j^{\boldsymbol{B}} / \left(ACG_{ij}^{\boldsymbol{B}}\right)^{\alpha}$ and $ED_i^{\boldsymbol{P}} = \sum_j M_j^{\boldsymbol{B}} / \left(ACG_{ij}^{\boldsymbol{Pf}}\right)^{\alpha}$, where $ACG_{ij}^{\boldsymbol{Pf}}$ is Project Case average generalised costs with fixed land use, that is, without the effects of demand changes arising from land-use changes (referred to as 'second round effects' in ATAP Part O8 Land use benefits of transport initiatives).

To estimate dynamic WB1, start at step 2 by re-calculating Project Case effective densities with using generalised costs with variable land use (i.e. with second round effects), $ACG_{ij}^{\boldsymbol{Pv}}$, and Project Case employment estimates (M_j^P) in equation 2 — $ED_i^{\boldsymbol{P}} = \sum_j M_j^{\boldsymbol{P}} / \left(ACG_{ij}^{\boldsymbol{Pv}}\right)^{\alpha}$. Base case effective densities are the same as for the static WB1 calculation.

In step 4, use the average of Base Case and Project Case employment as shown in equation 6.[6]

$$\Delta GVA_i = \frac{\Delta Productivity_i}{Productivity_i} \cdot GVApw_i^B \cdot \frac{(M_i^B + M_i^P)}{2} \qquad (6)$$

The result will be the total WB1 arising from both access and land-use changes, which can be referred to dynamic WB1. Note that dynamic and static WB1 should not added together. Dynamic includes static as illustrated in equation 7.[7]

$$WB1\ due\ to\ land\ use\ change = Dynamic\ WB1 - Static\ WB1 \qquad (7)$$

---

[6] The reason for using the average of Base Case and Project Case employment levels rather than one of the Base Case or the Project Case employment levels is to ensure that the WB1 change from an increase ED in a zone will be exactly reversed if the ED change is reversed. Say the WB1 for zone *i* from an ED change is calculated using equation 6. After the effective density change, the GVA per worker in the zone will be $GVApw_i^P = \left(\frac{ED_i^P}{ED_i^B}\right)^{\rho} \cdot GVApw_i^B$. Say the change is reversed with *ED*$_i$ returning to the Base Case level. WB1 for the reverse case will be $WB1_i^R = \left[\left(\frac{ED_i^B}{ED_i^P}\right)^{\rho} - 1\right] \cdot \left[\left(\frac{ED_i^P}{ED_i^B}\right)^{\rho} \cdot GVApw_i^B\right] \cdot \frac{(M_i^B + M_i^P)}{2} = -WB1_i$. This symmetry disappears when Project Case employment is used for the initial calculation and Base Case employment for the reverse case, or vice versa. There will be the illogical situation of having a net gain or loss in WB1 from making a change and then reversing the change.

[7] UK DfT (2020, p. 8) recommends an alternative way to separate the effects.

- Estimate WB1 with variable land use generalised costs and Base Case employment levels in the Project Case — $ED_i^{\boldsymbol{B}} = \sum_j M_j^{\boldsymbol{B}} / \left(ACG_{ij}^{\boldsymbol{B}}\right)^{\alpha}$ and $ED_i^{\boldsymbol{P}} = \sum_j M_j^{\boldsymbol{B}} / \left(ACG_{ij}^{\boldsymbol{Pv}}\right)^{\alpha}$ — to obtain WB1 attributable to access changes alone, and then
- Estimate WB1 with fixed land use generalised costs and Project Case employment levels in the Project Case — $ED_i^{\boldsymbol{B}} = \sum_j M_j^{\boldsymbol{B}} / \left(ACG_{ij}^{\boldsymbol{B}}\right)^{\alpha}$ and $ED_i^{\boldsymbol{P}} = \sum_j M_j^{\boldsymbol{P}} / \left(ACG_{ij}^{\boldsymbol{B}}\right)^{\alpha}$ — to obtain WB1 attributable to land use changes alone.

The two estimates will not necessarily sum to give the total dynamic WB1 obtained with the Project Case as $ED_i^{\boldsymbol{P}} = \sum_j M_j^{\boldsymbol{P}} / \left(ACG_{ij}^{\boldsymbol{Pv}}\right)^{\alpha}$. UK DfT (2020) recommends applying the proportions between the two estimates to the total dynamic WB1 estimate to split the dynamic WB1 estimate into the two parts. The difference between the UK DfT method and equation 7 is that the UK method treats the second round effects on generalised costs as part of static WB1 and the equation 7 method treats it as part of dynamic WB1. The ATAP Guidelines recommends using the equation 7 approach. It should be stated which method has been used.

2.5 Suggestions for developing the narrative for WB1

Discuss the transmission mechanisms through which the transport initiatives will have productivity impacts for static and dynamic clustering. Is there any evidence that locations near the transport initiative are likely to experience agglomeration economies?

The narrative could identify the parts of the city with the highest percentage increases in business-to-business effective densities, and those with negative changes caused by the initiative. This could be facilitated by producing a map showing percentage changes in effective densities in zones using colours for a single year in which WEBs were calculated. It could be pointed out where these coincide with locations of the high productivity elasticity business services group of industries.

As a check for realism, provide the maximum estimated percentage change in productivity and change in ED across all zones and industries for the static WB1 estimation and, if applicable, also for the dynamic WB1estimation.

3. Wider Economic Benefit 2 — Labour market and tax impacts

3.1 What are labour market and tax impacts?

Labour market and associated tax impacts comprise two distinct sources of benefit:

- WB2a: Change in labour supply — changes in the cost of transport cause a change in the perceived returns from working, encouraging people to supply more labour
- WB2b: Move to more (or less) productive jobs — greater transport accessibility brings more jobs within the travel budget of workers encouraging workers to switch jobs to where they can be more productive and so earn more.

The WEB arises from the market imperfection of income and payroll taxes creating a wedge between the cost of labour to employers and the take-home wage of workers. Conventional CBA fully captures the benefit of additional earnings accruing to workers from any changes in labour supply or take-home wages via the consumers' surplus benefits from generated and diverted trips. However, for each dollar of additional take-home pay, an amount of tax accrues to the government. In economic theory, employers engage labour up to the point where the cost to the employer equals the value of marginal product of labour. The cost of the employer is the worker's take-home wage plus income and payroll taxes. The value of marginal product of labour therefore includes the taxes paid. WB2 represents the value of this additional production, which is transferred to government.[8] The estimation methodology for WB2 therefore aims to estimate the income and payroll tax impacts of changes in the labour market.[9]

3.2 Calculating WB2a: change in labour supply

3.2.1 WB2a: Change in labour supply

In deciding whether to work and how many hours to work, a worker weighs, among other factors, travel costs associated with the job against the take-home or after-tax wage received from the job. Transport interventions that impact the generalised cost of commuting can affect the incentives for individuals to work. Improved access to employment locations may contribute to workers working longer hours, or encourage the under-engaged and disengaged workforce into active employment (UK DFT 2005).

[8] Say a transport initiative reduces the generalised cost of commuting from $8 per trip to $5 per trip. People who would earn $8.01 and above by making an additional trip will make the trip in the Base Case and still make the trip in the Project Case, so there is no additional work done and output produced. The benefit to this 'existing travel' is $3 per trip, the transport cost saving. People who earn anywhere between $8.00 and $5.00 from an additional trip will travel in the Project Case because they make a net gain between $3.00 and zero after deducting the cost of the trip. For this induced travel, the benefit is valued at $1.50, applying the rule-of-a-half. In economic theory, assuming perfect competition, the cost of labour to employers (the pre-tax wage) equals the value of marginal product of labour. So the consumers' surplus gain for induced travel captures the part of the benefit of the additional output produced that is returned to the worker as after-tax wages, net of the additional travel cost incurred by the worker. There remains the part of the value of the additional output paid to the government as tax, which is WB2.

[9] There is some confusion in overseas guidance as to the market distortions that give rise to WB2. The primary distortion in the Australian context is income and payroll tax on labour. New Zealand and UK guidelines include business (or corporation tax) and Goods and Services Tax (GST) in New Zealand and reduction in employment benefits in UK. These taxes are all distortionary and will give rise to surpluses additional to transport user benefits. However, the size of the distortion is not equal to the change in tax revenue and will not be proportional to changes in the labour market. GST is a market distortion related to changes in the output of final goods. Unemployment benefits create a distortion related to changing the level of unemployment which is not the same as increasing labour supply. Business taxes affect the level of capital in the economy.

WB2a for a transport intervention in a given year is estimated by undertaking the following six steps. Estimate the:

1. average generalised cost of a one-way commuting trip for each origin zone in the Base and Project Cases
2. perceived wages for a marginal worker net of taxes and transport costs
3. change in perceived net return from working between the Base and Project Cases
4. change in participation rate between the Base and Project Cases
5. change in total gross wages between the Base and Project Cases
6. change in tax revenue between the Base and Project Cases.

The following notation is used in addition that in the previous chapter. The estimation methodologies for the parameter values shown are in Appendix D.

- *Tc* = number of commuter trips
- *gc* = generalised cost of commuting
- *AGCC* = average generalised cost of commuting. This differs from *AGC* used for WB1, which is a weighted average over commuting and business trips and possibly also freight for a sensitivity test.
- *PNRW* = perceived weekly net return from working for a marginal worker
- *AGW* = Average gross weekly wage per worker
- *GW* = total gross annual wages earned by workers
- η_h = a reduction factor for the reduced working hours of a marginal worker relative to an average worker set at 0.7
- η_w = a reduction factor for the reduced hourly wage of a marginal worker relative to an average worker set at 0.8
- τ_w = tax wedge for a marginal worker set at 0.093
- *LFP* = labour force participation rate
- ε = the semi-elasticity of labour force participation with respect to the perceived net return from working set at 0.18
- *WAP* = working age population
- τ_p = average rate of payroll tax set at 0.027

Table 4 lists the inputs required to estimate WB2a.

Table 4 Inputs for estimation of WB2a: Change in labour supply

Input	Variable name	Cases	Spatial resolution	Modes	Time period	Source
Perceived generalised cost of commuting ($)	gc_{ij}^{m}	Base and project	By origin–destination travel zone pair	Car, Public transport (bus, train, light rail, ferry), Active travel (cycle, walk)	Typical weekday AM peak (e.g. 7am – 9am)	Strategic transport model
Commuting trip numbers	Tc_{ij}^{m}	Base and project	By origin–destination travel zone pair	Car, Public transport (bus, train, light rail, ferry), Active travel (cycle, walk)	Typical weekday AM peak (e.g. 7am – 9am)	Strategic transport model
Working age population by place of usual residence	WAP_i	Base only	By travel zone	N/A	N/A	Land-use projections as used in strategic transport model
Average gross wage per worker by usual residence	AGW_i	Base only	By travel zone	N/A	N/A	ABS Census

Note: Working age population may be defined as population aged 15 years or older, but the age limit can set higher if this is not available at the zone level.
Inclusion of active travel generalised costs and trip numbers is optional depending on data availability.

3.2.2 Calculation steps

Step 1: Estimate the average generalised cost of a one-way commuting trip for each origin zone in the Base and Project Cases

The average one-way, generalised cost of commuting $AGCC_i$ for workers residing in origin *i* averaged over all trips for a typical weekday AM peak (e.g. 7am – 9am) can be estimated using equation 8a for the Base Case and 8b for the Project Case. It is assumed here that the cost of the return journey in the PM peak is the same. The trip purpose superscripts are omitted because the equation applies only to commuting trips and the time superscripts omitted because it applies only to the AM peak. Commuting trip generalised costs and trip volumes can be sourced from a strategic transport model.

Where multiple Project Case options are assessed, it will be necessary to recalculate Base Case average generalised costs of commuting for each option because equation 8a features Project Case trip numbers. For each project option, there will be two average generalised commuting costs (Base Case and Project Case) for each origin zone.

$$AGCC_i^{\boldsymbol{B}} = \frac{\sum_{j,m}\left(Tc_{ij}^{B,m} + Tc_{ij}^{P,m}\right) gc_{ij}^{\boldsymbol{B},m}}{\sum_{j,m} Tc_{ij}^{B,m} + \sum_m Tc_{ij}^{P,m}} \qquad (8a)$$

$$AGCC_i^{\boldsymbol{P}} = \frac{\sum_{j,m}\left(Tc_{ij}^{B,m} + Tc_{ij}^{P,m}\right) gc_{ij}^{\boldsymbol{P},m}}{\sum_m Tc_{ij}^{B,m,t} + \sum_m Tc_{ij}^{P,m}} \qquad (8b)$$

See the suggested solutions for difficulties that may arise in calculation of average generalised costs in Section 2.4.1, step 1.

Step 2: Estimate perceived wages for a marginal worker net of taxes and transport costs for each origin zone in the Base and Project Cases

The perceived weekly net return from working $PNRW_i$ for a marginal worker[10] at origin *i* can be thought of as the net wage after taxes and generalised commuting costs. Equations 9a and 9b adjust the average gross weekly wage for each zone downward for income tax paid (τ_w) and the fact that the marginal worker works fewer hours (η_h) and earns less (η_w) than the average worker, and then deducts the cost of commuting. It is assumed that a full time worker makes five return commuting trips per week (10 trips in total) and a marginal worker makes fewer trips in proportion to fewer hours worked. Equation 9c shows how the preceding equations can be simplified after substituting in the recommended parameter values ($\tau_w = 0.093$, $\eta_h = 0.7$, $\eta_w = 0.8$).

$$PNRW_i^{\boldsymbol{B}} = \eta_h \cdot \eta_w \cdot (1 - \tau_w) \cdot AGW_i - 10 \cdot \eta_h \cdot AGCC_i^{\boldsymbol{B}} \qquad (9a)$$

$$PNRW_i^{\boldsymbol{P}} = \eta_h \cdot \eta_w \cdot (1 - \tau_w) \cdot AGW_i - 10 \cdot \eta_h \cdot AGCC_i^{\boldsymbol{P}} \qquad (9b)$$

[10] The term 'marginal worker' refers to the worker who is at the margins of decision making and weighs the benefit from working (wages after tax and transport cost) equally to the utility from other activities including leisure.

$$PNRW_i = 0.51 \cdot AGW_i - 7 \cdot AGCC_i \qquad (9c)$$

Average gross wages per worker (AGW) (by usual residence) can be estimated from ABS Census data at an SA2 level.[11] The analyst has to concord the average gross wages by SA2 to the zone system used in the strategic transport model relevant for a given appraisal.

If the value of time in the CBA is escalated over the analysis period in line with forecast increases in real wages, gross wages for WB2 estimation should be escalated at the same rate.

Each option will have a Base Case and a Project Case $PNRW_i$ for each zone.

Step 3: Estimate the relative change in perceived net return from working between the Base and Project Cases

The relative change in the perceived net return from working (PNRW) for a marginal worker between the Base and Project Cases for each origin *i* can be estimated using equation 10.

$$\frac{\Delta PNRW_i}{PNRW_i^{\boldsymbol{B}}} = \left(\frac{PNRW_i^{\boldsymbol{P}}}{PNRW_i^{\boldsymbol{B}}}\right) - 1 \qquad (10)$$

Step 4: Estimate the change in participation rate between the Base and Project Cases

The change in the labour force participation rate between the project and Base Cases for each origin *i*, $\Delta LFP_i = LFP_i^P - LFP_i^B$, can be estimated using equation 11 or equation 11a with the recommended value of 0.18 for of the semi-elasticity of LFP with respect to the PNRW substituted in.

The labour force participation rate is the labour force of a given age group (for example aged 15 or 18 years and over) expressed as a proportion of the civilian population for the same age group. It can be defined as $LFP_i = W_i/WAP_i$ where W_i is the number of workers usually resident at origin *i* and WAP_i is the working age population usually resident at origin *i*.

It is not necessary to obtain labour force participation rates to estimate WB2a. All that is required is the absolute magnitude of the *change* in the labour force participation rate given by equation 11. The change in the participation rate multiplied by the working age population yields the number of new entrants.[12]

---

[11] A suggested methodology for estimating average gross wages at an SA2 level for use in WB2a estimation is:

1. Extract the data for 'SA2 (UR) by INCP Total Personal Income (weekly)' from TableBuilder. This includes all income (wages, superannuation, government payments etc).
2. Use weighted averages of the bands provided to estimate the average personal income at the state level for those who had an income (i.e. excluding Negative income, Nil income, Not stated and Not applicable). For example, for Victoria in 2016, this was $968.
3. Source the Average Weekly Earnings estimate at the state level for the 2016 Census date (e.g. for Victoria in 2016 this was about $1102).
4. Scale up the individual SA2 values from Step 2 by the ratio of the outcomes of Step 3 and Step 2 (e.g. 1102/968 = 1.14).
5. Optionally, the practitioner might adjust for the proportion of people in any given SA2 that are non-wage income earners (primarily retirees and recipients of government payments) using other Census datasets to improve the resolution of the estimate.

[12] While both elasticity and semi-elasticity indicate the responsiveness of participation to a 1% change in wages, elasticity gives the percentage increase in participation while semi-elasticity gives the percentage-point increase. A semi-elasticity of 0.18 implies that a 1% increase in wages will cause the participation rate to rise by 0.18 percentage points, say from 67.0% to 67.18%.

$$\Delta LFP_i = \varepsilon \cdot \frac{\Delta PNRW_i}{PNRW_i^{\boldsymbol{B}}} \quad (11)$$

$$\Delta LFP_i = 0.18 \cdot \frac{\Delta PNRW_i}{PNRW_i^{\boldsymbol{B}}} \quad (11a)$$

Step 5: Estimate the change in total gross wages between the Base and Project Cases

The total change in total gross annual wages, ΔGW_i, earned by workers resident at each origin *i* attributable to the transport intervention can be estimated using equation 12. It estimates additional labour supplied in a zone as the change in labour for force participation times the working age population (WAP) residing in the zone, converts this to gross wages earned by multiplying it by the average gross wage (AGW), then adjusts it downward to allow for the fact that the marginal worker works fewer hours and earns less than the average worker. Equation 12a combines equations 11 and 12, multiplying together the recommended parameter values for ε, η_h and η_w.

$$\Delta GW_i \approx \eta_h \cdot \eta_w \cdot \Delta LFP_i \cdot WAP_i \cdot AGW_i \quad (12)$$

$$\Delta GW_i \approx 0.1008 \cdot \frac{\Delta PNRW_i}{PNRW_i^{\boldsymbol{B}}} \cdot WAP_i \cdot AGW_i \quad (12a)$$

Step 6: Estimate the change in tax revenue between the Base and Project Cases

WB2a or the total additional income tax and payroll tax revenue attributable to workers resident at each origin i as a result of the transport intervention can be estimated using equation 13. It multiplies the change in gross wages for each zone by the sum of the tax wedge for the marginal worker (τ_w) and the average rate of payroll tax (τ_p), and sums the results over all zones. Equations 13a substitutes in the combined recommended tax values and equation 13b (τ_w = 0.093, τ_p = 0.027) combines equations 12 and 13a.

$$WB2a = \sum_i \left[\left(\tau_w + \tau_p \right) \cdot \Delta GW_i \right] \quad (13)$$

$$WB2a = 0.120 \cdot \sum_i \Delta GW_i \quad (13a)$$

$$WB2a = 0.0121 \cdot \sum_i \left(\frac{\Delta PNRW_i}{PNRW_i^{\boldsymbol{B}}} \cdot WAP_i \cdot AGW_i \right) \quad (13b)$$

Equation 14 combines equations 9 to 13 to present the process in a single equation similar to that in UK DfT (2018, p. 11).[13] The term in square brackets is the relative change in $PNRW_i$ given by equation 10.

[13] A major difference between the ATAP Guidelines and UK approaches is that the increase in labour supplied is estimated by with a semi-elasticity of LFP with respect to the *PNRW* in the former and with an elasticity of labour supply with respect to effective wages in the latter. At a participation rate of 67%, the 0.18 semi-elasticity estimate is equivalent to a labour supply elasticity of approximately 0.18 / 0.67 = 0.27. This is considerably higher than the labour supply elasticity in UK DfT (2018) set at 0.1.

$$WB2a_i = (\tau_w + \tau_p) \cdot \varepsilon \cdot \eta_h \cdot \eta_w \cdot \left[\frac{10 \cdot (AGCC_i^{\boldsymbol{B}} - AGCC_i^{\boldsymbol{P}})}{\eta_w \cdot (1 - \tau_w) \cdot AGW_i - 10 \cdot AGCC_i^{\boldsymbol{B}}}\right] \cdot AGW_i \cdot WAP_i \quad (14)$$

3.2.3 Suggestions for developing the narrative for WB2a

Explain why the initiative is expected to significantly affect the incentives for individuals to join the labour force and/or work more hours. Is there evidence of poor connections to employment centres (such as inadequate public transport, or long, indirect routes), and/or high transport costs relative to income? If so, a number of conditions need to be met in order to have an increased labour supply WEB.

- The transport initiative being appraised will help address the problem
- Those expected to enter employment have the necessary skills
- The firms expected to hire the additional labour will respond. (UK DfT 2020, p. 6)

The latter two points recognise that the calculation method set out in the previous section assumes a competitive and frictionless labour market aside from commuting costs. Wages net of commuting costs are assumed to be the only constraint that prevents workers entering the labour market. For some segments of the labour market, for example, homemakers, who are in the main, women, face scheduling constraints that can have a strong bearing on whether they participate or not and which jobs they can accept. The calculation model assumes all marginal workers can find work without any mismatch between skills and employers' needs.

To help understand how the WB2a estimate relates to the transport initiative, a map could be produced using colours to show the percentage reductions in the average generalised cost of commuting for each zone, given by equation 15.

$$\%\Delta AGCC_i^{\boldsymbol{B}} = \frac{(AGCC_i^{\boldsymbol{P}} - AGCC_i^{\boldsymbol{B}}) \cdot 100}{AGCC_i^{\boldsymbol{B}}} \quad (15)$$

As a check for realism, provide the maximum estimated percentage change in *PNRW* across all zones.

3.3 WB2b: Move to more (or less) productive jobs and impact on tax

3.3.1 WB2b: Move to more or less productive jobs

Changes in the geographical distribution of employment as a result of a transport initiative can lead to productivity changes where there are labour productivity differences between locations. The productivity differences that give rise to WB2b are 'place-based effects'. They arise from the specific characteristics of locations such as natural resource endowments and agglomerations that confer productivity advantages on firms and individuals. Such effects are external to the firm or individual, that is, they only act upon firms and individuals in the specific location (UK DfT 2018, pp. 3-4). Differences in productivity between locations that arise from employee characteristics, such as skills, are not relevant. For example, an employee switching jobs to a location where average wages are higher because the existing employees there are more highly skilled, will not automatically acquire additional skills and be paid more. A bank teller currently working in a suburb will not become an investment banker simply by taking a job in the CBD.

The calculation methodology in UK DfT (2018) involves

- obtaining estimates for Base Case and Project Case employment levels by area from a land-use change model
- combining employment changes in each area with area-specific productivity differential indexes and national average GDP per worker to estimate the GDP change for each area, then
- multiplying the sum of changes for all areas by a marginal tax take for the average worker.

The zonal productivity differentials compared with the national average were estimated by Johnson et al. (2010). Their econometric study controlled for various factors influencing productivity differentials between areas including employee age, gender and years of tenure with the current employer, employer size, 81 occupation dummies and five industry group dummies. The estimated productivity differentials only distinguish between area, not occupations or industries. So applying the UK method for estimating WB2b, in effect, assumes the same productivity differentials apply across all occupations and industries, or alternatively that the occupational composition is uniform across all zones and across all jobs that move between zones. The results in Johnson et al. (2010) suggest that industrial composition does not affect productivity differentials between areas, but the effects of occupational composition were not investigated.

Also, the UK marginal tax take factor attempts to go beyond WB2b as discussed in footnote 9.

Johnson et al (2010) showed that the actual productivity differentials at a local authority level for all industries and occupations together are much smaller than average wage differentials and some cases differ in sign. So differences in earnings for within occupations and industries are not necessarily reliable guides to productivity differences.

Until research is undertaken into productivity differences by location, occupation and industry, the ATAP Guidelines is unable to offer a satisfactory methodology for WB2b estimation. Unless the proponents of business cases can reliably establish such a productivity index, it is recommended that estimates *not* be reported in Australian CBAs. If WB2b is considered to be likely to be significant for a transport initiative, a narrative should be provided to support the case. Estimates of numbers of jobs ‘created’ and ‘destroyed’ in different locations by industry, and if possible, by occupation can be reported and used to support the narrative.

If WB2b is reported in a CBA, it is recommended that it be treated as sensitivity test. The estimation methodology should be described, and the following issues addressed:

- The source of the productivity differentials, for example, an econometric study or derived from agglomeration elasticities and effective densities
- If output changes are estimated from wage data, possible divergences between wage and productivity differentials between zones
- Whether the WB2b estimate reflects other distortions in addition to income and payroll tax, in which case, the estimate represents more than WB2b. The ATAP Guidelines recommends that the tax wedge be for income and payroll tax only as for WB2a above
- The level of disaggregation at which the calculations have been undertaken in terms of zones, industries and occupations, and in particular, whether the productivity differentials between areas are assumed to be the same across industries and occupations as in the UK approach
- The extent to which averaging across industries, occupations and zones may have biased results.

The last three points will be particularly important where the WB2b estimate comes from a spatial equilibrium model.

Note that even with knowledge of productivity differentials, WB2b will be impossible to estimate where infrastructure investments radically transform the economic characteristics of zones.

3.3.2 Suggestions for developing the narrative for WB2b

The WB2b narrative has to establish that job shifts are likely to occur as a result of the transport initiative and that the shifts will be from low to high productivity areas. Evidence in support of likely job shifts will relate to land-use change forecasts and can refer back to the narrative for dynamic WB1. The effective density calculations undertaken for estimating WB1 will help distinguish between high and low productivity areas, as will a simple employment density measure. While the dynamic WB1 narrative would distinguish between industries, the WB2b narrative could extend to discussing occupations and employee attributes for shifting jobs as well.

Some considerations from the WB2a narrative may be relevant as well — evidence of poor connections to employment centres and/or high transport costs relative to income and that the transport initiative being appraised will help address the problems; the employees expected to change jobs have the necessary skills; and the firms expected to hire the shifting workers will respond.

It could be noted in the narrative that the WEB is not the full increase in productivity or earnings but the tax impacts only.

4. Wider Economic Benefit 3 — Output change in imperfectly competitive markets

4.1 What is an output change in imperfectly competitive markets?

In an imperfectly competitive market, prices may exceed production costs with outputs set below the economic optimum. Firms produce less output than they would under perfect competition because they restrict output to maintain higher prices. WB3: Output change in imperfectly competitive markets arises from a reduction in transport costs causing an increase in production or output of goods or services that use transport. Conventional CBA fully captures the gains to producers and consumers from the transport cost reduction in relation to existing output and the consumers' surplus gain from the additional output. However, the existence of a price above marginal social cost under imperfect competition implies that consumers' valuations or willingness to pay for the additional output produced exceeds the marginal social cost of producing that output. Thus, there is an economic welfare gain not captured by conventional CBA. This welfare gain accrues to the firm as profit earned on the increased output. Since CBA adds together costs and benefits regardless of to whom they accrue, increased profits to producers are just as much a benefit as gains to consumers.

Note that there is no suggestion that the transport initiative in question will improve industry competition (which is the source of WB4).

Estimation of WB3 requires an estimate of the total benefit from savings in generalised private costs of business and freight trips, which can be estimated using the outputs from the strategic transport model and the conventional CBA. Generalised private costs includes time, monetary costs, reliability, tolls, parking charges and public transport fares. Private costs are relevant because they are the costs faced by firms making output and pricing decisions in product markets. Any differences between private and social (or resource) costs of transport will be taken into account in the conventional CBA. Only trips paid for by firms or employers should be included — not non-work travel or commuting trips. Relevant passenger trips are those for business purposes, whether by car or public transport.

Transport cost savings for freight are also passed on to firms and can lead to output increases for imperfectly competitive industries. Hence, generalised private cost savings for commercial vehicles should be included.

To obtain WB3, the estimate of the total benefit of the transport initiative from savings in generalised private costs for business and freight trips is multiplied by an 'uprate factor', which is the ratio of the increase in profit to the total saving in costs from a downward shift of the marginal cost curve in the textbook monopoly model. The increase in profit is the gap between price and the marginal cost of the increase in output. As shown in Appendix E, for small changes, the uprate factor is approximately equal to the price–cost mark-up, $(price - marginal\ cost)\ /\ marginal\ cost$, times negative the price elasticity of demand.

The uprate factor recommended in these guidelines of 0.1 is based on indicative values of a 20% mark-up and –0.5 price elasticity of demand for goods and services averaged across all industries and cities.

4.2 Calculating WB3: Output change in imperfectly competitive markets

The inputs required for estimating WB3 are shown in Table 5.

Table 5 Inputs for estimation of WB3: Output change in imperfectly competitive markets

Input	Spatial resolution	Modes	Time period	Source
Benefit to business travel and freight transport from savings in private generalised costs due to the transport initiative	Aggregate for study area	All	All	Conventional CBA

4.2.1 Calculation steps

Step 1: Obtain the benefit to business travel and freight transport from savings in private generalised costs due to the transport initiative

The benefit to business travel and freight transport from savings in private generalised costs includes the consumers' surplus triangles for generated and diverted demand. This is the case with the Neuberger formula from ATAP Part T2 Cost–benefit analysis Appendix A and Part M2 Roads, Section 7.4, reproduced as equation 16, where *P* is perceived costs, *Q* is quantity of traffic and the subscripts 1 and 2 represent the Base Case and Project Case respectively. For business travel and freight transport, perceived costs and private costs are likely to be assumed to be identical. If they are different, use private costs, not perceived costs. Exclude any resource correction because it does not accrue to transport users.

Step 2: Multiply the benefit to business travel and freight transport by the uprate factor

$$Network\ benefit = \sum_{All\ trips} \frac{1}{2}(Q_1 + Q_2)(P_1 - P_2) \quad (16)$$

The step is shown in equation 17 and again in 17a with the 0.1 uprate factor.

$$WB3 = Benefits\ to\ business\ travel\ and\ freight\ transport\ \cdot uprate\ factor \quad (17)$$

$$WB3 = Benefits\ to\ business\ travel\ and\ freight\ transport\ \cdot 0.1 \quad (17a)$$

4.3 Suggestions for the WB3 narrative

Explain how the initiative is expected to benefit firms with a relatively high degree of market power. Evidence of high market power includes a small number of firms in the industry (high market concentration) and entry barriers. Any evidence that firms with market power may increase output as a result of the transport initiative is desirable. The proportion of total transport user benefits accruing to business cars and freight vehicles would be relevant information as it affects the relative size of the WB3 estimate compared with user benefits in the conventional CBA. From estimates of business and freight trips by origin–destination pairs that benefit from the initiative and the location of industry in the city, it may be possible to comment on the industries that benefit most from WB3.

5. Wider Economic Benefit 4 — Change in competition

In an isolated community where high transport costs make non-locally sourced goods expensive, a firm may be able to charge a price significantly above efficient production costs due to lack of competition. Building a new transport link, or greatly improving an existing link to the rest of the economy can introduce competition from outside. The local firm may be driven to reduce prices and improve production efficiency and service quality. The benefits to consumers in the area outweigh the losses to the previously protected firms in the area creating a net benefit to society as a whole.

Despite initial support for this benefit, the UK Department for Transport concluded that it did not expect significant WEBs under this category in the UK (UK DfT 2005, p. 25). Transport initiatives in developed countries characterised by reasonable transport access (as is the case for the UK and Australian cities and regional centres) are unlikely to generate large enough travel cost savings to have a material impact on competition. WB4 may be relevant in some cases in remote parts of Australia but no methodology or parameter values has yet been developed for quantifying the benefit. It may not even be possible to specify parameter values for general use because the size of the benefits would be highly case-specific.

Consequently, approaches and parameters for estimating WB4: Change in competition are not offered in the ATAP Guidelines.

6. WEB narrative summary table

Table 6 shows an example of how the narrative could be presented in summary form. It is a summary only, not a substitute for the suggestions given above.

Table 6 Example narrative summary table

WEB impact	Description of change in accessibility/output	Description of stakeholders affected	Estimated in the business case
WB1: Agglomeration			
Significantly increase access to intermediate inputs	Firms may have a large increase in accessibility to IT equipment providers	Concentrated in 20 producers	Yes – due to the significant increase in the range of customers for firms
Significantly increase access to buyers	A doubling of retail businesses accessible within a 30 min trip	Spread across approximately 60% of the local government area	Yes – due to the significant increase in the range of customers for firms
Significantly increase exchange of information	Unknown	Unknown	Yes – due to the significant increase in the range of customers for firms
WB2: Labour market			
Significantly affect incentives for individuals to join the labour force and/or work more hours	20% reduction in commute time to the CBD for two low SEIFA index areas	Approximately 30,000 unemployed persons	Yes – a significant increase in accessibility for a large number of consumers
Significantly increase movement to more productive jobs	None	None	No
WB3: Imperfect competition			
Significantly increase output of firms with relatively high market power	Firms X, Y and Z will see a 20% reduction in transportation costs and are expected to increase output	This firm has a high degree of market power within its industry, however only accounts for 0.1% of gross regional product	No – this cannot be considered a significant impact

Note: SEIFA = Socio-Economic Indexes for Areas

Appendix A Key terms

Term	DESCRIPTION
Effective density	Effective density is a quantitative measure of access to opportunities. An opportunity refers to any activity that a user wants to access. In the context of agglomeration, the relevant opportunity is typically jobs. Effective density is quantified using a measure of travel impedance, typically a function of distance, time or generalised cost of travel. Whereas *physical* density is the number of jobs within a given unit of area (i.e. jobs per square kilometre), *effective* density is the number of jobs accessible within a given travel impedance (e.g. jobs within a 30 minute travel time).
Proximity effects	Proximity effects, also called static effects, refers to increases in effective density enabled by reductions in travel impedance. For example, if a transport intervention reduces the travel impedance between a given origin and an employment-dense area, the effective density of employment at that origin will increase.
Dynamic effects	Dynamic effects, also called cluster effects, refers to increases in effective density enabled by increases in physical density. For example, if a greater number of jobs locate within a short travel impedance of a given origin, the effective density of employment at that origin will increase.
Travel impedance	Travel impedance is a measure of ease with which an opportunity can be accessed. Travel impedance is typically a function of travel distance, time or generalised cost. A low travel impedance means the opportunity is easily accessed and a high travel impedance means the opportunity is difficult to access. Travel impedance may vary by mode — for example, a public transport trip may take 30 minutes while a car trip for the same origin–destination pair may take 10 minutes.
Decay curve	Effective density is typically measured using a decay curve. The decay curve represents how quickly the attractiveness of an opportunity declines as the travel impedance increases. Decay curves reflect the fact that when travel impedance is low, attractiveness (or propensity to travel) is high.
Gross Value Added (GVA)	GVA is a measure of the value created during production. It represents the contribution of labour and capital to the production process. In the Australian System of National Accounts, GVA is defined as the difference between output and intermediate consumption at basic prices. It is closely related to Gross Domestic Product (GDP), which is composed of GVA plus net taxes (taxes minus subsides) on products. For the purpose of calculating WB1: Agglomeration economies, GVA per worker is used as a measure for industry productivity at a small area level.

Term	DESCRIPTION
Productivity elasticities	Productivity or agglomeration elasticities measure the responsiveness of productivity of an industry in a specific geographical location to changes in effective density. As the need to trade between businesses differs depending on the industry, the response to improved accessibility will also differ.
Generalised cost	Generalised cost of commuting comprises the monetary price and all costs incurred by a transport user in undertaking a door-to-door journey between origin and destination. For cars, it should include time, vehicle operating costs, tolls and parking. For public transport, it should include in-vehicle-time, expected and unexpected waiting time, access / egress time, discomfort due to crowding, and fares. Quality attributes such as time need to be expressed in dollar terms based on user valuations. Perceived generalised costs (similar to those typically used in a choice module in a strategic transport model) exclude any costs that transport users do not perceive.
Land Use Transport Interaction (LUTI) Model	LUTI models are able to simulate the dynamics of the transportation–land-use change process and incorporate the lagged responses to transport or land-use changes.
Marginal worker	Marginal worker refers to the worker who is at the margins of decision making and considers the benefit from working (wages after tax and transport costs) equal to the utility from other activities including leisure.

Appendix B Parameters for WB1 — agglomeration impacts

Efforts to estimate productivity elasticities and distance decay factors for Australian cities undertaken for these guidelines did not produce results of sufficient statistical quality to recommend for use. The procedure involves regression analysis to estimate production functions (output as a function of inputs of labour, capital and intermediate goods) that include effective density (ED) as a measure of access. Two research projects were undertaken on behalf of the ATAP Guidelines to estimate productivity elasticities for Australian cities and neither produced a set of elasticities that could be considered satisfactory (KPMG 2017; Harvey and Trott 2020).

Both studies used anonymised data for individual firms from taxation records obtained through the Australian Bureau of Statistics (ABS) under strict confidentially conditions. The second project took advantage of ABS's Business Longitudinal Analysis Data Environment (BLADE). Best practice for this type of work is to use data at the level of individual firms (Melo et al. 2009, p. 335).

The elasticity estimates from the first research project were criticised for appearing to be on the high side, estimated at too disaggregated a level (separate regressions for 19 industries in 8 cities resulting in smaller sample sizes such that more than half of the elasticity estimates were not statistically significant), not allowing for endogeneity, and using a decay curve specification that caused elasticity estimates to be higher for smaller cities.

The second research project for the ATAP Guidelines attempted to estimate decay curve parameters from the data following the methodology in Graham et al. (2009) whereby access to economic mass is measured by summing employment in concentric rings around each origin zone centroid. Both straight-line and distance by road measures of impedance were tested. The expected inverse relationship between productivity and distance was not found, with a mix of positive significant, negative significant and statistically non-significant coefficient estimates produced for the different distance bands. A variety of industry and city groupings was tested. Part of the problem appears to be that the anonymised firm data gave the location of firms as postcodes only. Postcode areas are too large to allow agglomeration effects over close distances to be observed. In the future, when firm data with more precise locations of firms becomes available, further attempts to estimate decay curve parameters and productivity elasticities might usefully be made.

Attempts were then made to estimate productivity elasticities for a variety of industry and city groups with EDs from inverse decay curves with parameters of 0.5, 1.0, 1.5 and 2.0 and testing both straight-line and road distances as the impedance measure. Regressions were undertaken for all industries combined and industries separated into groups similar to those in Graham et al. (2009). The productivity elasticity estimates obtained were statistically significant but negative. This is by no means the first time a negative relationship has been found between productivity and agglomeration. The survey of international estimates of productivity elasticities in Graham and Gibbons (2019) listed a number of negative estimates, the lowest being –0.8.

Since the first study undertaken for the ATAP Guidelines, ABS had changed its recommended way to measure labour, capital and intermediate goods in the production function. Switching to the earlier measures for the variables in the production function and using the EDs from the previous ATAP Guidelines project (which meant having to exclude observations from the sample) showed that the elasticity estimates were extremely fragile, changing significantly with changes to the sample and the way in which the variables in the production function were measured. While some results were statistically significant and positive, they were small and it would not be credible to simply pick the largest.

The econometric techniques applied were relatively unsophisticated. There is no point attempting to apply any of the techniques used in the literature to control for endogeneity if a simple ordinary least squares regression does not produce plausible results first.

Other estimates of elasticities for Australian cities were examined — Hensher et al. (2012), Rawnsley and Szafraneic (2010), SGS (2011), and Trubka (2011). A set of elasticities estimated from 2016 census data was supplied by LUTI Consulting. It was decided not to recommend any of the Australian estimates. The main reason is that they are all based on effective densities calculated with an assumed decay curve parameter of unity rather than estimating decay curve parameter from data. Harvey (2019) shows that the choice of decay curve parameter affects elasticity and agglomeration WEBs estimates. Higher assumed distance decay rates lead to lower productivity elasticity and lower agglomeration benefit estimates, and conversely. The UK DfT (2020) parameter values from Graham et al. (2009), which were estimated from data, show a large variation in decay curve parameters.

The Australia estimates examined were made using zonal not individual firm data. The latter is preferable but estimates from zonal data are still valid. In most cases, the Australian estimates were based on wages and hence related to labour productivity rather than total factor productivity, and did not correct for endogeneity. They were obtained from Sydney and/or Melbourne data only and excluded some industries.[14]

It was therefore decided to recommend overseas elasticities in this guideline. The elasticities from UK and New Zealand guidelines have fairly comprehensive industry coverage and used the ‘control function’ approach to adjust for endogeneity.[15] The UK elasticities and decay curve parameters were chosen because they used distance decay elasticities estimated from data rather than imposed by assumption and they are on the conservative side. The UK values have been simplified to some extent noting that:

- Econometric work both in the literature and undertaken for this guideline shows that elasticity estimates are strongly affected by the way data is collected and filtered, the way variables in the production function are measured and the econometric methodology.
- The UK elasticities are being transferred to another country for use in multiple Australian cities, each with its own characteristics.
- The UK elasticities are dated, being estimated in 2009 from data for an unspecified earlier year and do not account for any effects that the recent trend towards increased working from home might have on the agglomeration–productivity relationship.

The UK elasticities distinguish between four industry groups — manufacturing, construction, consumer services and business services. The grouping in Table 2 of this guideline is consistent with the UK groupings except that construction has been put into group 2, which corresponds with the UK consumer services group. In the UK guidelines, the construction industry is the sole industry in its group and has parameter values in between those of the other groups. The Australian elasticity estimates reviewed do not support treating the construction industry as a distinct group. Had the UK construction industry elasticity been estimated with the higher distance decay parameter assigned to it in Table 2 (1.8 instead of 1.562 in UK DfT 2020), it would have been lower.

To develop the recommended elasticities in Table 2, industries in the UK groups were assigned to ANZSIC codes based on information in the UK guidance. The decision to use the same decay curve factors for groups 2 and 3 was taken considering overlaps between the 95% confidence intervals for the UK estimates.

---

[14] Another Australian estimate of productivity elasticities is that of Hensher et al. (2014). They estimated distance decay and productivity elasticities for all south-eastern Australia for the purpose of assessing agglomeration impacts of high speed rail between Sydney and Melbourne. Being over long distances these elasticities were extremely low compared with the values estimated for cities — $\alpha = 0.000189$ and $\rho = 0.0025$ for work-related travel. The output elasticity here compares with 0.021 as the average for the Sydney metropolitan area estimated by Hensher et al. (2012). Hensher et al. (2014) did not estimate elasticities for different industries.

[15] UK elasticities published in UK DfT (2020) come from Graham et al. (2009). New Zealand elasticities published in NZTA (2020) come from Maré and Graham (2010).

Appendix C Small area gross output values

This appendix describes the derivation of the gross value added (GVA) estimates per worker by industry for small areas in the accompanying Excel workbook. Estimates are provided for 2015. Parameters for projecting the 2015 GVA estimate into the future are also provided. The approach broadly reflects that employed by the New Zealand Transport Agency and the UK Department for Transport. The approach involves the use of regional output estimates, and allocating gross value added (GVA) per small area proportionally according to employment and earnings in each small area.

For a detailed description of the concepts discussed below, refer to Australian System of National Accounts Concepts, Sources and Methods (ABS cat. no. 5216.0, 2015).

C.1 What is GVA?

GVA is a measure of the value created during production. It represents the contribution of labour and capital to the production process. Understanding the components of GVA and the way in which estimates are constructed helps to inform the methodology for deriving regional estimates.

In the Australian System of National Accounts, GVA is defined as the difference between output and intermediate consumption at basic prices. It is closely related to Gross Domestic Product (GDP), which is composed of GVA plus net taxes (taxes minus subsides) on products.

GVA is equivalent to GDP measured in basic prices (i.e., net of taxes and subsidies). This is expressed as:

$$GDP = GVA + taxes\ on\ products - subsidies\ on\ products$$

GVA can be estimated in three ways, the production approach and the income approach, which are outlined below.

Production approach to GVA: Viewed in terms of production, GVA represents the difference between output and intermediate consumption, i.e.

$$GVA = output - intermediate\ use$$

Due to data limitations at the state level in Australia, GVA estimates in the State Accounts are not produced using actual output and intermediate use data.

Income approach to GVA: GVA can be equivalently conceptualised as the sum of income flows from the factors of production and government.

GVA = compensation of employees (CoE)

+ gross operating surplus and gross mixed income (GOSMI)

+ other taxes on production

– other subsides on production

Compensation of employees (CoE) and Gross Operating Surplus and gross Mixed Income (GOSMI) can be conceived respectively as the portion of production attributable to labour and to capital, i.e. to the factors of production.

The above equation can therefore be simplified to:

$$GVA = total\ factor\ income + net\ other\ taxes\ on\ production$$

The ‘other taxes on *production*’ term included in the income approach to GVA differs from ‘taxes on *products*’ included in GDP in that the former applies to taxes and subsidies levied on the producer (e.g. payroll tax, motor vehicle tax) whereas the latter are levied on the final goods (e.g. GST, Tobacco excise).

Expenditure approach to GVA: A third approach considers GVA as the sum of final expenditures on goods and services, however this method requires data on net exports, and thus is not practically applicable for sub-national regions.

Each measure is theoretically equivalent but in, practice, each approach produces a different result. GVA figures in the National and State Accounts as reported by the ABS are constructed by balancing and/or averaging multiple methods.

Annual estimates of GVA by industry are published at the state level in the Australian System of National Accounts: State Accounts (ABS cat. no. 5220.0). The ABS does not currently produce estimates of GVA for small areas. The estimation of agglomeration economies, which by their nature operate on a sub-regional level (i.e. within cities), necessitates the construction of a synthetic database with output data for areas that can be practicably concorded to a travel zone system.

C.2 Methodologies for small area estimates

The challenge in creating small area estimates is to relate data compiled at different levels of aggregation to the desired spatial level. Often, statistics are compiled for national or state purposes and are unsuitable for direct application to small areas. Most methodologies therefore require supplementary indicators that can be used to ‘regionalise’ economic data.

The Eurostat Manual on regional accounts methods (European Commission 2013) provides a useful overview of the various methods of regionalisation, which fall broadly into three categories:

- **Bottom-up methods** involve collecting data on individual units (e.g. households or businesses) and then aggregating up to the desired regional level. Pseudo-bottom-up methods can be used where individual data is unavailable or has gaps. In this case, data on individual units can be estimated based on regional indicators then aggregated up to obtain regional totals.
- **Top-down methods** take aggregate, high level data and regionalise it by distributing the totals down to smaller areas using regional indicators that correlate with the variable to be estimated.
- **Mixed methods** are a combination of the above approaches. Pure bottom-up methods are rarely feasible as there are usually gaps in the data. In these cases, missing data can be filled using pseudo-bottom-up or top-down methods.

Each of the above methodologies can be applied to give satisfactory estimates. As described in the previous section, GVA can be compiled from the perspective of production or of income. This means that there are a wide variety of essentially equivalent approaches to creating regional estimates of GVA. The choice is generally driven by the availability of regional indicators and economic data at appropriate levels of aggregation.

C.2.1 Australian estimates of regional output

In Australia, there has been a number of efforts by Government agencies to create regionalised estimates based on National Accounts data. The following sources were reviewed in the preparation of this report.

Queensland Treasury and Trade (QTT), Experimental Estimates of Gross Regional Product 2000-01, 2006-07 and 2010-11, QTT (2013)

Queensland Treasury and Trade produced experimental estimates of GDP for each Statistical Division of Queensland as defined by the Australian Standard Geographical Classification (ASGC) 2006. Statistical Divisions are analogous to SA4s in the ASGC 2011.

Estimates of GDP were produced using the income approach whereby the income components were separately derived and then added together. State values for CoE and GOSMI were distributed separately to the Statistical Divisions of Queensland for each industry.

- Compensation of Employees (CoE) was allocated to the regions by industry using the number of employees weighted by income band, sourced from the ABS.
- The methods for allocating GOSMI varied between industries with disparate levels of availability of regional indicators. Where specific indicators were unavailable, GOSMI was allocated in the same manner as CoE.
- Net taxes on production were sourced from the Australian National Accounts: State Accounts (ABS Cat. no. 5220.0) and distributed to regions in proportion to their factor income.
- Net taxes on products were allocated using an equal weighting of population and income shares. Taxes on products cannot be adequately allocated to particular industries and therefore were used to calculate regional GDP while the industry composition of regions was analysed in terms of GVA.

Department of Industry, Innovation and Science (DIIS), Australian Industry Report 2016, (DIIS 2016)

As part of the 2016 Australian Industry Report, DIIS released, for the first time, experimental estimates for each SA4 in Australia. The methodology was based on the Queensland Treasury and Trade approach described above.

Estimates were produced based on data from the 2014-15 ABS National Accounts using the income approach. The income components of GSP were apportioned to each region using derived SA4-to-State ratios.

- Compensation of Employees was allocated based on the number of ‘employees not owning business’ weighted by income ranges.
- By default, GOSMI was allocated by the number of employees weighted by income ranges, except where industry-regional data was available. Industry-regional data were obtained from public and non-public sources for selected industries.
- Taxes less subsidies on production was allocated by industry to SA4s using share of factor income as an indicator.

DIIS provided the experimental estimates of total factor income by SA4 used in the production of the 2016 Australian Industry Report.

C.2.2 International practice

Agencies in a number of overseas jurisdictions have produced regional and small area estimates of GVA for the purposes of assessing agglomeration and otherwise. The methodologies adopted by each of the below sources were reviewed and are briefly described below.

United Kingdom – Department for Transport, WebTAG: TAG unit A2-1 wider impacts, (UK DfT 2014)

In the UK, the Department for Transport provides guidance on the assessment of the impact of agglomeration economies.

The recommended approach relies on an estimate of local GDP per worker at the Local Authority District (LAD). Projections at five-year intervals are provided for four industry sectors.

GDP per worker figures are sourced from Experian estimates of local employment and GDP, which are a regionalisation of GDP figures from the UK Office of National Statistics (ONS). Productivity estimates from Experian and HM Treasury are used to forecast GDP.

The methodology used to derive the regional estimates is not openly examinable.

New Zealand Transport Agency, Economic evaluation manual, NZTA (2016)

The New Zealand Transport Agency (NZTA) publishes the Economic evaluation manual containing guidelines for the evaluation of transport projects including the estimation of agglomeration benefits.

NZTA does not provide regional output estimates but does suggest a method for producing GDP by zone. The approach consists of deriving regional estimates of GDP by industry based on Statistics New Zealand data then distributing it to the chosen spatial zone system in proportion to employment.

European Commission — Eurostat, Manual on regional accounts methods, European Commission (2013)

In the European Union, member states compile regional accounts including GVA at the NUTS 3 level (analogous to Australian Local Government Areas) under the auspices of a harmonised regional accounting methodology.

The European Union's statistical office, Eurostat, provides guidance on the compilation of regional GVA by industry. The Eurostat guidelines are not heavily prescriptive and discretion given to the individual member states to make best use of available data.

In reference to the accuracy of regional accounts methods, three groups are recognised (European Commission 2013, p. 42):

- A-methods represent the actual values or approximate the ideal as closely as possible.
- B-methods are acceptable alternatives: they are further away from the ideal but still provide an acceptable approximation.
- C-methods are too far away from the ideal to be considered as acceptable and should be improved if possible.

Top down methods of regionalising components of GVA, such as those employed by DIIS and QTT, are considered A-methods where the regional indicator is closely related to GVA. The guidelines emphasise the importance of using an appropriate regional indicator to regionalise GVA.

Regionalisation of GVA based on compensation of employees is considered an A-method for industries where the consumption of fixed capital is closely related to compensation of employees and a B-method for industries where this is not the case (European Commission 2013, p. 42) .

C.3 Methodology

C.3.1 Data sources

ABS tailored data

The ABS provided custom data consisting of 2011 Census data disaggregated by Destination Zone (DZN) and broken down by industry at the 1 digit level according to the Australian and New Zealand Standard Industrial Classification (ANZSIC). The following data was provided and used in the analysis:

- Count of employed persons by place of work DZN and industry of employment (ANZSIC 1 digit level)
- Mean weekly individual income of employed persons, by place of work DZN and industry of employment (ANZSIC 1 digit level).

Data quality issues

Missing/inadequate industry response: The count of employed persons dataset includes respondents who did not adequately describe their industry of employment. These persons were considered to be distributed proportionally among all industries according to employment.

Non-geographic place of work (POW) response: There are two special purpose DZN identifiers used where place of work is not stated or not applicable and no state is applicable. Where POW was not stated, workers were assumed to be proportionally distributed among all DZNs.

There are similarly four special purpose DZN identifiers for each state and territory. These are listed in Table 7 below along with the approach to each.

Table 7 Special purpose destination zone number (DZN) identifiers

Code	Approach
Migratory – Offshore – Shipping	Disregard
POW Capital City undefined	Apportion to DZNs in Capital City according to employment
POW State/Territory undefined	Apportion to DZNs in Rest of State according to employment
POW No Fixed Address	Apportion across DZNs in state according to employment

Census undercounting: For various reasons, whenever a census is conducted, some people are missed and some are counted more than once. In the 2011 census, the net undercount was estimated to be 1.7% (ABS Cat. no. 2940.0, 2012). While the net undercount rate varies between areas in Australia, there is no evidence that workers in particular industries are more or less likely to be undercounted.

Employment figures were not adjusted for undercounting when apportioning GVA to DZNs. However when calculating GVA per worker, 2011 employment figures are inflated to 2014-15 levels for each state based on ABS Labour force data. This is done to match the employment figures to the year in which GVA is counted but also has the effect of mitigating undercounting, which would otherwise upwardly bias GVA per worker figures.

State accounts

Total GVA for each industry at the state level was derived from the respective State Accounts (ABS Cat. no. 5220.0, 2016). The state accounts contain yearly estimates of GVA broken down by industry according to the 19 ANZSIC divisions. For each state, the June 2015 current price measure of GVA for each industry was obtained.

Total factor income (TFI)

The Commonwealth Department of Industry Innovation and Science (DIIS) has produced experimental estimates of GRP by SA4 for 2014-15 as part of the Australian Industry Report 2016 (DIIS 2016). These estimates are derived from the 2014-15 State Accounts. DIIS provided the experimental estimates of Total Factor Income (TFI) which are used to formulate GRP as part of the income approach.

The DIIS estimates of TFI were used as an indicator to allocate each state's GVA to SA4s. Estimated GVA for each SA4 was then distributed among the DZNs in each.

The figures provided represent the first iteration of experimental estimates produced by the Department. Appendix 7.1 of the 2016 Australian Industry Report (DIIS 2016) contains a full discussion of the methodology used to produce the estimates and the limitations, which include:

- The use of 2011 Census data may not capture changes in regional or industry composition that have occurred since 2011.
- Head office effects (i.e. where business data such as profit is recorded in a capital city head office, rather than where economic activity occurs) have not been fully accounted for. These effects were mitigated to an extent by using industry specific regional datasets to allocate production to the region it occurred.

Despite these limitations, the experimental estimates produced by DIIS represent the best available attempt at regionalising State level economic activity. DIIS was able to use industry-regional datasets that are not publicly available and thus were able to produce SA4 estimates of a higher quality than would be possible otherwise. This is particularly advantageous for industries like mining where the nature of economic activity and the input mix differs significantly between capital cities and regional areas.

Employment data

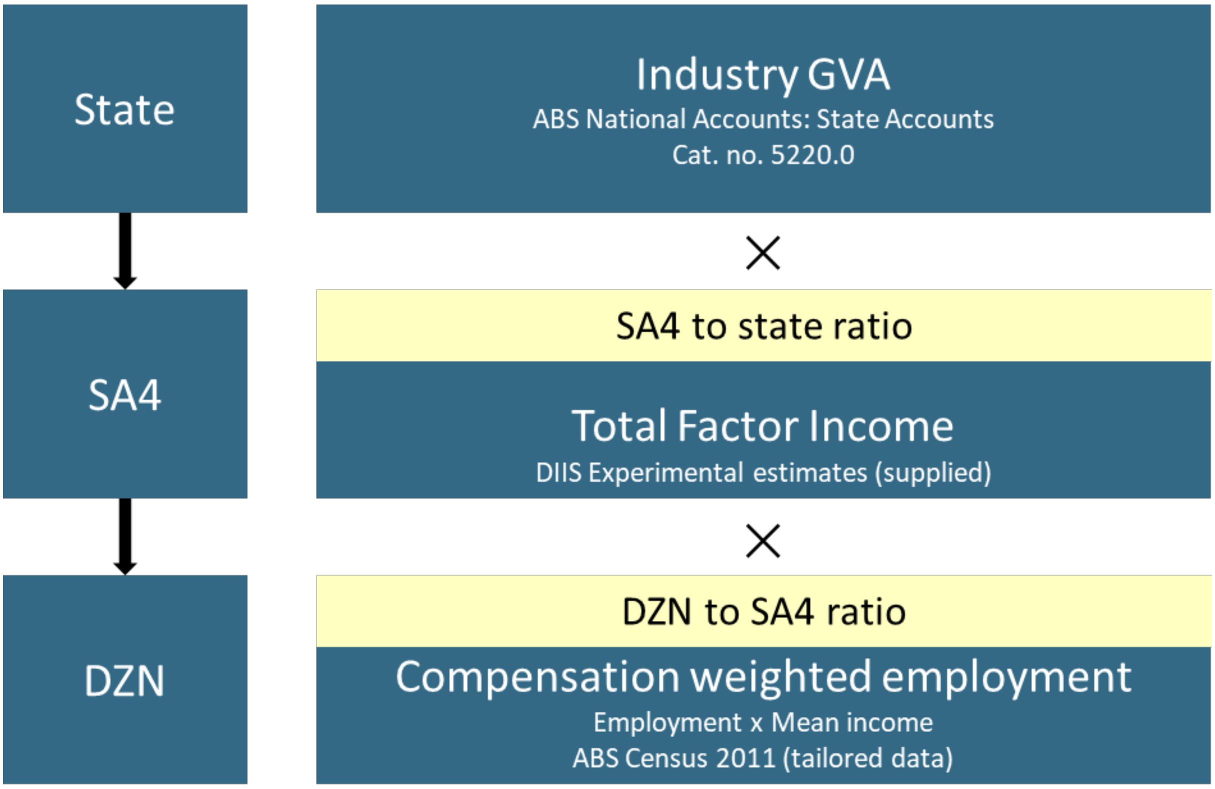
Time series data on employment by industry were used to inflate the census derived employment numbers provided by the ABS. *Labour Force, Australia, Detailed, Quarterly, Nov 2016* (ABS, Cat. No. 6291.0.55.003, 2016) was used to estimate the change in employment by industry between the 2011 census and 2014-15.

Regionalisation of GVA per worker

Estimates for GVA by industry by DZN were produced using a two-stage top-down approach. The choice of top-down approach was driven by the availability of data. A lack of firm-level microdata makes a bottom-up approach infeasible for this purpose.

Figure 1 below illustrates the methodology by which estimates of GVA for each DZN were derived.

Figure 1 Methodology for apportioning industry GVA to DZN



Stage 1: State level aggregate GVA for each industry was distributed among the SA4s in each state using experimental estimates of TFI provided by DIIS as a regional indicator.

As described in Section C.1, industry GVA under the income approach can be thought of as the sum of total factor income and other taxes less subsidies on production. Distributing industry GVA according to TFI implicitly assumes that the distribution of net taxes on production to SA4s within a state is proportional to TFI for a particular industry. In the absence of state by industry figures for taxes and subsidies, this is a reasonable approach and the same approach used by DIIS in preparing their estimates of regional GVA.

The major benefit of generating these control totals is in accounting for industries whose main source of production is located outside major cities, e.g. agriculture and mining. Production in these industries that takes place in capital cities is likely to be very different in character to production that takes place in rural areas in terms of the type of labour employed and labour/capital mix. Specifically, the ratio of CoE to GOSMI may differ significantly between urban and non-urban regions. Attempting to distribute state level GVA directly to destination zones using compensation weighted employment is likely to overstate the value of production in capital cities. Because the DIIS estimates of TFI use regional indicators to allocate CoE and GOSMI, they provide a more robust valuation at the SA4 level.

Stage 2: Once an industry control total is established for each SA4, GVA is then further disaggregated into DZNs. From the income perspective, GVA is made up of CoE, GOSMI and net other taxes on production. Ideally, GVA would be distributed based on regional indicators for both CoE and GOSMI however in practice, indicators for GOSMI at a small area are not available.

An indicator for industry CoE was developed using tailored data supplied by the ABS on employment and median income by DZN. For each industry, the number of employees was multiplied by the mean income in each zone to produce a compensation weighted employment index.

Because DZNs aggregate to SA2s, each DZN belongs to only one SA4 with no overlaps. DZNs were grouped into SA4s and weightings created by dividing the compensation weighted employment for each zone by the SA4 total. GVA for each industry was then distributed by multiplying the weights for each zone by the SA4 values derived in Stage 1. Given that regional indicators of GOSMI are not available at the DZN level, this approach implicitly assumes that for a particular SA4 and industry, the ratio of CoE to GVA is consistent across all DZNs.

The use of data from the 2011 census as an indicator of the industry structure in 2014-15 means that any changes in industry composition that may have occurred in the intervening period would not be captured.

Stage 3: To produce industry GVA per worker by DZN, the values derived in Stage 2 are divided by the number of workers in each industry in each zone. In this context, the number of workers is based on employment in that zone rather than workers who live there.

Whereas the estimates of GVA are based on 2014-2015 data, the data on employment provided by the ABS is derived from the 2011 census. In order to create an estimate of GVA per worker, employment in each zone was inflated based on the industry growth in employment by state using ABS Labour Force data (ABS, Cat. no. 6291.0.55.003, 2016).

Unlike the DZN employment data, the Labour Force time series is based on place of residence rather than place of work. Using state level labour figures to inflate the employment by DZN assumes all workers live in their state of employment. Any changes in the spatial distribution of employment in the intervening period between the census and 2014-15 are not considered.

Inflating employment figures to match the ABS Labour force data for each state has the effect of mitigating Census undercounting at the state level, but does not control for regional differences in undercounting rates.

C.3.2 Projecting Small Area GVA into the future

Agglomeration benefits are realised when productivity gains increase the value of GVA per worker relative to the base case. Estimating the impact of agglomeration in the future requires an estimate of base case industry GVA for all assessment years, accounting for real growth. Real GVA growth is a function of the number of workers and productivity. Increases in the number of people working or the amount produced per worker drive output growth in an industry.

To estimate GVA for future years, it is necessary to have forecasts of industry employment growth and industry productivity growth. Employment by DZN by industry is a necessary input to be provided as part of the transport modelling process. Industry estimates of GVA per worker by DZN are provided as an attachment to this report.

Estimate of GVA per worker by DZN were produced using data from 2014-15 at current prices. When applying these values to estimate productivity impacts in future years, it may be desirable to adjust for changes in labour productivity over time over the appraisal period.

Whether assuming constant productivity in the future or productivity growth, GVA per worker can be adjusted to the current year using the labour productivity index from the ABS publication *Estimates of Industry Multifactor Productivity (ABS Cat. No. 5260.0.55.002, Table 6)*. In the productivity growth scenario, an annual growth rate of 1.5% can be applied to subsequent years based on Commonwealth Government projections of long term labour productivity growth published in the 2015 Intergenerational Report (Commonwealth of Australia 2015). Changes in hours worked per employee are assumed to be negligible.

Ensuring consistency between conventional CBA and WEBs analysis

When adopting a productivity growth assumption for estimating agglomeration economies, it is highly desirable that the conventional cost–benefit analysis (CBA) for the same project also incorporates future growth in real wages due to productivity improvements for assessing value of time benefits for instance. In other words, to ensure the overall economic appraisal is internally consistent, both the conventional CBA and the WEBs estimation should use consistent assumptions on productivity growth.[16]

Table 8 Recommended productivity growth assumptions

Scenario	Rate 2015-present	Rate present - 2046
Constant productivity	By industry ABS Cat. no. 5260.0.55.002; Table 6	0%p.a.
Productivity growth	By industry ABS Cat. no. 5260.0.55.002 Table 6	1.5%p.a as per Inter-generational report[17]

It is noted that the projections based on the data provided are subject to inherent uncertainty. They are intended to serve as a reasonable basis upon which to estimate the effects of agglomeration economies and are not predictions of the future.

C.4 Results

The detailed estimates of GVA per worker by industry by DZN is contained in an Excel workbook available on the ATAP website in the Technical Support Library.

C.5 Application

This section describes how the estimates of GVA per worker are applied in calculating agglomeration impacts.

C.5.1 Zone system

The estimates of small area productivity are provided by Destination Zone (DZN). Destination Zones were designed by State and Territory transport authorities and therefore align roughly with the zone systems of state transport agencies. The spatial data is available in category 8000.0 at the ABS website[18]. They are of similar size to the zones that may be used as part of a strategic transport model allowing concordance with a high degree of accuracy.

There are many possible approaches to transforming data between zone systems. Practitioners should select the method appropriate to the situation and data available. The following section describes a procedure for an area-based concordance.

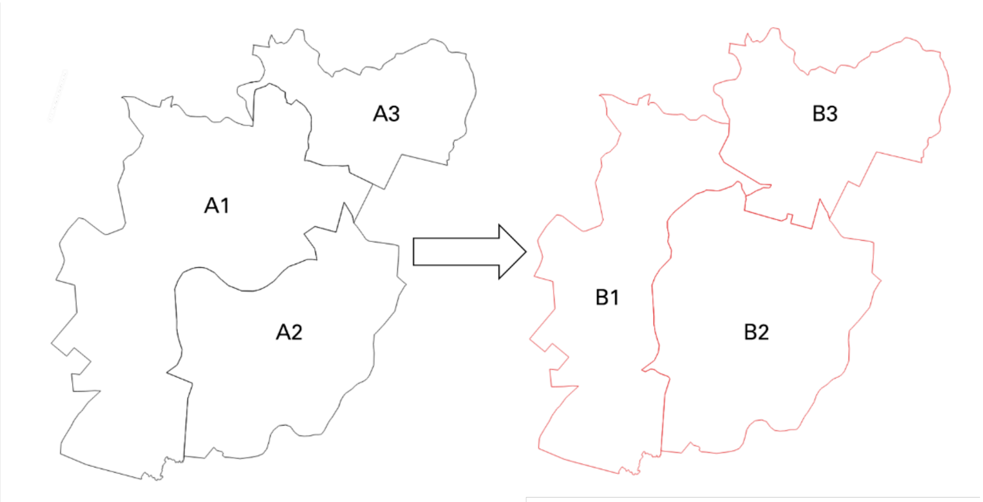
The area-based approach is a method in which the properties of one zone system (System A) are applied to another zone system (System B) based on the proportion of area A contained within area B (see Figure 2). The calculation of intersection area is performed using GIS software.

[16] On indexing unit costs for increases in real wages over the appraisal period, see ATAP Part T2 Cost–benefit analysis, Section 6.1.

[17] Commonwealth of Australia (2015)

[18] http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8000.0August%202016?OpenDocument

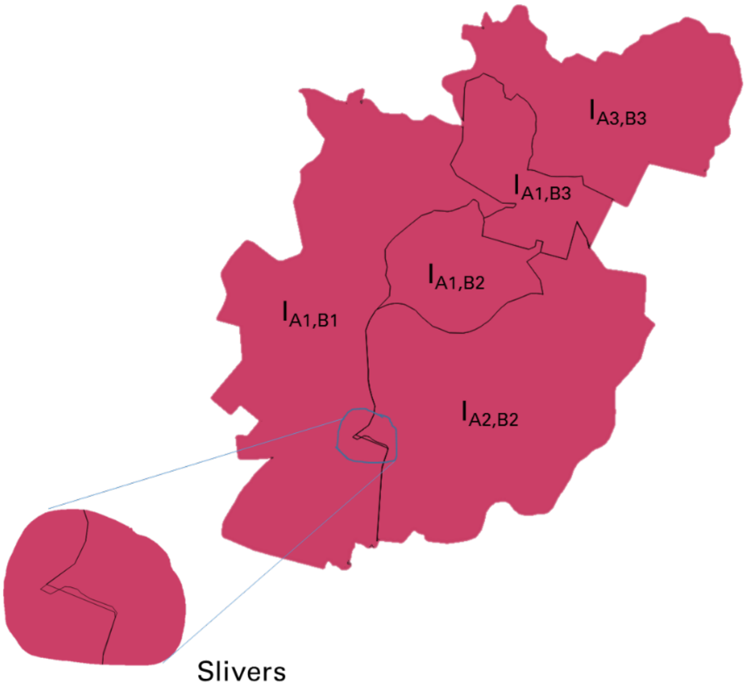
Figure 2 Concordance is the process of transforming information from one zone system to another



The procedure is as follows:

1. Calculate the area of each zone for both systems. This can be done using GIS software. It is advisable to use an equal-area map projection (e.g. Albers Equal Area) to ensure that the relative areas of zones are not distorted.
2. Intersect the two zone systems to create a new layer. Each element in the intersection layer will be located within exactly one zone from System A and one from System B. If the borders of the two zone systems do not neatly align, then slivers will be created (see Figure 3). The size of these slivers is often negligible and it is generally safe to neglect areas with ratios less than 1%.

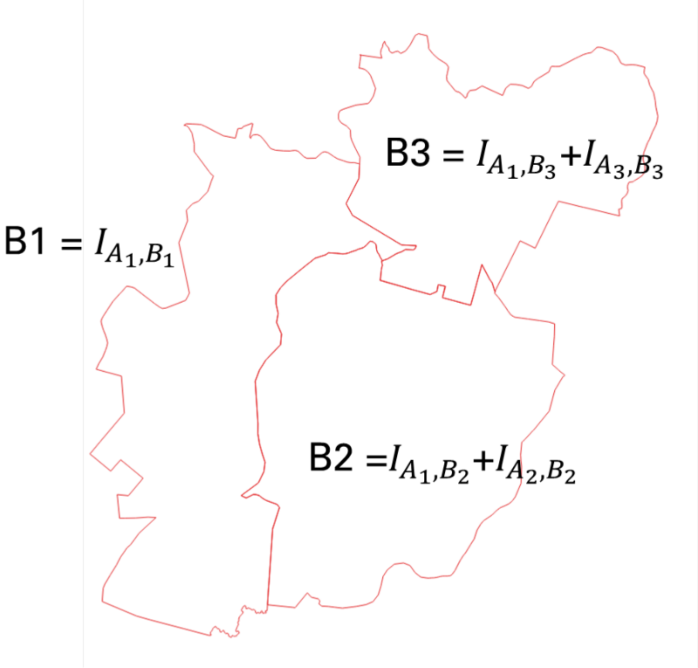
Figure 3 Intersection of System A and System B



3. For each intersection element, find the ratio of the area of the element to the area of the zone from System B.

4. Each zone in System B can be described in terms of the sum of its component intersection elements multiplied by their respective ratios (see Figure 4).

Figure 4 System B can be described in terms of System A using an area based concordance



C.5.2 GVA per worker

It is assumed that the practitioner will supply employment estimates in the zone system of the transport model they are working with. The task is then to assign productivity to these workers based on the GVA per worker estimates by DZN. Assuming that workers are evenly distributed within a zone, the number of workers in each intersection element can be calculated using the ratio of the area of intersection to the ratio of the zone in System B. The productivity of the zone is the employment weighted average productivity of the composite intersection zones.

For example, in Figure 4 above, the industry GVA per worker (GVAPW) in Zone B2 is given by:

$$GVAPW_{B2} = \frac{GVAPW_{A1} \times (Workers_{B2} \times I_{A_1,B_2}) + GVAPW_{A2} \times (Workers_{B2} \times I_{A_2,B_2})}{Workers_{B2}}$$

Where I_{A_1,B_2} is the ratio of the area of the intersection of zones A1 and B2, and the area of B2.

Appendix D Parameters for WB2 — labour market and tax impacts

D.1 Productivity of marginal workers

A person who enters the labour force is likely to be less productive than a worker already employed, both in terms of output produced per hour and hours worked. Those existing workers benefit from an accumulation of skills and experience relative to non-participants. It is also likely that those who are on the margins of participation who do enter the labour force would tend to move into part-time rather than full-time work. It is therefore important that in estimating the additional output produced by new entrants, the average output of marginal workers relative to the average worker be considered.

D.1.1 Relative hourly productivity

The marginal worker productivity factor (η_w) is used to adjust for the relatively lower productivity of new entrants to the labour force.

A standard approach in comparing productivity levels is to use the hourly wage as a proxy for a worker's productivity. The Household Income and Labour Dynamics in Australia (HILDA) survey contains data on thousands of individuals labour force status, weekly earnings and weekly hours.

Using HILDA, the weekly wages of each working respondent was calculated for the 2014 wave. A subset of new entrants to the labour force was selected by considering the labour force status in the previous year. Those respondents who were employed in wave 14 but not in the labour force in wave 13 were considered to be new entrants for the purposes of the comparison.

The marginal worker productivity factor is calculated as the ratio of the average hourly wage of new entrants to the average hourly wage of all workers. The value of η_w was determined to be 0.8 based on the hourly wages of workers in wave 14.

D.1.2 Relative hours worked

The marginal worker hours factor, η_h, is used to adjust for the relatively lower working hours of new entrants to the labour force.

Using the same method as above, the average number of hours worked per week in the 2014 wave was determined and compared with the average. It was found that the average new entrant worked 70% of the mean hours worked per week, yielding a value for η_h of 0.7.

On average across the waves 1 to 14, an employed person who was not in the labour force in the previous year was found to earn approximately 50% of the average employed person each week due both to lower than average hours worked and lower than average hourly wages. For the purposes of estimating tax impacts, new entrants to the labour force were therefore assumed to earn half as much as the average worker.

D.2 Tax take parameters

D.2.1 Overview

The additional welfare benefit associated with increased labour supply is the additional tax revenue accruing to government as a result of more people working. The tax is generated both on the wages earned by new workers and on the additional output they produce. The tax on the additional output generated by new entrants comprises income tax (levied on new workers' wages) and payroll tax (levied on business payrolls which grow as a result of new workers).

D.2.2 Income tax

Income tax in Australia is progressive, meaning that the proportion of income paid in tax increases with income. The marginal rate, that is the percent paid in tax on every additional dollar earned, is divided into brackets based on gross yearly income. In addition to income tax, a Medicare levy of 2% applies on incomes above a certain threshold, with a reduced rate for low incomes.

The amount of tax due on an income of the average new entrant to the labour force earning $29,562 in 2016-17 is $2,875, an effective tax rate of 9.3%.

D.2.3 Payroll tax

In Australia, payroll tax is levied by the states on business payrolls. The salaries of new workers will be an addition to the total wage bill of their employer and subject to taxation. The rules governing which businesses are subject to tax, the thresholds and the rates all differ between states. To arrive at a suitable aggregate figure the relationship between total labour cost and total payroll tax was examined.

Total employee compensation and payroll tax are closely related. Comparisons of total payroll tax collected in Australia with total 'Compensation of employees' from the National Accounts showed from with for each year from 2013-14 to 2018-19, for every dollar paid in compensation to employees, 2.7 cents was collected in payroll tax.

D.3 Elasticity of labour force participation

As a transport intervention reduces the effective distance between jobs and people's homes, some people outside the labour force will find the perceived benefits from working now exceed the opportunity cost of forgone leisure time and will choose to enter the labour force. Econometric analysis of Melbourne data did not find a statistically significant positive association between changes in transport accessibility and the probability of entering the labour force, at a 5% confidence level. So a review of published participation elasticities was undertaken.

Although a large number of estimates of wage elasticity of labour supply exist for Australia, few focus specifically on participation. We have assumed based on previous research that the effect of changes in transport costs will have a negligible impact at the intensive margin and hence require an elasticity that isolates the impact on participation. Dandie and Mercante (2007) performed a review of Australian labour supply elasticities finding that most past studies have focused specifically on a single demographic group.

Buddelmeyer et al. (2007) estimated the percentage point increase associated with a 1% increase in wages for men and women, both single and married. In order to arrive at an aggregate figure we adopted the approach of Kernohan and Rognlien (2011) in finding the average figure weighted by their share of the population not in the labour force. Table 9 shows the semi-elasticities from Buddelmeyer et al. and the share of non-participants for each group.

Table 9 Semi-elasticity of labour supply

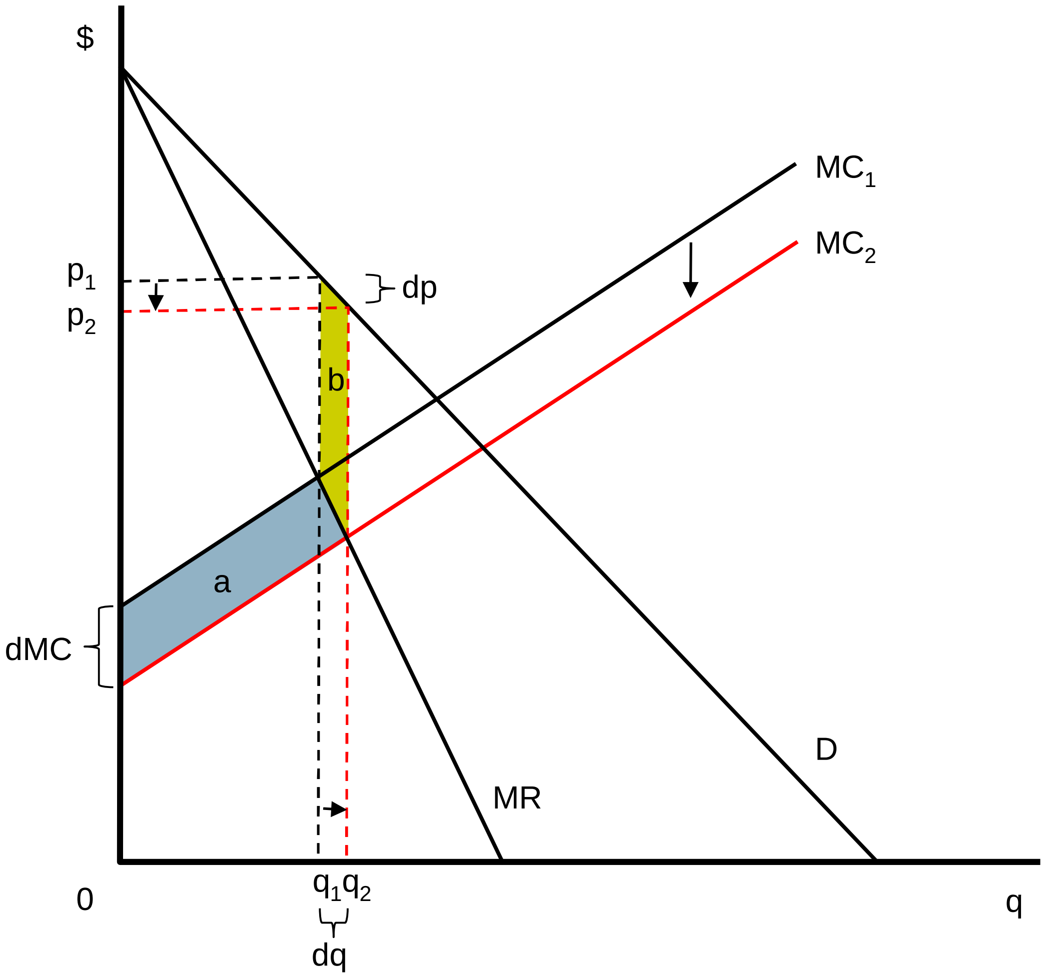
	Married Men	Married Women	Single Men	Single Women
Participation rate increase	0.15	0.2	0.16	0.19
Share of non-participants	20.6%	32.2%	19.2%	28.0%

The population weighted average semi-elasticity of labour supply calculated from Table 9 is 0.18. This means that a 1% increase in wages will on average result add 0.18 percentage points to the participation rate. At a participation rate of 67% this is equivalent to an elasticity of approximately 0.27. To operationalise the parameter in the context of increased labour supply, the change in the participation rate multiplied by the working age population yields the number of new entrants.

Appendix E Uprate factor for WB3 — Output change in imperfectly competitive markets

Figure 5 shows the textbook monopoly pricing model with a fall in the marginal cost curve. Maximum profit occurs the level of output where marginal cost (MC) equals marginal revenue (MR). Price is read off the demand curve at the point where consumers will purchase all the output produced. The transport initiative reduces input costs, shifting the MC curve down from MC_1 to MC_2. The profit maximising output increases from q_1 to q_2 and price falls from p_1 to p_2.

Figure 5 Monopoly diagram with cost reduction



Area '*a*', between the Base Case and Project Case MC curves is the saving in generalised costs (time and vehicle operating cost savings) for business cars and freight. It is the consumers' surplus area estimated by a conventional CBA. Area '*b*' is the WEB, the difference between consumers' willingness-to-pay for the additional output and the cost of producing it. Area *a* accrues to the firm as additional profit.

The uprate factor is the ratio of WB3, area *b*, over the conventional CBA benefit, area *a*.

- Uprate factor $= \frac{b}{a} = \frac{(p - MC) \cdot dq}{-q \cdot dMC}$
- Assume $dMC = dp$, which is an approximation.
- Uprate factor $= -\frac{(p - MC)}{q} \cdot \frac{dq}{dp}$
- Demand elasticity (made positive for simplicity): $\eta = -\frac{dq}{dp}\frac{p}{q}$, from which $-\frac{dq}{dp}\frac{1}{q} = \frac{\eta}{p}$. Substituting this into the uprate factor formula:
- Uprate factor $= \frac{b}{a} = \frac{(p - MC)}{p}\eta$
- The uprate factor is the price/marginal cost mark-up times the elasticity of demand for the product.

References

Australian Bureau of Statistics (2012*) Census of Population and Housing — Details of Undercount, 2011, Cat. no. 2940*. Retrieved from Australian Bureau of Statistics: http://www.abs.gov.au/ausstats/abs@.nsf/Products/2940.0~2011~Main+Features~Estimates+of+net+undercount?OpenDocument

Australian Bureau of Statistics (2015) *Australian System of National Accounts Concepts, Sources and Methods, cat. no. 5216.0.* Canberra: ABS.

Australian Bureau of Statistics (2016, November 25) *Table 2-7. Expenditure, Income and Industry Components of Gross State Product [All states], Chain volume measures and current prices, Cat. no. 5220.0*, Retrieved from Australian National Accounts: State Accounts, 2015-16: http://www.abs.gov.au/AUSSTATS/abs@.nsf/productsbyCatalogue/E6765105B38FFFC6CA2568A9001393ED?OpenDocument

Australian Bureau of Statistics (2016, December 22) *Employed persons by State, Territory and Industry division of main job (ANZSIC), Cat. no. 6291.0.55.003.* Retrieved from 6291.0.55.003 — Labour Force, Australia, Detailed, Quarterly, Nov 2016: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6291.0.55.003Nov%202016?OpenDocument

Commonwealth of Australia (2015) *2015 Intergenerational Report: Australia in 2055,* Canberra.

Buddelmeyer, H., Creedy, J. and Kalb, G. (2007) *Tax policy design and behavioural microsimulation modelling*. Edward Elgar Publishing, Cheltenham.

Dandie, S. and Mercante, J. (2007) *Australian labour supply elasticities: Comparison and critical review*, Treasury Working Papers, (2007-04).

Department of Industry, Innovation and Science (DIIS) (2016) *Australian Industry Report,* Commonwealth of Australia, Canberra.

Douglas, N. and O'Keeffe (2016) *Wider Economic Benefits – When and if they should be used in evaluation of transport projects*, Australian Transport Research Forum Proceedings.

Duranton, G. and Puga, D. (2004) Micro-foundations of urban agglomeration economies. In *Handbook of regional and urban economics* (Vol. 4, pp. 2063-2117), Elsevier.

European Commission (2013) *Manual on regional accounts methods*, Publications Office of the European Union, Luxembourg.

Graham, D.J., Gibbons, S. and Martin, R. (2009) *Transport investment and the distance decay of agglomeration benefits*. Report to the Department for Transport.

Graham, D.J. and Gibbons, S. (2019) Quantifying Wider Economic Impacts of agglomeration for transport appraisal: Existing evidence and future directions. *Economics of Transportation*, 19, pp. 100-121.

Harvey, M.O. (2019) The role of distance decay in estimating wider economic benefits from agglomeration, *Australasian Transport Research Forum 2019 Proceedings*.

Harvey, M.O. and Trott, D. (2020) *Estimating agglomeration elasticities using BLADE data*, Unpublished working paper, Bureau of Infrastructure, Transport and Research Economics (BITRE), Canberra.

Hensher, D., Truong, T., Mulley, C., & Ellison, R. (2012) Assessing the wider economy impacts of transport infrastructure investment with an illustrative application to the North-West Rail Link project in Sydney, Australia. *Journal of Transport Geography*, 24, 292-305.

Hensher, D.A., Ellison, R.B. and Mulley, C. (2014) Assessing the employment agglomeration and social accessibility impacts of high speed rail in Eastern Australia. *Transportation*, *41*(3), pp.463-493.

Johnson, D.H., Dargay, J. and Reilly, K. (2010) *Regional Productivity Differentials in Great Britain*. Report to the Department for Transport.

Kernohan, D. & Rognlien, L. (2011) *Wider economic impacts of transport investments in New Zealand*, NZ Transport Agency research report 448, Wellington.

KPMG (2017) *Measuring WEBs in Australian cities*. Department of Infrastructure and Regional Development. Canberra.

Laird, J.J. and Mackie, P.J. (2014) Wider economic benefits of transport schemes in remote rural areas. *Research in Transportation Economics*, *47*, pp.92-102.

Maré, D. C., & Graham, D. (2010) *Agglomeration Elasticities and Firm Heterogeneity*. London: SERC Discussion Paper 43. Spatial Economics Research Centre (SERC), London School of Economics and Political Science.

Melo, P.C., Graham, D.J. and Noland, R.B. (2009) A meta-analysis of estimates of urban agglomeration economies. *Regional science and urban economics*, 39(3), pp. 332-342.

New Zealand Transport Agency (NZTA) (2016) *Economic evaluation manual*, NZ Transport Agency, Wellington.

New Zealand Transport Agency (NZTA) (2020) *Monetised benefits and costs manual, version 1*.

Queensland Treasury and Trade (QTT) (2013) *Experimental Estimates of Gross Regional Product 2000-01, 2006-07 and 2010-11.* The State of Queensland.

Rawnsley, T. and Szafraneic, J. (2010) *Agglomeration and labour productivity in Australian cities*. Knowledge Cities World Summit, Melbourne.

SGS (2011) *Agglomeration Benefits of the Melbourne Metro: Final report*. Department of Transport, February.

Trubka, R.L. (2011) *Agglomeration Economies in Australian Cities: Productivity benefits of increasing urban density and accessibility*. PhD Thesis, Curtin University.

Venables, A.J. (2016) *Incorporating wider economic impacts within cost-benefit appraisal*, International Transport Forum discussion paper no. 2016/05) OECD Publishing.

UK Department for Transport (DfT) (2005) *Transport, Wider Economic Benefits, and Impacts on GDP*. UK Department for Transport.

UK Department for Transport (DfT) (2014) TAG UNIT A2.1 *Wider Impacts*.

UK Department for Transport (DfT) (2018) *Transport Analysis Guidance (TAG) UNIT A2.3: Employment effects*.

UK Department for Transport (DfT) (2020) *Transport Analysis Guidance (TAG) UNIT A2.4: Appraisal of productivity impacts*.

INFRASTRUCTURE AND TRANSPORT MINISTERS