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Wider Economic Benefits – When and if they should be used in evaluation of transport projects

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Abstract

In the early-mid 2000s, the CrossRail project in London demonstrated the increase in project net worth from adding Wider Economic Benefits (WEBs), in particular the benefits from agglomeration, as derived from the application of new economic geography.

Since CrossRail and with the adoption of United Kingdom (UK) Treasury style 'Business Case' evaluations in Australia and New Zealand (NZ), the augmentation of benefits for WEBs in major transport evaluations has become the norm. Nevertheless, despite approaching ten years of 'practice', WEBs remain poorly understood and not universally accepted.

The criticisms of WEBs largely concern the validity of the assumptions and their estimation and application in specific evaluations. For agglomeration benefits, there is confusion over 'static' versus 'dynamic' agglomeration, the concept of effective density, the direction of causality between transport interventions and agglomeration, the agglomeration elasticities and the measurement of transport cost. There is also insufficient understanding of the vertical structure of industries and the inter-relationships between economic activities including government. Dynamic agglomeration has, for modelling convenience, largely been assumed away. However the relationship between land use and density and constraints on land use can be argued to decouple the relationship between transport and the agglomeration.

In NZ, static agglomeration WEBs have been accepted into the 'official' evaluation framework. In Australia, Infrastructure Australia's framework requires the exclusion of WEBs in the central case evaluation with their inclusion as sensitivity tests to add 'texture'.

This paper reviews the basis and application of WEBs and summarises some of the major studies in Australia and NZ where they have been applied. The aim of the paper is to stimulate a debate on whether or not WEBs should be used, and help guide where further research could be undertaken to improve their accuracy and applicability.

1.0 Introduction

The conventional Cost Benefit Appraisal of transport projects has been a comparison of transport user benefits usually travel time and vehicle operating cost savings, accident savings and pollution related externality benefits with project costs (capital and recurrent).

There has always been the thought that there should be something more however. In the early-mid 2000s, the CrossRail project in London demonstrated the increase in project net worth from adding WEBs, in particular the benefits from agglomeration, as derived from the application of new economic geography.

Section 2 of this paper looks at the standard WEB framework developed initially in the UK and then subsequently in NZ. Section 3 looks at the theory behind agglomeration benefits which was given impetus in the 1990s with the developments in new economic geography. Section 4 looks at dynamic agglomeration and land use change which tends to have taken a back seat with the emphasis of WEBs on static agglomeration. Section 5 provides other criticisms that have been made with the application of WEBs. Section 6 provides some case examples where WEBs have been estimated for Australia, NZ and the UK, and section 7 makes some concluding remarks.

2.0 Standard WEB Framework

The UK Department for Transport (DFT) has developed a standard framework for assessing the WEBs of transport improvements. The framework is based around the theoretical work of Venables (2015) and the empirical estimates of Graham (2005). The NZ Transport Agency (NZTA) has largely adopted the same framework but with elasticities calibrated to NZ conditions. The method has also been applied in several Australian business cases but is not accepted by Infrastructure Australia into central case evaluation as at June 2016. More recently (August 2016), the Australian Transport Assessment and Planning Guidelines recommends that practitioners should follow Infrastructure Australia's advice and present evaluation results without WEBs, and then with WEBs, treating WEBs effectively as a sensitivity test.

Three categories of WEBs are outlined in the UK DFT Guidelines (2014), in the NZTA Economic Evaluation Manual (EEM), and the Australian guidelines:

WEB1 – Static agglomeration benefits

WEB2 – Output change in imperfectly competitive markets

WEB3 – Labour supply tax impacts (including labour supply impacts and moves to more or less productive jobs).

2.1 Static Agglomeration (WEB1)

The approach is to measure the effect of a transport improvement on 'economic scale' and 'density' through an 'Access to Economic Mass' $(ATEM_i)$ or 'Effective Density' measure for each location (i). The measure typically takes the form $ATEM_i = \sum_j f(D_{ij}) EMP_j$ which means that location i's access to economic mass, $ATEM_i$ is the sum of employment (EMP) in all districts (j) weighted by some function of the distance to i $(f(D_{ij}))$. With this specification, if a location is near to other locations with high employment it will have a high $ATEM$.

The second step links a location's $ATEM$ to its productivity $(PROD_i)$ through the relationship, $PROD = f(ATEM_i)$. As section 3.0 will show, there have been many studies that have attempted to estimate the underlying relationships using different specifications of economic distance (distance, generalised cost) and with economic activity measured by employment or firms or other criteria and with various controls imposed to take account of other determinants of productivity.

The third step sums across all the locations to calculate a system-wide measure before and after the transport improvement.

2.2 Imperfect Competition (WEB2)

Under perfect competition, equilibrium output is where price equals marginal costs and the value of additional production equals the gross marginal labour cost of additional hours worked. Conventional economics measures the value of the travel time savings during work as the saving in gross labour cost but if price cost margins exist, a 'wedge' between gross labour costs and the market value of what is produced is introduced. As a result, a transport-induced increase in output will cause WEB2 identical to the size of the 'wedge'. Figure 1 helps illustrate the size of the 'wedge'.

Figure 1: Effect of Imperfect Competition

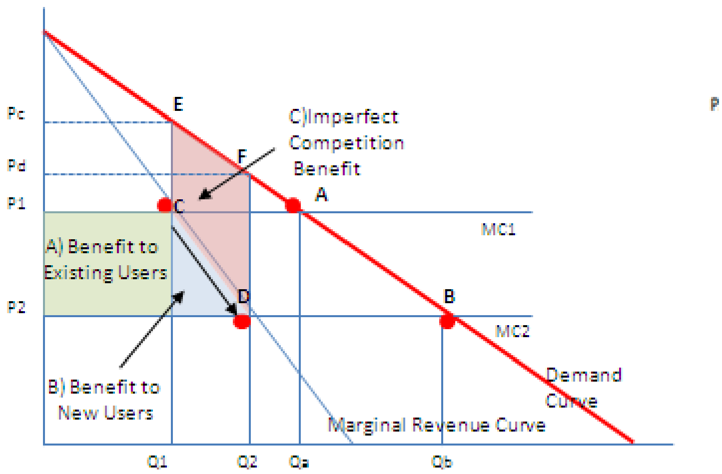

Figure 1 shows the effect of a fall in marginal cost from MC1 to MC2 associated with an improvement in transport infrastructure which moves the equilibrium position from C to D, (compared with A to B in the perfectly competitive case). Firms expand output from Q1 to Q2 with the increase in welfare equal to rectangle A + triangle B + trapezium C. The trapezium C equals the extra gains from increased output in an imperfectly competitive market which are omitted by the standard approach. The easiest way to calculate area C is as a proportion of A+B. The proportion (τ) can be determined by reference to the average price cost margin $((P-MC)/MC)$ and the aggregate demand elasticity (ε) through the equation:

$$\tau = \frac{\varepsilon PMC}{(\varepsilon PMC)-1}.$$

For the UK and also NZ, a price - cost margin of 20% and a demand elasticity of -0.6 (having been adopted as default parameters) gives an estimated WEB2 from imperfect competition of 10.7% of conventional business time savings plus vehicle operating cost savings (to both passengers and freight).

In terms of size, the NZTA EEM comments that imperfect competition can add 5% to conventional transport user benefits.

Not included are benefits from increased competition reducing the P-MC margin towards zero. In this regard, the UK DFT considers it unlikely for transport improvements to increase competition. Indeed, it considers that there is a potential for negative impacts if increased integration leads to fewer sellers holding greater market power.

2.3 Increased Labour Supply (WEB3)

WEB3 from increased labour supply is argued to occur from the presence of a ‘tax wedge’ on wage income. This means that when people choose to supply more of labour they generate a positive externality equal to the tax wedge between gross and net income. Improved transport by reducing commuting transport times is argued to increase labour participation.

The UK DFT has developed a framework which takes account of the elasticity of labour supply with wages and average tax rates. For NZ an elasticity of 0.4, an average income tax take of 33% and tax wedge for new entrants of 26% have been derived by Kernohan and Rognlien (2010). These parameters have been adopted in the NZTA EEM which typically adds 10% in benefits when compared to conventional transport user benefits.

3.0 New Economic Geography

The basis for agglomeration benefits, by far the largest component of WEBs, can be sourced back to the new economic geography theories advanced by Krugman (1991a), ,Fujita and Thisse (2002) and Duranton and Puga (2005), who sought to explain the agglomeration of economic activity, and in so doing get *“economists to think about location and spatial structure” (*Krugman, 2010).

The prefix ‘new’ in new economic geography is somewhat of a misnomer however since the ideas date much further back to Marshall (1890) who theorised that agglomeration by reducing the ‘*transport costs’ of goods, people and ideas improved economic performance’*. Marshall (1890) argued that firms by locating near suppliers and customers saved transport costs as did labour market ‘pooling’ of specialised skills. Intellectual ‘spill-overs’ whereby *“the mysteries of the trade become no mystery, but are, as it were, in the air”* were the third source of agglomeration benefits. Of the three sources, only the third appears, at first blush, to be additional to conventional travel time and vehicle operating cost savings however.

Hotelling (1929) showed, in contrast to Marshall, how ‘spatial’ competition for market share could lead to over agglomeration and economic disbenefit. The oft cited example is of ice cream sellers gravitating to the centre of the beach where a stable competitive solution was reached. However in doing so they increased the average sunbather’s walk to the ice cream stall compared to a ‘planned solution’ where the stalls would be spread out evenly.[1] The result of locational decisions made independently by firms, Hotelling (1929) argued, was for *“our cities to become uneconomically large and the business districts within them are too concentrated”*. Thus for Hotelling, myopic competitive behaviour caused negative wider economic benefit.

Krugman (1991b), through economic modelling, sought to explain the development of cities and, in so doing, assess whether the economic outcome was positive as hypothesised by Marshall or negative as hypothesised by Hotelling. Krugman’s ‘core-periphery’ model took account of economies of scale, transport costs, and market size but omitted Marshall’s

[1] Hotelling showed that the stable competitive position for two ice cream sellers on a beach with evenly distribute customers would be in the middle whereas the planned solution which minimized walking distance would be a quarter and three-quarters along the beach. It can be shown that the competitive solution would increase walking distances by an eighth on the planned solution. Thus for the competitive ‘agglomerated’ solution to beat the planned ‘spaced out’ solution would require demand or supply advantages that outweighed the one eighth increase in walking distance.

intellectual spill-overs which Krugman considered ‘dormative’ and ‘invisible’.[2] In Krugman’s model, increasing returns at the manufacturing plant level created an incentive for a geographical concentration of production. Transport costs created an incentive to locate plants closer to large markets. Under the right conditions, Krugman found that circular causation resulted in increasing agglomeration.

Alongside the theory, hundreds of empirical studies have been undertaken to quantify the effects of agglomeration on productivity. Most studies have focused on manufacturing productivity with fewer studies on the service sector, government and education which tend to dominate city activity. Table 1, borrowing from Venables (2015) with other studies added, provides a summary of the estimated productivity elasticities.

Table 1: Review of Agglomeration Productivity Elasticities

Unit of Observation	Study	Productivity Elasticity with Respect to Agglomeration	Distance Decay	Controls
Places	Ciccone & Hall (1996)	0.03	Fixed	Education
	Rosenthal & Strange (2004)	0.05 - 0.11		Review
	Rice et al (2006)	0.04	Travel Time	Occupation skill
	Graham (2007)	0.01 - 0.2		Review
	Melo (2009)	0.03		Review
Firms	Graham (2009) UK	Manufacturing 0.021 Construction 0.034 Consumer Services 0.024 Business Services 0.083 Average 0.043	Distance	Firm characteristics e.g. age of firm
Workers	Combes (2008) France	0.024 - 0.035	Fixed	Occupation, age skill, experience
	Puga & Roca (2012) Spain	0.023 - 0.046	Fixed	
	SERC (2009) Car UK	0.05 - 0.08	Gen Time	
	SERC (2009) Rail UK	0.05 - 0.258	Gen Time	

Source: Based on Venables (2015) with other studies added

Rosenthal and Strange (2004) found from a review of studies that “in sum, doubling city size seems to increase productivity by an amount that ranges from roughly 3-8%”. These results imply an elasticity of productivity with respect to city size of 0.05 to 0.11. A review of 19 studies by Graham (2007) established a range in urbanisation manufacturing productivity elasticities of 0.01 to 0.2 with most values under 0.1. A meta-analysis by Melo (2009) of several hundred studies produced a lower elasticity of 0.03. Similar elasticity values have been estimated using firm and worker data controlled for various characteristics. For example, the study by Graham (2009) which provides the values for UK DFT for transport evaluations, estimated elasticities from 0.021 for manufacturing to 0.083 for business services with an average value of 0.043. In summary, the empirical studies do provide evidence of increased productivity from increased city size.

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[2] Krugman wanted to avoid ‘dormitive properties’ (a reference to Moliere’s doctor, who triumphantly explains that opium puts people to sleep because of its ‘dormitive properties’). The economics equivalent is the assertion that production clumps together because of agglomeration economies. Krugman wanted to derive the agglomeration economies which meant downplaying invisible external economies like information spillovers.

Using the framework presented by Veryard (2016), Figure 1 shows how the insights and techniques from economic geography have been fed into the Cost Benefit Appraisal of transport initiatives.

On the left hand side of Figure 2, the conventional effects of transport initiatives are shown as savings in time and cost to the users of the network.

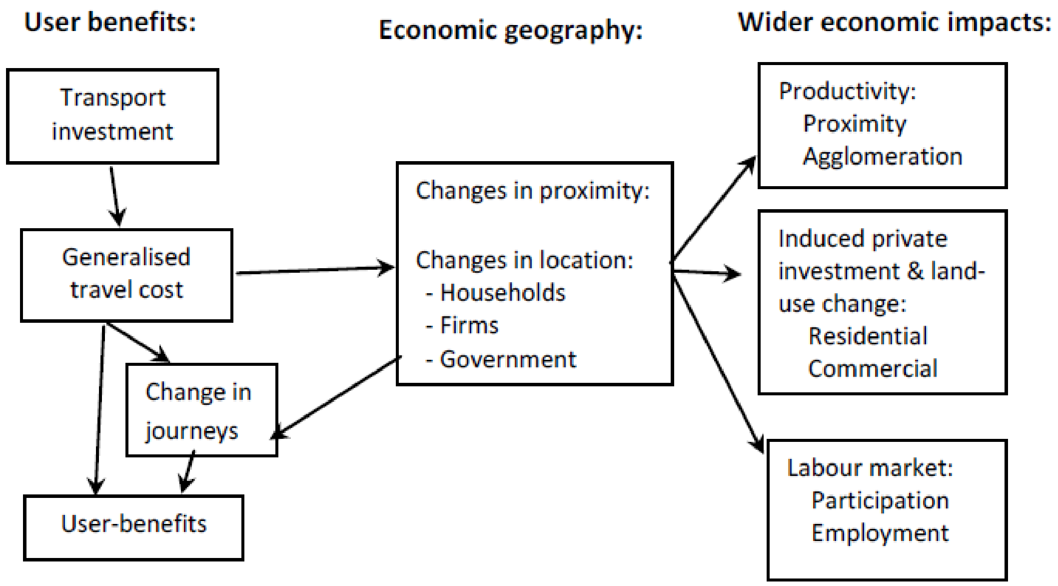
The central box describes the changes in economic geography or proximity, which have been neglected by transport models and hence standard Cost Benefit Analysis (CBA).

WEBs, shown on the right hand side of Figure 2 stem from two types of effect. The first type of effect is static agglomeration which results from the transport initiative improving ‘economic proximity’ despite the location of economic activity (land-use) remaining unchanged or ‘static’. By increasing effective density, larger and deeper labour and product markets are creating increased productivity.

Transport improvements may also cause dynamic agglomeration effects by making some places become more attractive to invest thereby creating jobs and increasing wages and income. The social value effects of these dynamic effects are harder to assess however, because expansion in one area may simply be the expense of another area.

Finally, changes in location and economic activity are also likely to affect the level and pattern of travel and hence produce ‘feedback’ effects on the level of transport user benefits.

Figure 2: Transport User Benefit, Economic Geography & Wider Economic Impacts



Source: Veryard (2016)

4.0 Land Use Change and Dynamic Agglomeration

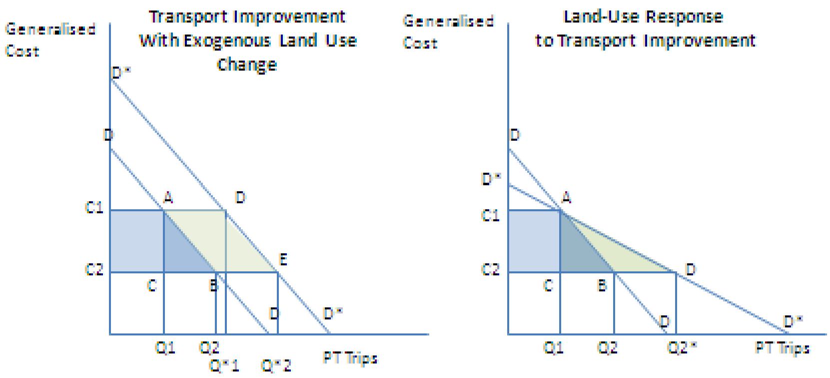
4.1 Conventional Appraisal

Most transport appraisals, allow for future increases in demand due to population and employment to increase transport user benefit. These changes are usually ‘exogenous’ to the project i.e. they would happen in both the Base Case and Project Cases.

The diagram on the left hand side of Figure 3 shows how transport user benefit (in this case, public transport (PT)) would be measured with an exogenous increase in demand for PT shifting the demand curve from D to D*. The PT project reduces the generalized cost of travel from C1 to C2. Before the exogenous shift in demand, PT demand increases from Q1 to Q2 with the benefit to PT users equal to rectangle (C1-C2).(Q1) plus the benefit to new users ½(C1-C2)(Q2-Q1). Total transport user benefit is the trapezium C1ABC2. With exogenous growth, the benefit would increase by the size of the demand shift to C1DEC2.

The right hand diagram shows the situation where the transport improvement induces a change in land-use. In addition to diverted trips, the project also generates trips from additional residents/employees. Reflecting this, the demand curve D* is more responsive (flatter) with transport user benefit equal to the trapezium C1ADC2.

Figure 3: Conventional Transport Benefits & Land Use Change



Infrastructure Australia's current evaluation framework requires that if land use change does change as a result of the project then *"typical transport user benefits should be based on fixed land use scenarios only (using the Base Case land use in the Project Case)"*.[3]

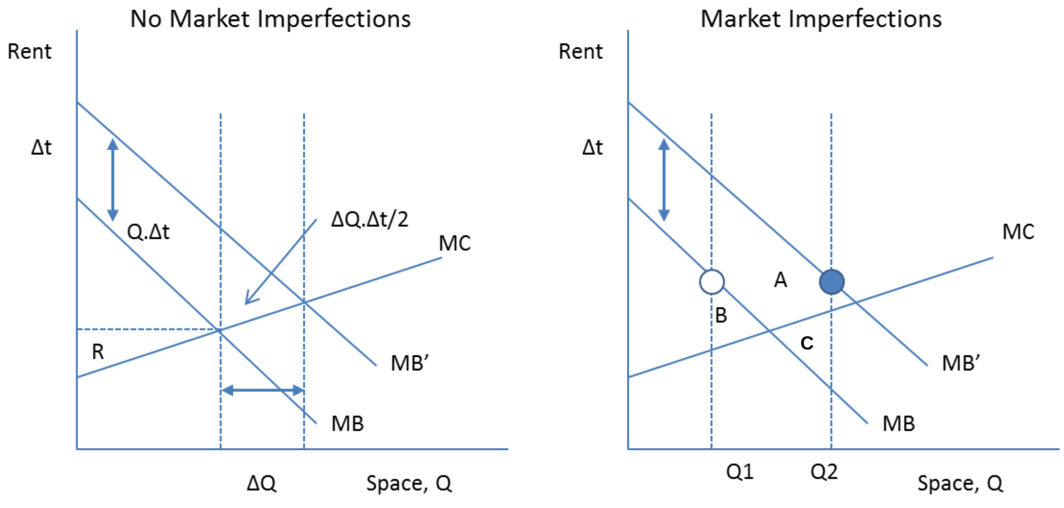
4.2 Effect of Transport Improvement & Land Use Change

Venables (2015) has looked at the effect of transport improvements in 'unlocking' changes in land-use to assess the circumstances under which there will be benefits additional to those accounted under conventional transport user benefits.

Figure 4 shows two situations: a perfectly competitive market on the left and a market with imperfections on the right. In both diagrams, the horizontal axis measures the space available on a piece of land (with space varying because of the possibility of building taller buildings or because a fraction of the land area is initially used). The marginal cost of space (building taller) is the rising MC curve. MB denotes the demand curves for space.

[3] Infrastructure Australia Assessment Framework - Detailed Technical Guidance p40 footnote 23.

Figure 4: Land-Use & Dependent Development



Source: Venables (2015)

In the perfectly competitive market (left hand diagram), the initial equilibrium is the white circle with total rent paid equal to triangle R. Improving access creates shifts the demand curve to MB' with user-benefits equal to Δt. The new equilibrium is the solid circle with total user benefit equal to the conventional rule of a half Q.Δt +ΔQ.Δt/2. There are no wider economic benefits.

The right hand diagram shows the same transport improvement but with sub-optimal situations before Q1 and after Q2 with rent greater than marginal cost. The benefit from the improvement is Q1.Δt + A +B, whereas the standard 'rule-of-half' benefit would be Q1.Δt+ΔQ.Δt/2 = Q1.Δt + (A+C)/2. Conventional transport user benefit would underestimate the gain because at the margin, an activity has been expanded that is valued higher than the marginal cost.

Restrictive planning controls with permission for development given only when a transport improvement is made or where planning controls are tighter than socially optimal (after taking account of congestion and other environmental externalities) would be a reason for market imperfections.

Coordination failure and low level traps (where nobody invests anywhere) are a third source of market imperfection. To break the low level trap, government could improve transport that gives initial developers a competitive advantage or a reason to invest in a regeneration area. Venables concludes that the transport provision is unlikely to be transformative alone.

The experience in Australia has been that transport interventions have usually been in advance of, during or subsequent to overall land developments and it is difficult to isolate the transport component of overall benefit. For instance in the Inner West of Sydney, the first stage of the Sydney Light Rail (opened 1997) was part of urban renewal of the Darling Harbour and Pyrmont that began in the late 1980s and continued through the 1990s.

In Brisbane, $86 million of urban renewal activity by Government within the Newstead-Teneriffe area commencing in the mid late 1990's has been argued to have stimulated $5.5 billion in private sector investment in new residential and commercial development[4]. The investment in transport (e.g. augmented bus services such as the high frequency CityGlider

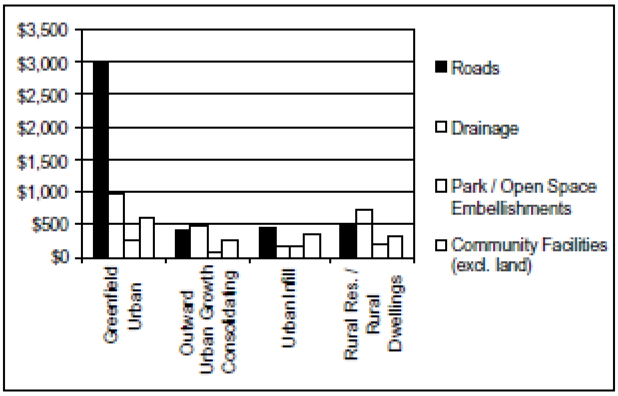
[4] Property Council & QUT (2016) Investing in Australian Cities, The Legacy of the Better Cities Program.

implemented in 2010) was only a small part of this scope of Government investment, which included a major upgrade of the main sewer line. Although urban renewal investment has accelerated in the area since 2010, this can be attributed to decisions of major anchor tenants (e.g. Bank of Queensland, TAB Corp) to relocate, low interest rates and international investment. In the equivalent period, further transport related investment has been on a smaller scale with a ferry terminal renewal.

4.3 Urban Consolidation Benefits

Urban consolidation is the process of raising city densities through redevelopment or infill that can utilise existing infrastructure, and through higher density housing generally (Industry Commission,1993). Studies have looked at the costs of consolidated growth in established urban areas with fringe development and generally shown net savings can be made by accommodating more households in infill and redevelopment situations. Figure 5 shows that a large proportion of infrastructure savings is from the augmentation of 'physical' infrastructure (water supply, sewerage, drainage, roads, power and telecommunications).

Figure 5: Weighted Average Costs of Infrastructure Augmentation (Selected Items) per Dwelling Victoria 2001



Source: Development Contributions Review Steering Committee, Victoria, 2002

During the 1990s, urban rail projects in Sydney included benefits from the encouragement of 'brown field' rather than peripheral 'green field' development. An example is the Airport Rail Link (ARL) Economic Evaluation undertaken by Denis Johnson and Associates (1994) for the NSW Department of Transport. The evaluation include the 'urban consolidation savings' from redevelopment of the Central Industrial Area of Sydney from the construction of Green Square and Mascot stations.

Since the 1990s, the funding of infrastructure in Australia has moved towards a user pays basis through commercialisation, corporatisation and privatisation of infrastructure agencies, and through the extension of development contribution policies within statutory planning systems (SGS Economic and Planning, 2003). With a correctly configured user pays system, metropolitan policy makers, as the Industry Commission in the 1990s argued[5,] should be indifferent as to whether households choose locations of high or low physical infrastructure costs as these households will be making trade-offs which are best for them.

5 Industry Commission *"Taxation and Financial Policy Impacts on Urban Settlement",* The Industry Commission. Vol. 1, No. 30, April 1993.

The current (2016) Transport Infrastructure Council's (TIC) stance regarding the inclusion of urban consolidation infrastructure savings in transport Cost Benefit Appraisal reflects 'user pays' infrastructure charging: *"If prices (and hence changes in willingness-to-pay) equal marginal social costs, there are no additional net benefits. For example, if the households and businesses that locate on the urban fringes in the base case pay for the full resource cost of the additional land, infrastructure and services they require and the externalities they create, the resource cost is fully offset by the benefits to the land users."*

Thus TIC argues that *"There are only benefits to the extent that prices are below marginal social costs. For example, if the governments meet some of the costs of establishing and maintaining new outer suburbs in the base case, there is a net benefit from not having to create these suburbs in the project case. However, the benefit is limited to the difference between the resource cost and the private cost incurred by people who move to the new outer suburbs in the base case, not the full avoided resource cost of the creating the new suburbs. In other words, the benefit of the saving in the resource costs of creating and maintaining the new outer suburbs has to be reduced by the lost willingness-to-pay of the people who would have lived in those suburbs."*

5.0 Criticisms of WEBs

A range of concerns have been raised about the direction, size and estimation of agglomeration benefits.

1. Does proximity always lead to productivity gains?
2. Difficulties in observing the externality effects of agglomeration
3. Publications bias – the tendency to publish results that support agglomeration but not publish results that contradict it
4. Transferability of parameters - using parameters estimated in one country in evaluations undertaken in another.
5. Causality – does transport produce the agglomeration or agglomeration produce the transport.
6. Estimating transport costs
7. Static versus dynamic agglomeration

5.1 Proximity & Productivity Gains

Work by Graham (2007) has suggested that there are industries in which agglomeration is a disadvantage and pointed to UK Standard Industry Classification (SIC) 25 (ie. rubber and rubber products, and medical and precision equipment) with negative elasticities of agglomeration with respect to productivity. Graham (2007) explained that there are three principal reasons for negative estimates. Firstly, it may be an indication that firms within these industries tend to be more productive where effective employment densities are lower. Secondly, market competition for output may be more intense in dense areas, therefore lowering prices and therefore measured output, and thirdly because of non-linear agglomeration effects that are being estimated linearly.

This aspect is particularly relevant in Australia where many projects are outside the "relatively dense" inner urban areas, and the level of industry is lighter.

5.2 Difficulties in Observing the Externality Effect of Agglomeration

Graham, one of the world's leading experts, considers that a limitation of agglomeration is that the *"identification of agglomeration economies is fraught with difficulties"* because the actual processes that give rise to externalities are unobservable, (e.g. Krugman's invisible intellectual spillovers) (Graham 2007). In addition, Graham considers that the *"measurement and analysis of productive efficiency poses a number of problems, as do the classifications available to describe industrial and functional heterogeneity."* As a consequence, Graham argues that the empirical literature has not been able to determine the source of productivity effects thus in the context of transport appraisal, it is not possible to know what share of agglomeration benefits are due to transport movements.

5.3 Publication Bias

Melo, Graham and Noland et al. (2013) raised the issue of publication bias that strengthens the argument that as transport investment boosts output, so output elasticity estimates are expected to be positive and statistically significant. Bias could come from both researchers and reviewers. Melo et al. (2013) tested this theory by examining the standard errors associated with the estimates of elasticity from a number of papers going back to 1995, and concluded that there is no evidence of positive publication bias in the results reported.

5.4 Transferability of Parameters

One of the key problems with the estimation of agglomeration effects is the paucity of data relevant to the industries being surveyed. Graham (2007) for instance pointed out at that time that there were no readily available measures of agglomeration for British metropolitan areas and little understanding of the agglomeration effects between adjoining urban areas such as greater Manchester and Liverpool.

When the WEBs methodology was introduced into Australia, the tendency was to use elasticities from the UK in the absence of any local meaningful data. The exception has been in the large projects around Australia where the time and investment has been made to estimate elasticities specific to the urban areas where the projects are located. As well as providing "quick" estimates of agglomeration benefits, it can also result in overestimations of "uplift" factors in using data borrowed from locations such as London as indicated by Dobes (2015). Melo et al. also identified the problems in using elasticities across countries of different stages of development as well as differences between the US and Europe, with the explanation that the higher usage of road transport in the US affects the elasticity estimate.

5.5 Causality

Dobes (2013) argues that the "Achilles' heel" of empirically estimated agglomeration economies is causality which he argues has rarely been demonstrated in CBAs.

Dobes (2013), quoting the work of Laird and Mackie (2010), argued that the estimates of Gross Value Added (GVA) were overstated in relationship to the size of overall project.

The issue of displacement of activity has been raised in that improved transport supply to and within one region can result in the displacement of economic activity from other regions. Displacement has been observed in high speed rail projects in Spain (Albilate and Bel 2010).

5.6 Transport Costs

Measuring the distance decay function is problematic especially in a multi-modal context. If a new public transport mode is introduced, should a mode-weighted average travel time be used (which might increase) or a composite cost measure directly related to the demand model (typically the 'logsum')?

5.7 Focus on "static agglomeration" rather than "dynamic agglomeration"

Much of WEBs emphasizes static agglomeration which is estimatable but invisible and largely unprovable. Dynamic agglomeration is an observable response which can be forecast and assessed post implementation. The problem (like static agglomeration) is attributing agglomeration to the transport improvement as outlined in Section 4.2 and 4.3. There is also the need to take account of the disbenefit to areas which are weakened.

6.0 Case Studies

In this section, seven case studies are reviewed to assess the calculation and estimated WEBs in relation to conventional transport user benefits:

- London CrossRail
- Auckland City Centre Rail Link & Waitemata Harbour Crossing
- Brisbane Cross River Rail
- Sydney North West Rail Link
- West Connex Road Project Sydney
- Melbourne Metro
- Canberra Light Rail.

6.1 London CrossRail

The first major application of WEBs and the example most often cited was CrossRail in London. CrossRail is a 21 kilometre largely underground rail link connecting the Great Western Main line near Paddington with the Great Eastern Main Line near Stratford. The western section is due to be operational in 2018 and eastern section in 2019. The economic case for CrossRail centred around new private sector investment producing increased employment densities around CrossRail stations that would attract 100,000 additional jobs and bring an additional 1.5 million people within a 45 minute commute of the employment centres of the West End, City and Canary Wharf.

Early evaluations of Crossrail used agglomeration elasticities taken from US studies with city size productivity elasticities ranging from 0.04 to 0.11. In 2005, the UK Department for Transport (DFT 2005) undertook a new CBA evaluation using a WEBs methodology developed by Venables (2007) and agglomeration elasticities estimated by Graham (2005). These elasticities were higher than the USA estimates with an average value of 0.12. Subsequent work by Graham (2009) estimated lower elasticities that averaged 0.043 and are thus more in line with the US estimates.

With only conventional transport user benefits included, CrossRail benefits totalled £52.5 billion compared to costs of £26.6 billion. At 1.97, the resultant Benefit Cost Ratio (BCR) was not considered high enough by the DFT for funding purposes. Agglomeration benefits were estimated at £12.6 billion (24% of the transport user benefits) with labour supply WEBs (movement to more productive jobs) adding £29.9 billion (32%). With both WEBs included, the BCR increased to 3.2. This is the highest observed estimate of WEBs, reflecting the size and power of the London economy.

6.2 Auckland – City Centre Rail Link & Waitemata Harbour Crossing

The inclusion of WEBs into the evaluation of the City Centre Rail Link (CCRL) generated much debate between Local and Central Government. Following the preparation of the Business Case by consultants APB&B, the methodology was reviewed.

In the original business case, a source of agglomeration benefit was a predicted increase in employment in the CBD from the CCRL. For 2041, the predicted employment uplift was 22,000 jobs which was a 15% increase on 'Base Case' CBD employment of 144,000. The economic benefit was calculated by multiplying the additional employment with the additional premium wage differential that an employee would earn in the CBD rather than elsewhere in Auckland. The additional value was calculated at $3.3 billion.

The more conventional 'static' agglomeration benefit was not included in the WEB analysis as it was considered included in the employment estimate. The review took a different stance and suggested that agglomeration was different to employment changes outlined above and should be included. The review calculated effective density by reference to total employment rather than individual industry sectors. An overall productivity elasticity of 0.078 was also used rather than the NZTA economy wide estimate of 0.063. Agglomeration was considered likely to contribute 33% to 52% of conventional transport user benefits which is relatively high in comparison to other studies.

In 2010, the NZTA commissioned Steer Davies Gleave to develop a WEBs methodology for NZ using existing practical approaches and the latest academic evidence. The methodology necessarily borrowed from the UK but included NZ agglomeration elasticities and calibrated parameters to NZ conditions. The study also required the methodology to include a case study.

The proposed Additional Waitemata Harbour Crossing (AWHC) was selected. Around 170,000 vehicles use the existing Auckland Harbour Bridge per day with population and economic growth expected to increase the number by 22% by 2041. The preliminary business case for an additional AWHC saw benefits from reduced congestion and improved access; increased resilience from a 'backup' facility; and, improved opportunities for public transport, walking and cycling (NZTA, 2010a).

Agglomeration benefits were estimated at $72 million which was 22% of conventional user benefits estimated at $322 million. Labour supply WEBs added 22 million (7%) and imperfect competition 4%.

6.3 Brisbane Cross River Rail

Brisbane Cross River Rail (CRR) was first proposed as a 9 kilometre underground rail link from Salisbury in the South of Brisbane CBD to Bowen Hills in the north. By providing two additional tracks through Brisbane's CBD, CRR provides an alternative river crossing in the inner city to the Merivale Bridge.[6]

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[6] With the preparation of the Environmental Impact Statement (EIS) of CRR in 2011, the project was substantially re-scoped with a bus tunnel and developed as the Bus and Train (BaT) project. The BaT project was abandoned in early 2015 and the CRR revisited. The commentary below therefore refers to the original project of 2011.

Graham (who developed the agglomeration elasticities for London CrossRail) was commissioned to review the evidence for agglomeration elasticities in Australia and found no suitable estimates. In their absence, UK agglomeration elasticities were used for CRR and justified on the basis that the variation in agglomeration elasticities between sectors was likely to be much stronger than variation across cities and countries (Deloitte 2011).

The calculated elasticities ranged from 0.004 in Herston at the northern end of the link to 0.043 in the inner city. Although one would expect that agglomeration elasticities to be highest in the inner city, there were higher elasticities for outer residential suburbs such as Chapel Hill and Bridgeman Downs.

Due to the low density of employment compared to London CrossRail, the average agglomeration elasticity was estimated to be significantly lower. For a capital cost of $4.5 billion, the total user benefit in the first year of operation (2021) was $362 million with agglomeration being an additional $52 million. The next significant WEB was labour supply with a benefit of only $17 million in 2021. The other WEBs were insignificant. The BCR for the project at a 7% discount was 1.42 and 1.63 with WEBs.

The Brisbane analysis shows that in an early application of WEBs in the Australian context, that the agglomeration elasticity is relatively flat and that the application of WEBs does not raise the BCR significantly.

6.4 Sydney North West Rail Link

The North West Rail link (NWRL) is a 23 kilometre largely underground rail line between Rouse Hill and Epping where it connects to the Sydney rail network. The project includes six new stations and serves a population of 360,000, growing to 485,000 by 2021, and by 2036, the rail link is expected to service a region with more than 145,000 jobs.

Hensher (2012) estimated a set of agglomeration elasticities using an integrated transport-location-economy-wide model system known as TRESIS-SGEM which simulates individual, household and vehicle travel choices.

Legaspi et al (2015) estimated an overall increase in effective density from the NWRL of 0.3%. Agglomeration benefits added $321 million (5%) to conventional transport user benefits of $6.4 billion with other WEBs (imperfect competition and labour supply) adding $185 million. The result was to increase the BCR from 0.9 to 0.97.

6.5 WestConnex Sydney

The WestConnex project is a network of approximately 33 kilometres of road projects within Inner Western Sydney connecting the M5 and M4 motorways as well as providing enhanced access to Sydney Airport and the Port of Sydney. The agglomeration elasticities estimated by Hensher (2012) were used.

Increases in effective density were primarily in the areas around Balmain and Mascot, with marginal improvements elsewhere. The bulk of the estimated agglomeration benefit was attributable to the Sydney CBD due to high employment density but with small improvements. In Mascot, agglomeration benefits were somewhat less due to a large increase in effective density but with lower employment density.

Agglomeration benefits were calculated as $1.7 billion, 7% of conventional transport user benefits of $22.2 billion. Labour supply (WEB2) added a further 2% to conventional benefit. The result of including WEBs was an increase in the BCR from 1.71 to 1.88.

6.6 Melbourne Metro

The Melbourne Metro is an underground rail project consisting of two 9-kilometre rail tunnels from South Kensington to South Yarra via the CBD with five new underground stations. The line will run from the north-west to the south-east and combine the Sunbury Line with the Cranbourne/Pakenham Line.

Two estimates have been undertaken of agglomeration elasticities in Melbourne. The first general estimate for Melbourne was by Rawnsley and Szafraneic (2010). The key findings were that for all industries, a doubling of the job density increased labour productivity by 7%. Firms in the manufacturing and wholesale trade industries were not influenced by agglomeration. Both in manufacturing and wholesale trade as well as transport and storage, the level of agglomeration leads to a reverse effect over time as increased competition for land (resulting in increased rents and land prices) result in firms moving elsewhere. Finance and insurance, property and business services, education and health & community services are industries likely to benefit the most from agglomeration.

In their analysis they also pointed to some trends not related to transport. The Accommodation, Cafes and Restaurants industry elasticity may due to establishments congregating around particular locations for their beauty or amenity (e.g. The Yarra Valley). The cultural and recreational services cluster around existing employment centres, e.g. the CBD, for the reason of the large pool of potential customers. The highest productivity for Government is around the CBD because that is simply where Government (and the Parliament) is located. Construction (with a relatively high elasticity) is due to demand for buildings occurring in areas of high agglomeration. It is questionable whether this industry should be included. The short term nature of construction and the fact that construction is happening due to other factors (low interest rates, foreign investment boom) makes it questionable as to whether it can be attributable to a transport intervention.

The second set of agglomeration elasticities were made for the Metro Business Case itself and they differ in several regards from the Rawnsley and Szafraneic estimates. The Victorian Survey of Travel and Activity was used to derive a decay curve that explains the relationship between travel time for business to business trips and effective employment density rather than using the generally accepted exponential factor. The exponential factor derived was -0.05 which compares with Graham's estimate of -0.07.

The Melbourne Metro Business Case did not make clear whether the agglomeration estimation includes an expansion of employment within Melbourne or redistributes the same jobs as was done for the Sydney NWRL. However, the assessment did allow for agglomeration benefits by industry and for a spatial distribution of agglomeration effects with the CBD.

In total, agglomeration provided an additional $1.5 billion in benefits which was 19% of the total conventional benefit. Labour supply benefits provided an equal amount of benefit, lifting the overall BCR from 1.1 to 1.5.

6.7 Canberra Capital Metro Light Rail

The Capital Metro Project is a proposed 12 km light rail line between the northern suburb of Gunghalin and the city centre. Capital Metro the project proponent identified urban densification as a key benefit with the business case (p 68) stating: *"land use change and urban renewal induced by an integrated transport system underpinned by light rail will enable greater access to jobs as well as better services and facilities for the people of Canberra".*

The BCR was only 0.49 when limited to conventional transport user benefits. Two additional economic benefits were brought into the BCR labelled “Wider Economic Benefits” and “Land Use Benefits” which increased the BCR to 1.2. In presenting the BCR, land use benefits were included with transport user benefits to give a reported BCR of 1.0. Adding in WEBs, increased the BCR to 1.2.

In total, WEBs added $198 million, 49% of conventional transport user benefits. The assessment followed UK Guidelines but used Australian evidence. Key assumptions included a doubling of employment density increasing productivity by around 5%[7]; increased distance from the city centre by 1% decreasing productivity by 0.13% and doubling travel time to the city centre decreasing productivity by 15%. Agglomeration elasticities estimated by Hensher for the Sydney North West Rail Link were used (see Section 4.3). In total, agglomeration benefits totalled $165 million. Tax from increased labour supply added $31 million and increased output from imperfect competition added $2 million.

Land use benefits were larger than WEBs and totalled $381 million, 94% of conventional transport user benefits. Three types of benefit were included: (i) ‘Urban densification benefits’ worth $72 million from ‘agglomeration’ (the productivity uplift from increased density of urban areas), job productivity (increase in Gross Regional Product per worker from locating jobs in productive locations) and energy efficiency from urban infill versus Greenfield development (ii) ‘value of change in land use’ worth $168 million from LRT unlocking additional development, employment and population along the corridor and (iii) infrastructure efficiency savings worth $140 million.

6.8 Comparisons of Agglomeration Estimates

Although the overall urban form of the Australia’s East Coast capital cities are reasonably similar, with broadly similar industry densities, the estimated agglomeration elasticities vary quite noticeably as can be seen from Table 2.

Certainly the estimates of WEBs across the three Eastern Australian Capital cities reflect the differing locations and differing economies of the cities as well as different stages of the development of the methodology. The Melbourne Metro has the largest relative benefit from agglomeration due to the metro being focussed on the CBD where agglomeration effects are already happening. This is in accordance with Rawnsley and Szafraneic’s (2010) work on the relationship between productivity and the size of the city and the existing spatial interactions.

The agglomeration benefits associated with each of the schemes in Australia are shown in Table 3 and are compared to London’s CrossRail. Some interesting trends emerge. CBD oriented projects all reflect the high density of employment that they target and show a consistent level of agglomeration benefit, with Melbourne showing a higher level of agglomeration, reflective of the larger economy than Brisbane or Auckland, two cities of a similar size. Both NWRL and WestConnex appear to show the largest agglomeration benefits in mid-western Sydney, and although the largest area of economic concentration in the Australia is the Sydney CBD, it seems to only obtain a marginal benefit from these projects. In addition, the proportion of agglomeration benefit appears to be independent upon the type of project, whether road or rail.

[7] Cited in SGS for the Council of Australian Governments, Productivity and Agglomeration Benefits in Australian Capital Cities, June 2012

Table 2: Comparison of Agglomeration Elasticities

Industry by ANZSIC Divisions	UK1	UK2	NZ	SYD	MEL 1	MEL 2
A - Agriculture Forestry and Fishing	-	0	0.032	0.047	0.07	0.09
B - Mining	-	0	0.035	0.163	0.07	0.09
C - Manufacturing	0.077	0.047	0.061	0.035	-0.04	0.09
D - Electricity Gas & Water Supply	-	0	0.035	0.108	0.07	0
E - Construction	0.072	0.072	0.056	0.051	0.11	0.08
F - Wholesale Trade	-	0.042	0.086	0.034	0.01	0.05
G - Retail Trade	-	0.042	0.086	0.003	0.08	0.12
H - Accommodation Cafes & Restaurants	-	0.042	0.056	-0.011	0.09	0.05
I - Transport and Storage	0.223	0.168	0.057	0.044	-0.09	0.02
J - Communication Services	0.082	0.168	0.068	0.051	0.07	0.07
K - Finance and Insurance	0.237	0.116	0.087	0.058	0.13	0.05
L - Property and Business Services	0.192	0.020	0.087	0.057	0.18	0.07
M - Government Admin & Defence	-	0.004	0.087	0.049	0.01	0.08
N - Education	-	0.004	0.076	0.047	0.05	0.05
O- Health and Community Services	-	0.004	0.083	0.029	0.1	0.1
P - Cultural and Recreational Services	-	0.004	0.053	0.032	0.29	0.06
Q - Personal and Other Services	-	0.004	0.065	0.007	0.07	na
Not stated	-	0.043	0.065	0.021	0.07	na
Overall	**0.119**	**0.043**	**0.065**	**0.021**	**0.07**	**0.09**

Source: UK1 Graham (2005); UK2 Graham (2009); NZ NZTA (2010); SYD1 Hensher (2012) MEL1 Rawnsley & Szafraneic; MEL2 KPMG (2016)

The outlier is the Canberra Light Rail which has wider economic benefits in a similar proportion to London's CrossRail, (a total employment of 4.46 million in London versus 211,000 in the Australian Capital Territory).

Table 3: WEBs from urban rail projects in proportion to conventional benefits

Type of Scheme	Location	Scheme	Agglom-eration	Other WEBs	Total additional
Rail	**Major City**	**Crossrail, London**	**24%**	**32%**	**56%**
Rail/Road	**Major City**	**Waitemata Harbour Crossing, Auckland**	**22%**	**11%**	**33%**
Rail	**Major city**	**North West Rail, Sydney**	**5%**	**3%**	**8%**
Road	**Major city**	**WestConnex, Sydney**	**7%**	**2%**	**9%**
Light Rail	**Conurbation**	**Capital Metro, Canberra**	**40%***	**8%**	**48%**
Rail	**Major City**	**Melbourne Metro, Melbourne**	**19%**	**20%**	**39%**
Rail	**Major City**	**Cross River Rail, Brisbane**	**14%**	**5%**	**19%**

* When land use benefits are included agglomeration is 20% of the "conventional" benefit

7.0 Conclusions

This paper has reviewed the basis for augmenting conventional transport user benefits for WEBs largely due to agglomeration.

The review covered both the theory and the practice. Although a theoretical basis has largely been agreed favouring positive benefits outlined by Marshall (1890) over negative competitive effects hypothesised by Hotelling (1929), their application relies on a set of key economic assumptions being met. In terms of measurement, two areas where an improper assessment could result were identified. Firstly, the wide range in industry productivity / density elasticities measured even in the same city at different times and by different estimators. Secondly, the assignment of productivity effects to transport.

The wide range of elasticities could become problematic if a transport project affects an area dominated by a particular industry or groups of industries. For some industries such as mining, farming, manufacturing construction and distribution, productivity elasticities could decrease with effective density.

As Rawnsley and Szafraneic (2010) pointed out in their analysis of Melbourne, not all agglomeration is related to transport and they are a corollary of a number of other environmental and social factors. Estimation of agglomeration benefits tends to attribute the agglomeration entirely to the transport intervention and therefore could overstate the benefit.

This paper also demonstrated that the size of agglomeration benefit is dependent upon the location of the project. Agglomeration theory suggests that the higher the concentration of employment (or effective density) the higher the agglomeration benefit. This means that the bigger the city is the greater efficiency and productivity per worker. This naturally favours projects that are CBD-centric and located in the largest city economies. The danger is that when comparisons are made between projects in different economic context. For instance is an inner city project inherently more value than a regional project when they may be of equal value when compared to their specific objectives?

There is also somewhat of a disconnect between conventional economic analysis and economic analysis inclusive of WEBs in that the conventional economic benefits are based around solving congestion and/or lowering travel costs (an issue of what the project contributes at times of peak demand) whilst agglomeration analysis focuses on the overall contribution to the economy. An economic analysis with WEBs will combine these two issues together, but it can lead to confusion as to why the project is being undertaken.

Too much emphasis has been placed on static agglomeration benefits (keeping the land-use pattern unchanged) and not enough on the dynamic land use effects of projects which can be positive if actual (as opposed to effective) densification occurs but negative if ‘sprawl’ results. Assessing dynamic effects would distinguish between different projects (roads versus rail) and options (different routes) but would require a return to transport analysts and planners making predictions about likely population, employment and land-use response rather than applying assumption laden ‘black box’ agglomeration formulae as has increasingly become the norm.

In conclusion, the inclusion of WEBs, (particularly agglomeration), do attempt to address the improvement in productivity due to an increase in effective density caused by better access. The issue of agglomeration needs to be approached with caution however due to the uncertainties in what is being estimated and what is attributable to a transport intervention. However, it does include more information as to the probable impact of a transport intervention.

Therefore, the approach taken by the Infrastructure Australia Assessment Framework and the Australian Transport Assessment and Planning Guidelines is prudent in that:

a) WEBs are to be reported separately, and

b) they be only used as a sensitivity test, rather than a key element of the evaluation.

Disclaimer

This paper represents the views of the authors and does not purport to represent any policy of Brisbane City Council.

References

ABS 6202.0 - Labour Force, Australia

Albalate D. and Bel G. (2010) High Speed Rail Lessons for Policy Makers from Experiences Abroad, Working Paper GIM-IREA Universitat de Barcelona.

Auckland CBD Rail Tunnel Assessment Inter-agency working group (May 2011) Assessing Wider Economic Benefits, Workstream Report DRAFT.

Buchanan, Volterra (2007) The Economic Benefits of CrossRail Final Report, Department for Transport (DFT).

Byett, A, J Laird, A Stroombergen and S Trodd (2015) Assessing new approaches to estimating the economic impact of transport interventions using the gross value added approach. NZ Transport Agency research report 566.

Commonwealth Department of Infrastructure and Regional Development (2016) Australian Transport Assessment and Planning Guidelines T3 Wider Economic Benefits, prepared for the Transport and Infrastructure Council.

Deloitte (2011), Cross River Rail Economic Evaluation Final Report, Queensland Department of Transport and Main Roads.

Denis Johnson and Associates (1994) 'Airport Rail Link Economic Evaluation', report by Denis Johnson and Associates for the NSW Department of Transport.

Dobes, L., and Leung, J., (2015) Wider Economic Impacts in Transport Infrastructure Cost-Benefit Analysis – A Bridge Too Far? Agenda, A Journeal of Policy Analysis and Reform.

Duranton, G. and D. Puga (2005). From sectoral to functional urban specialisation. Journal of Urban Economics 57, 343-370.

Eberts, R. and D. McMillen (1999). Agglomeration economies and urban public infrastructure, Chapter in HP Cheshire and E S Mills (eds) Handbook of regional and urban economics, Volume III. New York: North Holland.

Fujita, M. and J. Thisse (2002). The economics of agglomeration: Cities, industrial location and regional growth. Cambridge: Cambridge University Press.

Glae Economics (May 2016) London's Economy Today, Greater London Authority

Graham, D. J. (2005). Wider economic benefits of transport improvements: link between agglomeration and productivity, Stage 1 Report. London: DFT.

Graham D.J., (2006) Agglomeration, Productivity and Transport Investment, Journal of Transport Economics and Policy, Volume 41, Part 3.

Graham (2007) “Agglomeration Economies and Transport Investment”, Discussion Paper No. 2007-11,December 2007 for the Joint Transport Research Centre, International Transport Forum OECD.

Hensher et al (March 2012) Assessing the wider economy impacts of transport infrastructure investment with an illustrative application to the north-west rail project in Sydney, Australia. Working Paper ITLS-WP-12-05, Institute of Transport and Logistics Studies, The University of Sydney.

Hotelling H., (1929) “Stability in Competition”, The Economic Journal, 39, 1929: 41-57.

Industry Commission "Taxation and Financial Policy Impacts on Urban Settlement", The Industry Commission. Vol. 1, No. 30, April 1993.

Infrastructure Australia (January 2016), Assessment Framework – Detailed Technical Guidance, Australian Government

KPMG Advisory (2015) Developing productivity elasticities for estimating WEBs in Australia – Scoping Study, Final Report.

Krugman, Paul. (1991a). Geography and Trade. Cambridge: MIT Press.

Krugman, P.R. (1991b): "Increasing returns and economic geography," Journal of Political Economy, 99, 483-499.

Krugman P.R. (2010) “The New Economic Geography, Now Middle-Aged” paper presented to the Association of American Geographers, April 16, 2010. https://www.princeton.edu/~pkrugman/aag.pdf

Laird, J. and Mackie, P. (2010) ‘Review of Methodologies to Assess Transport’s Impacts on the Size of the Economy’, Institute for Transport Studies, University of Leeds, Leeds UK.

Legaspi, J., et al., Estimating the wider economic benefits of transport investments:The case of the Sydney North West Rail Link project. Case Stud. Transp. Policy (2015), http://dx.doi.org/10.1016/j.cstp.2015.02.002

KPMG (2015) WestConnex Full Scheme: Economic Appraisal, Report Prepared for the WestConnex Delivery Authority.

Marshall A. (1890), Principles of Economics, Macmillan, London.

Melo, P.C., D.J. Graham and R.B. Noland (2009) A meta-analysis of estimates of urban agglomeration economies, Regional Science and Urban Economics, 39, 332-342

Melo P. et al, (2013) The productivity of transport infrastructure investment: A meta-analysis of empirical evidence, Regional Science and Urban Economics, Vol43 Issue 5.

New Zealand Transport Agency (NZTA) (2010a) “Additional Waitemata Harbour crossing - preliminary business case”.

Property Council & QUT (2016) Investing in Australian Cities, The Legacy of the Better Cities Program.

Rawnsley T. and Szafraneic J. (2010) Agglomeration and Labour Productivity in Australian Cities, SGS Economics and Planning, Knowledge Summit – A Success for Melbourne.

SGS Economics & Planning Urbecon Bulletin, Dec 2003.

UK Department for Transport (January 2014), Transport Analysis Guidance (TAG) Unit A2.1, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/427091/webtag-tag-unit-a2-1-wider-impacts.pdf

Venables, A.J., (2015) Incorporating wider economic impacts within cost-benefit appraisal, Draft Discussion Paper, International Energy Agency, Paris, France.

Veryard (2016) "Roundtable summary and conclusions Discussion Paper 2016-06" from the Roundtable: Quantifying the Socio-Economic Benefits of Transport 9-10 November 2015, International Energy Agency, Paris, France Daniel Veryard International Transport Forum Paris France