ASSESSING THE WIDER ECONOMIC BENEFITS OF TRANSPORT PROJECTS: THE NEW ZEALAND EXPERIENCE

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ABSTRACT

Conventional transport appraisal provides valuation of the main impacts of transport in a comprehensive way. However, it fails to account for some of the new developments in economic theory and evidence that have been developed over the last ten years. In recent years there has been growing consensus that conventional transport appraisal does not represent well the impact schemes have on the wider economy. Over the last few years a significant body of literature has addressed the potential for transport to deliver wider economic benefits that are not captured in standard appraisal. The New Zealand Transport Agency commissioned research to identify and quantify the Wider Economic Impacts that are applicable to New Zealand. This included the development of methodologies and estimation of key variables for agglomeration, imperfect competition, labour supply and job relocation impacts.

1. INTRODUCTION

Transport appraisal is a relatively mature discipline. For more than 40 years transport professionals have been using economic and modelling techniques to estimate the contribution of transport schemes to society.

The New Zealand Economic Evaluation Manual (NZTA, 2010) has procedures to evaluate the economic efficiency of transport activities submitted for funding. Economic efficiency is typically assessed by the benefit-cost ratio (BCR). Three types of benefits (or disbenefits) are considered in economic evaluation of transport activities:

- benefits with monetary values derived from the marketplace, e.g. vehicle operating costs (VOC) and the value of work travel time

- benefits that have not been given a standard monetary value, either because it is inappropriate or it has not been possible to establish a standard value e.g. cultural, visual or ecological impact

- benefits that have been given a standard monetary value include:

  - the statistical value of human life
  - the value of non-work travel time
  - the comfort value gained from sealing unsealed roads
  - the frustration reduction benefit from passing opportunities

- the carbon dioxide reduction benefit.

The New Zealand Transport Agency methodology includes a wide variety of impacts across various different types of transport projects. Table 1 shows the existing scheme-benefit matrix indicating different types of benefits attributable to each scheme type.

Table 1: New Zealand Transport Agency, Scheme Benefit Matrix

	Road	Demand management	Services	Walking and Cycling	tion, promotion arketing	Parking and land use	e sector financing ad tolls
el time cost savings	•	•	•	•	•	•	
cle operating cost savings	•	•	•	•	•	•	
dent cost savings	•	•		•	•	•	
extension benefits	•						
er frustration benefits	•						
reduction benefits	•	•	•		•		•
cle emission benefits	•					•	
r external benefits	•	•	•	•	•	•	•
e change benefits		•	•	•			
king and Cycling health benefits		•		•	•		
sport service user benefits			•			•	
ing user cost savings		•			•	•	
nal Strategic factors	•	•	•		•		

Source: NZTA (2010)

Conventional transport appraisal therefore generally seeks to measure the direct economic impacts only. Given certain assumptions, crucially the existence of perfect competition in all markets, this approach is valid. The direct benefits neither magnify nor diminish as they pass through the economy. So the value of the time saved by the account equals the sum of the increase in wage, the reduction in price and any increased profit margin.

Conventional transport appraisal provides valuation of the main impacts of transport in a comprehensive way, but it fails to account for some of the new developments in economic theory and evidence that have developed over the last ten years which have produced a significantly improved understanding of the interactions between transport and the economy now widely referred to as the wider economic benefits or wider economic impacts of transport.

In recent years there has been growing consensus that conventional transport appraisal does not represent well the impact schemes have on the wider economy (DfT 2005, Eddington 2006, Venables 2007, Graham 2007). Over the last few years a significant body of literature has addressed the potential for transport to deliver wider economic benefits – that is benefits which are not captured in standard transport appraisal. These additional benefits may arise where market failure causes the direct transport impacts to be magnified as they pass through the economy.

2. WIDER ECONOMIC BENEFITS

In response to the concern about the omission of wider economic impacts from standard cost benefit analysis the New Zealand Transport Agency commissioned a programme of research to explore ways of identifying and quantifying these wider economic impacts (SDG, 2011).

Stage one of the project involved a review of the literature and practice on the wider economic impacts of transport investments. The review carried out looked at both the theoretical aspects found through scientific research and literature and how the Wider Economic Impacts are calculated and dealt with in practice.

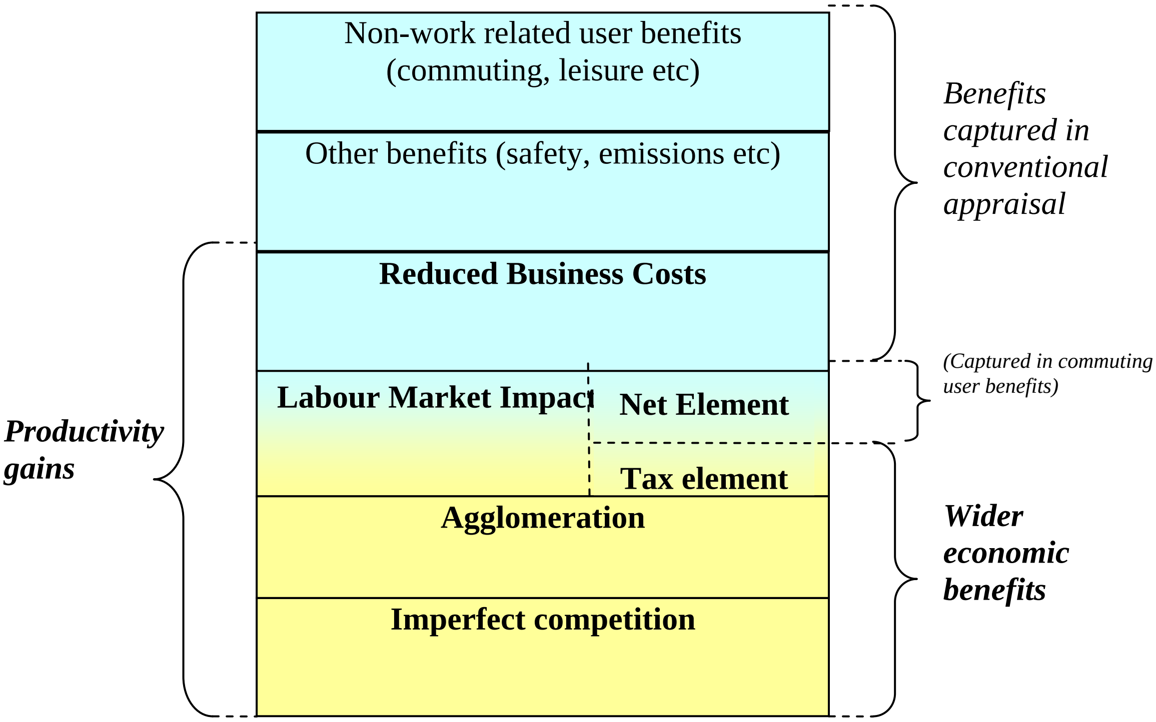
The review assessed state of the art methods for assessing the wider economic impacts of transport. The methods assessed ranged from top-down macro approaches (such as computable general equilibrium models, regional econometric models and impacts on property values) relating transport investment to some measure of economic growth, to bottom up or 'incremental' approaches that consider the incremental effects from Wider Economic Impacts where time savings may be magnified when affecting the rest of the economy.

The review found that top-down/macro approaches do not offer the ability to identify separately Wider Economic Impacts from those that are already captured as part of conventional cost benefit analysis. Existing New Zealand models do not have the capability to represent interactions with transport with sufficient accuracy, both because of limitations on spatial detail and the ability to separately identify Wider Economic Impacts from traditional cost benefit analysis benefits. The review concluded that the most appropriate approach for introducing Wider Economic Impacts in transport appraisal in New Zealand is to adopt the incremental approach.

The incremental approach to assessing Wider Economic Impacts identifies each WEB separately from benefits captured elsewhere in the cost benefit analysis and makes the best use of information that are either typically already available as part of appraisal (e.g. transport model outputs) or readily available from published sources (e.g. employment and output by sector).

Figure 1 below summarises the different types of economic impacts of a transport scheme, how they contribute to economic welfare and productivity and how they fit with conventional transport appraisal and wider economic impacts, respectively.

Figure 1 Relationship between conventionally measured benefits, wider economic benefits and productivity gains

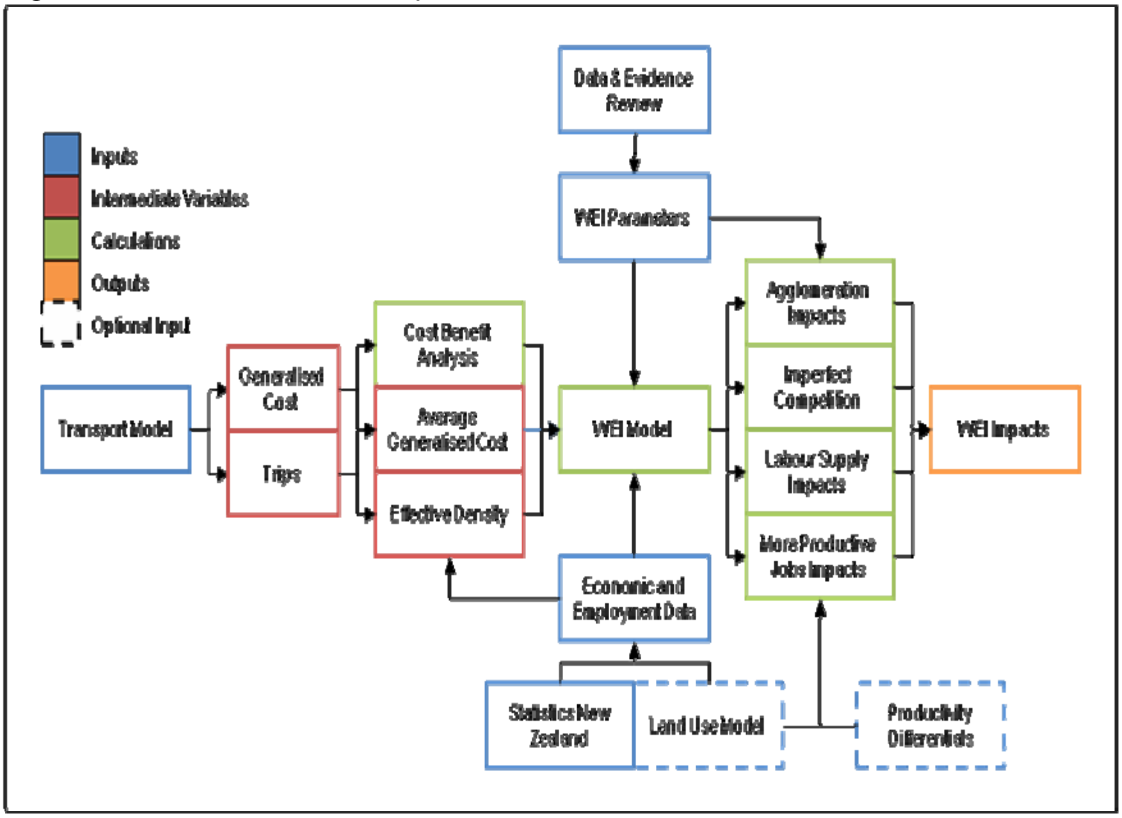


Following analysis of the existing theory and an assessment of the availability of data the following wider economic impacts were identified:

- agglomeration benefits
- imperfect competition benefits
- labour supply benefits
- job relocation benefits.

The second stage of the research project was to develop methodologies for assessing the wider economic impacts identified above and to estimate the critical parameters. Figure 2 shows an overview of the key parameters required and the methodology for calculating the Wider Economic Impacts. Each of the Wider Economic Impacts identified are discussed below.

Figure 2: Wider Economic Impacts Model Overview



3. AGGLOMERATION IMPACTS

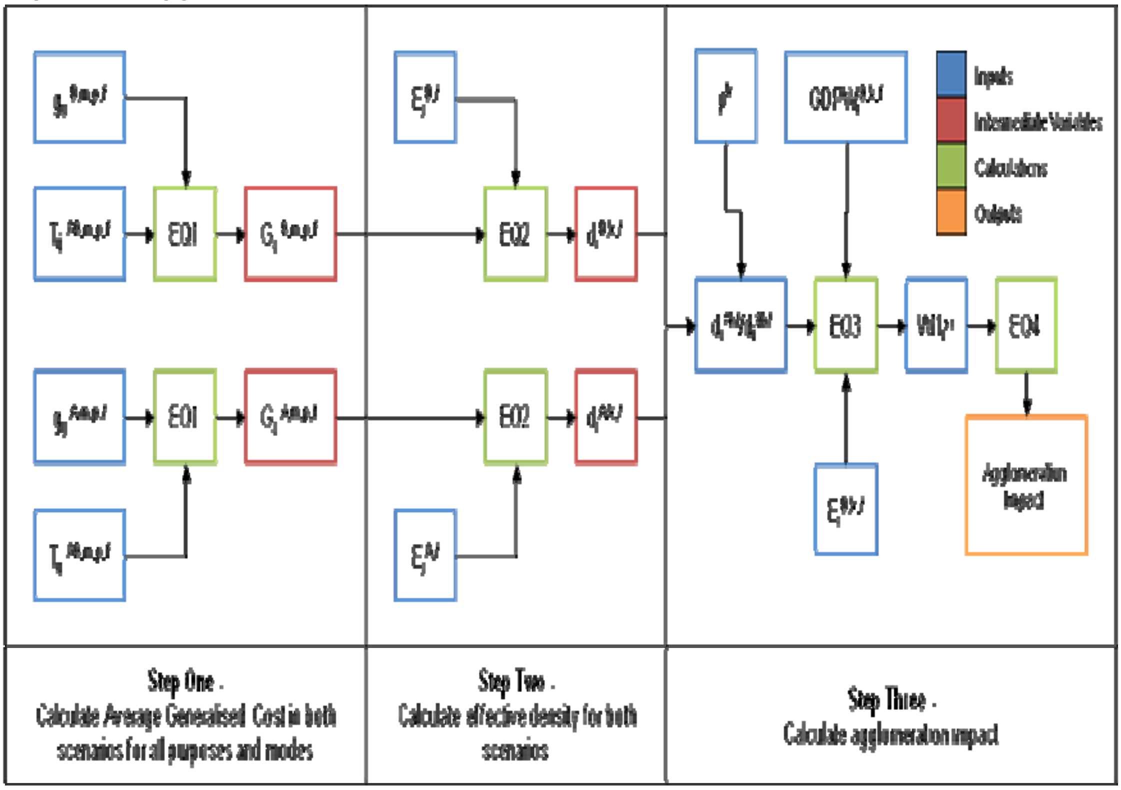
Agglomeration simply means the geographic clustering of firms and workers. Industrial clusters and cities are types of agglomeration. Firms and workers cluster because scale effects mean many activities are more efficiently undertaken and services more efficiently provided when concentrated (Duranton and Puga, 2004). Typically, firms are more productive when near other firms because they have access to a large variety of inputs to their activities. It is also often argued that proximity to other similar firms increases the chances of acquiring new knowledge and of building connections and networks which support or increases productivity. Research shows, for instance, that face to face contact is very important for some business environments (Rosenthal and Strange 2004).

Many firms are also more productive when they have access to a large labour market since this makes recruitment quicker and it is easier to find workers with the exact skill match that they are after. Evidence supports all this by showing that, as a city grows and becomes denser, its firms become more productive.

When we talk of the density of a city in this context, we really mean the number of firms and workers that are accessible, rather than the number of jobs or workers per square km. It is more natural to consider the number of workers located within *x* generalised minutes (a composite measure of travel time and cost). In other words, the role of transport in supporting accessibility, and therefore agglomeration is important. If transport is made cheaper or quicker, more firms and workers will be located within reach and, according to the literature on agglomeration, productivity will increase. Importantly, these agglomeration benefits are additional to those already captured in the conventional appraisal.

The methodology developed for estimating the agglomeration impacts involves three main steps using four equations as shown in Figure 3 below.

Figure 3: Agglomeration Benefits Calculations



The variables used in each process are described and explained inTable 2.

Table 2: Agglomeration Variable Descriptions

/ariable	Description
$g_{ij}^{S,m,p,f}$	eralised cost for mode (m), purpose (p), forecast year (f), scenario (S), between origin zone (i) and destination e (j).
$T_{ij}^{AB,m,p,f}$	total number of trips for mode (m), purpose (p) and cast year (f), between origin zone (i) and destination zone nd summed across the two scenarios (Do Minimum and Something)
$G_{ij}^{S,m,p,f}$	average generalised cost across modes (m), purposes forecast year (f), and scenario (S), between origin zone (i) destination zone (j).
$E_j^{S,f}$	l employment in destination zone (j), scenario (S) and cast year (f).
$d_i^{S,k,f}$	effective density of zone (i) by sector (k), forecast year (f) scenario (S).
ρ^k	elasticity of productivity with respect to effective density ector (k).
$DPW_i^{B,k,f}$	ss Domestic Product per worker by sector (k), forecast (f), zone (i) in the Do Minimum scenario.
$WI1_i^{k,f}$	lomeration Impact by sector (k) forecast year (f) and zone

The first step is the calculation of **Average Generalised Costs**. The average generalised cost is calculated by averaging the generalised cost of travel across all modes or journey purposes (or both). The formal equation for the calculation is shown below. It should be noted that the number of trips is used for weighting purposes only and that the same weights must be used for each scenario. The trip weights used are the sum of the Do Minimum and Do Something scenarios (denoted by the “AB” superscripts).

Equation 1

$$G_{ij}^{S,m,f} = \frac{\sum_p g_{ij}^{S,m,p,f} \cdot T_{ij}^{AB,m,p,f}}{\sum_p T_{ij}^{AB,m,p,f}}$$

The next step is to calculate the **Effective Density**. The effective density of a zone is calculated by summing the employment in all neighbouring zones by the generalised cost of accessing those jobs from the origin zone. The formal equation is shown below.

Equation 2

$$d_i^{S,k,f} = \sum_{j,m} \frac{E_j^{s,f}}{\left(g_{ij}^{S,m,f}\right)^{\alpha}}$$

The final step is the calculation of the **Agglomeration Impact**. Once average cost and effective density have been calculated the agglomeration impact can be estimated by calculating the change in effective density between the Do Minimum and Do Something scenarios. The formal equations for the calculations are shown below:

Equation 3

$$WI1_i^{k,f} = \left[\left(\frac{d_i^{A,k,f}}{d_i^{B,k,f}}\right)^{\rho^k} - 1\right] GDPW_i^{B,k,f} \cdot E_i^{B,k,f}$$

Equation 4

$$Agglomeration\ Impact = \sum_{i,k} WI1_i^{k,f}$$

The calculation of agglomeration impacts is dependent on the agglomeration elasticity which provides the sensitivity of the productivity of a given sector (k) to changes in effective density. The higher the elasticity, the greater the productivity impact of a given change in generalised cost. The New Zealand Transport Agency commissioned research that estimated the agglomeration elasticites for different industrial sectors in New Zealand (Mare and Graham 2009). Table 3 shows a summary of the agglomeration elasticities estimated by sector. The average elasticity across all sectors is 0.065 meaning that a 1% increase in effective density is associated with a 0.065% increase in productivity for a given zone.

Table 3: Agglomeration Elasticities in New Zealand

ductivity wrt effective density glomeration Elasticity)	ue
culture, forestry & fishing	2
ng	5
tricity, gas water and waste services	5
ufacturing	1
struction	6
lesale Trade	6
il Trade	6
ommodation and food services	6
nsport, postal and warehousing	7
rmation, media and telecommunication	8
nce and insurance services	7
essional, scientific and technical ices	7
tal, hiring and real estate services	9
cation and training	6
lth care and social assistance	3
and recreation services	3
ndustries	5

Source: NZTA Economic Evaluation Manual (Volume One) Section A10.2

4. IMPERFECT COMPETITION IMPACTS

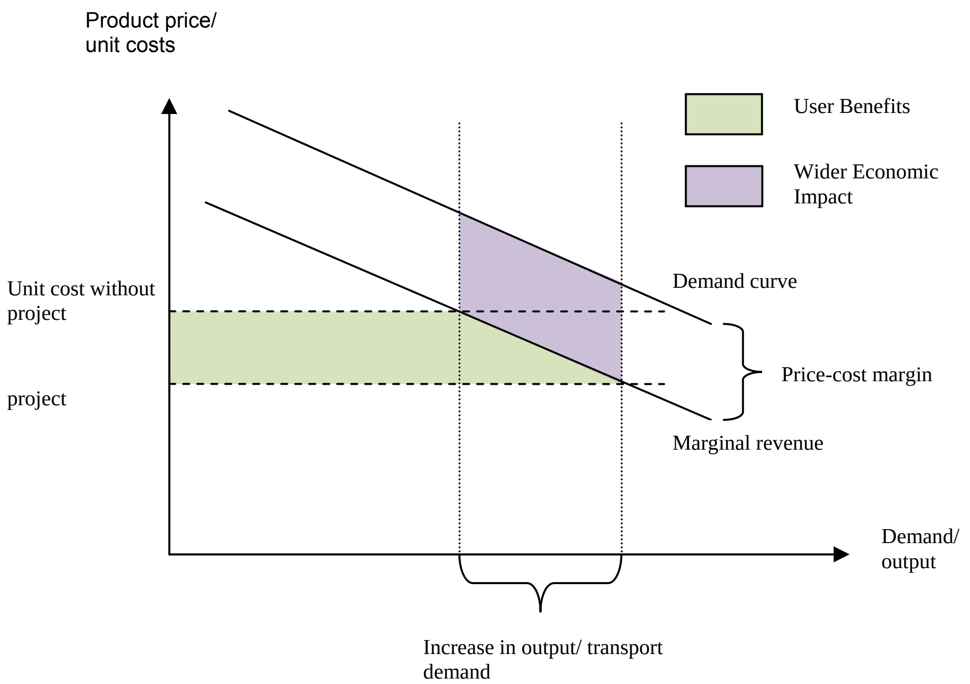
The assumption of perfect competitive markets in standard appraisal methodology is unrealistic and leads to a systematic underestimate of the level of economic impact for a given transport project.

The Wider Economic Impact from Imperfect Competition can occur if a transport improvement causes output to increase in sectors where there are price-cost margins.

If transport improvement causes a reduction in travel time for in-work travel it is fair to assume that the time saved will be put to productive use. The value of one hour saved for a business traveller is therefore the market value of what the worker can produce in that hour. Because conventional cost benefit analysis assumes all transport-using sectors operate in perfect competition, where price equals marginal costs, the value of the additional production is identical to the gross marginal labour cost of the additional hour worked. Cost benefit analysis therefore measures the value of the travel time savings as a saving in gross labour cost.

However, if a price-cost margins exist, they by definition, cause a wedge between the hourly gross labour costs and the market value of what is produced in that hour. Therefore, where there are price-cost margins, a transport induced increase in output will cause a Wider Economic Impact identical to the size of this wedge. Figure 4 illustrates the conventionally measured user benefits in light green and the “missing” wider benefit in purple.

Figure 4: Wider Economic Impacts from Imperfect Competition



The existence of imperfect competition means that the increased output delivered delivered by the project will lead to further gains, shown as purple in Figure 4. It is clear from the figure that the magnitude of this Wider Economic Impact is equal to the price cost margin multiplied by the increased output.

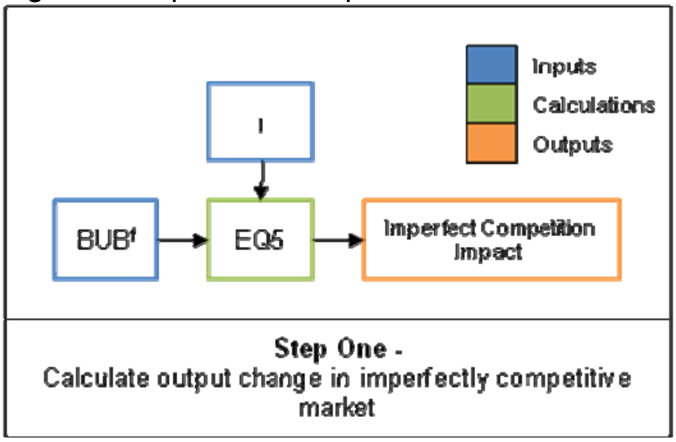
The output increase from a given transport improvement is difficult to measure directly. However, it can be shown from economic theory that the additional benefits are closely related to the magitude of conventionally measured benefits to in-work travel. In fact, the Wider Economic impact from imperfect competition turns out to be a fixed proportion of business time savings. This proportion is equal to:

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

Where **PCM** is the price-cost margin [defined as (price – marginal cost)/price], **e** the market aggregate demand elasticity (i.e. the elasticity of total output with respect to a change in overall prices) and **n** the “notional “ number of firms competing in the market. Consequently, to enable the assessment of imperfect competition benefits we need estimates of price-cost margins and the aggregate demand elasticity in New Zealand. Based on the best available evidence we estimated a 20% aggregate price cost margin for the New Zeland economy and an aggregate demand elasticity of -0.6. Academic research also indicated a Hefindahl index of around 0.223 which implies an average of around nine firms per ANZIC four digit sub sector. Based on these values we assessed that imperfect competition can be estimated as a direct 10.7% uplift on business user benefits (SDG, 2011).

Imperfect competition benefits are calculated through a simple multiplication of business user benefits by an uplift factor. Figure 5 provides a diagram of the process.

Figure 5: Imperfect Competition Benefit Calculation



Business user benefits are calculated from a standard cost benefit analysis by aggregating the benefits attributable to business and freight users. Table 4 provides a description of each of the variables shown in figure 5.

Table 4: Imperfect Competition Parameters

iable	Description
3^f	otal business user benefits, including freight by forecast year (f)
I	Imperfect competition parameter

The formal equation used to estimate the benefit is shown below.

Equation 5

$$Imperfect\ Competition\ Impact = \sum_{f} \iota \cdot Business\ User\ Benefits^{f}$$

5. LABOUR MARKET IMPACTS

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

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

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

Figure 5 below illustrates the presence of the tax externality (the tax wedge) on labour supply. A reduction in travel costs increases the number of trips and the labour supply. Increased labour supply increases the levels of income, and tax which is a direct social benefit.

The two key pieces of evidence required to assess the magnitude of the Wider Economic Impacts from labour supply are therefore:

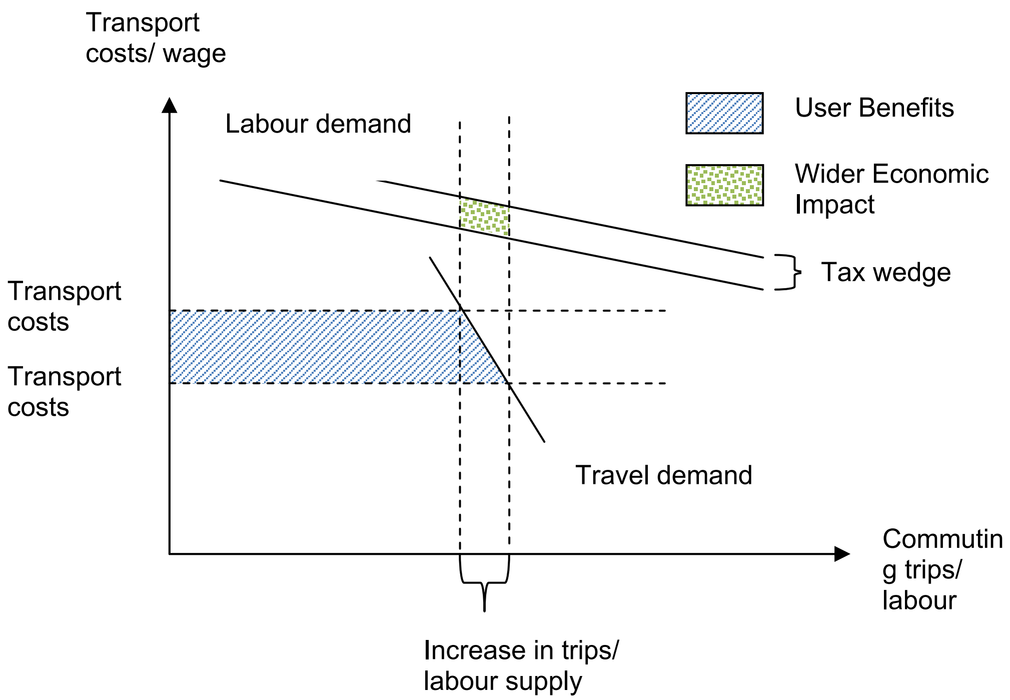
- the change in labour supply following a transport improvement; and
- the tax wedge.

Based on our analysis of tax, income and spending data in New Zealand and research into labour market impacts and commuting times we find that the labour market impacts of transport are most likely to take effect through higher rates of labour participation rather than through a direct increase in the labour supply of existing employees. From academic research we estimated an elasticity of labour participation with respect to wages of 0.4 (SDG 2011, Kalb 2003).

On average we estimate that each new entrant to the labour market will earn on average $35K some 19% less than the average for the labour market as a whole because of different personal and labour supply characteristics. Based on this estimate each new entrant to the labour market is likley to generate around $9k in additional tax revenue.

Analysis of the tax system shows that the tax wedge for New Zealand is relatively small compared with other developed nations, and is approximately equal to 32% of labour costs. For new entrants to the labour market the wedge is slightly less and based on estimates of lower productivity and spending of new entrants we estimate a 26% tax wedge for this group.

Figure 5: Wider Economic Impacts from Increased Labour Supply



Following the estimation of the key variables a methdology was developed to quantify the labour supply benefits. Table 5 shows and describes the key variables used and Figure 5 the steps involved in calcuating the labour supply impacts.

The methodology involves three steps:

The first step is the calculation of the round trip commuting cost in the Do Minimum and the Do Something scenarios. This is achieved by calculating the average generalised cost of travel to each and from each zone across all commuting trips.

Equation 6

$$G_{ij}^{S,c,f} = \frac{\sum_m \left(a_{ij}^{S,m,c,f} + a_{ji}^{S,m,c,f} \right) \cdot T_{ij}^{B,m,c,f}}{\sum_m T_{ij}^{B,m,c,f}}$$

Next, the toal annual commuting cost savings for workers living in zone I is calculated by mutliplying the change in commuting cost for each destination by the number of commuters and summing:

Equation 7

$$dG_i^f = \sum_j W_{ij}^{S,f} \left(G_{ij}^{A,c,f} - G_{ij}^{B,c,f} \right)$$

The labour supply response is then calculated by assessing the magnitude of the commuting cost changes in relation to workers' net wage for each area and multiplying by a labour supply elasticity as shown in Equation 8.

Equation 8

$$dE_i = \varepsilon^{ls} \frac{1}{y_i(1-\tau_i)} dG_i^f$$

The increased output from the increased labour supply is estimated using the equation shown Equation 9.

$$LS\ Impact = \sum_i dE_i \eta m_i$$

Finally, the Wider Economic Impact from increased labour supply is the proportion of the additional output that is taken in taxation:

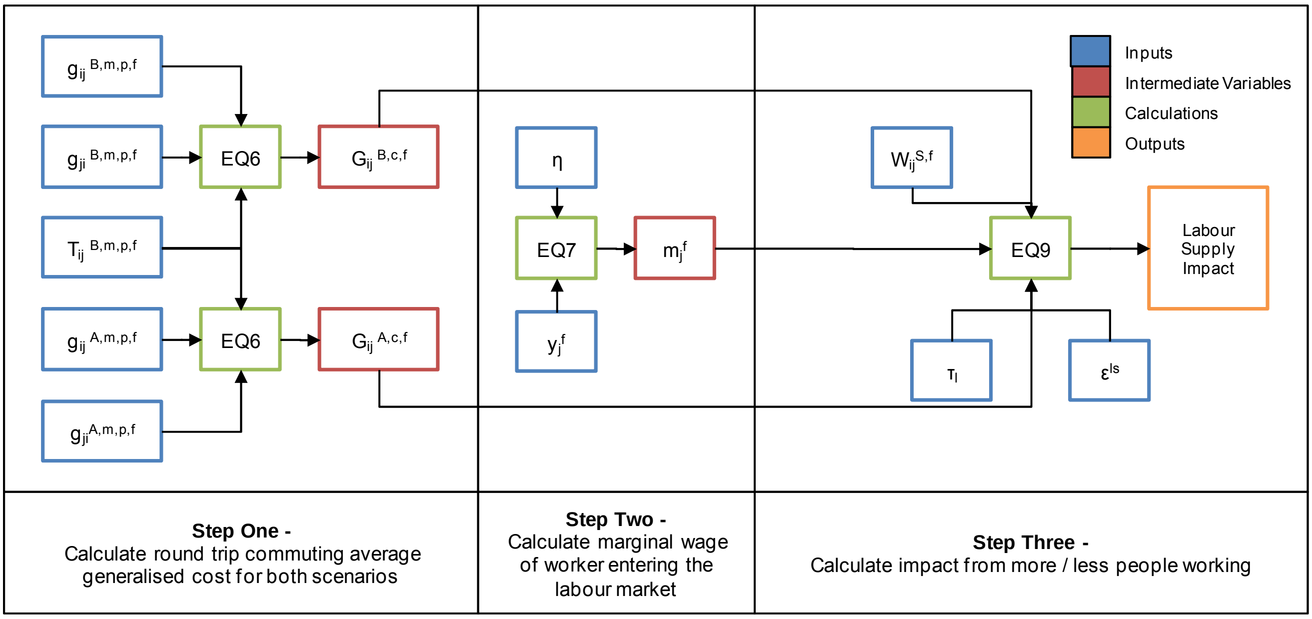
$$WEI\ from\ increased\ Labour\ Supply = LS\ Impact\ x\ t^{LS}$$

Table 5: Labour Supply Impact Variable Descriptions

Variable	Description
$g_{ij}^{S,m,p,f}$	eralised Cost for mode (m), purpose (p), forecast year (f),

	scenario (S), between origin zone (i) and destination e (j).
$T_{ij}^{B,m,p,f}$	total number of annual home to work trips for mode (m), ose (p), forecast year (f), between home zone (i) and k zone (j) in the Do Minimum scenario. (Also known as the ne to work' matrix in the base (B) case.
$G_{ij}^{S,c,f}$	average generalised cost across mode (m), **commuting oose** (c), forecast year (f), and scenario (S), between n zone (i) and destination zone (j).
η	productivity of marginal labour market entrants relative to average.
y_i^f	ss mean residence based earnings in zone i.
m_i^f	ss mean residence based GSP per worker in zone i.
$W_{ij}^{S,f}$	number of workers commuting from zone i to zone j in nario (S) and forecast year (f).
τ	tor to convert gross to net earnings.
t^{LS}	take on increased labour supply
ε^{ls}	elasticity of labour supply with respect to effective (real) es.

Figure 6: Labour Supply Impacts Calculations



6. PRODUCTIVITY DIFFERENTIALS FROM JOB RELOCATION

The concept here is that savings in commuting time encourage some workers to move to more productive and higher paid employment, for example from outside the central business district to the central business district. To claculate the increase in output, estimates are needed of the number of people who will move and the wage differentials between areas. This is expressed as:

$$\Delta Q_i = \Delta E_{ij} \times \Delta W_{ij}$$

Where ΔE_{ij} = the change in employment in area *i* in industry *j* and ΔW_{ij} = the increase in wage in area i in industry j compared with the initial area.

In New Zealand there is evidence of productivity differentials taking account of personnel and industry characteristics at a regional level (Mare 2008). However, at a local geographical level this is not the case, and this severely reduces the accuracy of the assessment because relatively few transport schemes are likely to cause significant job relocation effects at the regional level. The effect is likely to be much more significant at the territorial authority level for which pure productivity differentials are not avilable. While wage data at the territorial authority level can serve as a rough proxy for productivity differentials this is likely to bias estimates of the relocation effect where relocating individuals are not likely to see significant increases in wages because of their personnel and labour supply characteristics. It was therefore decided that until better estimates can be obtained this Wider Economic Impact should not be used in evaluations unless estimates at the sub-regional level are available.

CONCLUSION

Transport appraisal counts the direct impacts of an intervention on the transport users in an economy, such as time and cost savings to travellers, accident savings etc. Recent developments in appraisal techniques have identified important indirect benefits to the rest of the economy that are not typically counted in the conventional appraisal. Thse wider economic benefits are fully additional to the benefits normally identified.

In reponse to these concerns the New Zealand Transport Agency commissioned research that identified the wider economic benefits. Methodologies to quantify the wider economic benefits were developed and this included estimation of key variables.

The use of wider economic benefits in transport appraisal is still relatively new and while some consider that they are appropriate other have reservations. For example, the Eddington study (Eddington 2006) considered that there is sufficient evidence to include such wider economic benefits for large scale transport projects and not including them would result in understating the benefits and lead to underinvestment. However, others consider that the empiricial methods used to quantify the wider benefits are not yet precise to use in transport appraisal. Graham and Van Der (2010) consider that while the conceptual case for agglomeration economies is strong the method used to quantify this benefit, such as use of effective density, has limitations and that it is too early to include such wider economic benefits in transport appraisal. It is important that we review such concerns and that we refine the methodologies. This can be achieved by applying the wider economic impact methdologies to transport projects and carrying out post evaluation studies so that we can get a better understanding of the issues and problems.

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