Wider economic impacts of transport investments in New Zealand
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Abbreviations and acronyms

ACC	Accident Compensation Corporation
AWHC	Additional Waitemata Harbour crossing
CBA	cost-benefit analysis
CGE	computable general equilibrium (models)
DfT	Department for Transport (UK)
DM	do minimum (scenario)
DS	do something (scenario)
DTI	Department of Trade and Industry (UK)
EB	employer business
EC	European Commission
EEM	*Economic evaluation manual* (NZTA)
EEM1	*Economic evaluation manual*, volume 1
EEM2	*Economic evaluation manual*, volume 2
FDI	Foreign direct investment
FTA	Federal Transit Administration (US)
GST	goods and services tax
HBW	home-based work
HEATCO	Harmonised European Approaches for Transport Costing and Project Assessment
LEED	Linked Employer-Employee Database (Statistics New Zealand)
LUTI	land use/transport interaction (models)
NPV	net present value
NZTA	New Zealand Transport Agency
REM	regional economic model
SACTRA	UK Standing Advisory Committee for Trunk Road Assessments
SAFETEA-LU	Safe Accountable Flexible Efficient Transportation Equity Act: a Legacy for Users
SCGE	spatially computable general equilibrium (model)
SDG	Steer Davies Gleave
SKM	Sinclair Knight Mertz

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Executive summary

Overview

This project aimed to develop a methodology for the NZ Transport Agency and practitioners in New Zealand to follow when assessing the wider economic impacts of proposed transport projects. Wider economic impacts are a class of economic benefits from transport investment that are excluded from current appraisal methods. The project was completed in three stages:

- Stage 1 comprised the literature review which provided an overview of the theory of wider economic impacts in transport appraisal, and developed methods for assessing these impacts based on a comprehensive examination of the existing evidence and research for New Zealand.
- Stage 2 built on the findings and recommendations of stage 1 in order to develop the evidence and methods required to enable the assessment of wider economic impacts for transport projects in New Zealand
- Stage 3 demonstrated the application of the method developed in stage 2 to a case study.

The project examined the latest research and evidence to derive values for the key parameters of the wider economic impacts calculation methodology for impacts relating to:

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

Imperfect competition benefits

The perfect competition assumptions made in standard economic appraisal result in a systematic bias in the estimation of benefits related to the deviation of price from marginal cost.

By using an oligopoly model to provide a more accurate context for economic appraisal we were able to show from first principles how the standard method would underestimate the true welfare impacts of a fall in marginal cost, and that this underestimation was proportional to the business user benefits estimate in a standard appraisal.

We found there was evidence of imperfect competition in the New Zealand economy, based on the presence of a 20% price cost margin. Together with evidence on how the economy responds to a reduction in transport costs, our findings implied a general imperfect competition uplift factor of around 10.7% of business user benefits.

Increased competition benefits

Because of the spatial nature of economic activity and the frictions produced by transport costs, it was conceivable that a transport project could improve the level of competition in an economy by increasing market overlap and concentration which in turn would reduce the price cost margin and increase competitive pressure leading to more innovation and cost control.

However, despite the theoretical justification for a link between transport and market competitiveness we found the actual relationship was complicated, and likely to vary across different sectors of the economy. Two-way effects where transport improvements could actually reduce competitiveness were also possible for industries with economies of scale.

Overall, we did not find sufficient evidence for using an empirical relationship in the appraisal of increased competition effects. Furthermore, regardless of the lack of empirical evidence we believed it was unlikely transport projects in general would provide a significant impact on a developed economy with well-established economic regulation in place. Because of these issues, we believed increased competition effects were only likely in certain situations where:

- a scheme generated a major improvement in accessibility for the study area
- there was evidence of a lack of competition in some or all sectors of the local economy
- the impact of the scheme on levels of competition and the price cost margin could be fully quantified
- the economic value of this reduction could be measured.

In such cases scheme promoters should seek to develop their own evidence.

Labour supply benefits

The labour supply benefits of transport projects occur because of the presence of a tax wedge on wage income, which means when people choose to increase their labour supply they generate a positive externality equal to the tax wedge between gross and net income.

Because of the indivisible structure of the labour market people are constrained in their actual labour market decisions at the microeconomic level through, for example, the rigidity of full-time or part-time contracts. Because of this, the strongest link between transport improvements and labour supply is most likely to occur through reduced commuting times increasing the rate of labour market participation.

We have presented a framework for assessing this effect as well as the evidence required for a practical assessment. The framework makes use of evidence from academic research on labour participation with respect to wages, which we found to be 0.4, and an average income tax take of 33% based on an analysis of the New Zealand tax system. The ‘missing’ appraisal benefit relates to the tax wedge of new entrants, which we estimated to be 26%.

Job relocation impacts

The productiveness of economic activity differs across space for many reasons. One reason is agglomeration economies, which means activity taking place in large cities is inherently more productive than elsewhere.

However, locating in areas with a high concentration of economic activity also has costs, such as higher wages and rents as well as higher transport costs. If a transport project reduces the costs of operating in dense locations (for instance by increasing local labour supply through lowering perceived journey costs), more activity may be attracted to the location.

As a consequence, a transport project that causes a relocation of jobs may affect the productivity of these jobs, everything else being equal. Job relocation may hence cause an externality through the tax wedge in the same manner as labour supply benefits. We found academic evidence for pure productivity differentials across the New Zealand regions which could be used to estimate the job relocation impacts of transport projects where land-use effects are modelled. These productivity differentials are shown in table ES.1.

Table ES.1 Regional productivity differentials

Region	Productivity differential (relative to Auckland)
Auckland	0.00%
North Island (north)	-8.01%
North Island (central)	-10.44%
Wellington	4.32%
Canterbury	-8.23%
South Island	-8.71%

Source: Kalb (2003)

However, we suggest job relocation effects are not likely to be very significant at a regional level for all but the most extensive transport schemes such as high-speed rail or strategic highway projects. While pure wage differences could serve as a proxy for the impact, there is an evidence gap for pure productivity effects at a territorial authority level which should be made a research priority. In addition, the assessment of job relocation impacts requires evidence on job relocation caused by the project, which may be costly to obtain. The application of this assessment will therefore be associated with disproportionate costs for many projects. We therefore do not recommend the method be required as part of standard evaluations, although there may be national significant projects where there are sufficient resources available to undertake the required research.

Parameter values

Table ES.2 summarises the wider economic impact parameter values derived from the research and analysis in the report.

Table ES.2 Wider economic impacts parameter value

Parameter	Description	Value
T	Ratio of imperfect competition benefits to business user benefits	0.107
εad	Aggregate demand elasticity	-0.6
pcm	Price cost margin	20%
τL	Indirect tax parameter (to convert gross to net earnings)	32%
εls	The elasticity of labour participation with respect to wages:	0.4
τLS	The tax take on increased labour supply.	26%
τLm	The tax take on the move to more productive jobs	32%

Abstract

This paper develops a methodology and evidence to enable the assessment of wider economic impacts of transport. Quantifying these wider economic impacts is important as they are likely to be non-trivial in magnitude and they are currently excluded from the current appraisal methods. The paper derives New Zealand-based values of key parameters on imperfect competition benefits, increased competition benefits, labour supply benefits and job relocation benefits. The methodology and the key parameters are then applied to a transport project to demonstrate how the wider economic impacts can be quantified.

PART 1: LITERATURE REVIEW

1 Purpose and structure of the literature review

Part 1 documents the findings of a review of the literature on the wider economic impacts of transport investments and their practice. We look at both theoretical aspects found through scientific research and literature and how the wider economic impacts are calculated and dealt with in practice.

The review builds an understanding of the full range of wider economic impacts that can follow transport improvements, and the potential methods for quantifying these. The review considers which of these methods could be appropriate for inclusion within the New Zealand appraisal framework.

The literature review is structured as follows:

Chapter 2 discusses what we mean by 'economic impacts' for the purpose of this report; which types of economic impacts may ensue from a transport investment; and which economic impacts are wider economic impacts.

Chapter 3 reviews theory and evidence internationally on identifying economic impacts of transport.

Chapter 4 reviews the appraisal framework in selected countries and identifies whether and how wider economic impacts are incorporated in these.

Chapter 5 summarises the findings and concludes with the most appropriate approach to pursue for inclusion in New Zealand transport appraisal.

Building on the findings of the review, chapter 6 confirms the scope for stage 2 of the project.

2 Economic impacts of transport

2.1 What we mean by 'economic impacts' in this context

There is no univocal definition of 'economic impacts'. For some it may mean impacts on gross value added or productivity, others will use the term to describe impacts on jobs or employment, while some would interpret it to include all impacts that have an economic value – including for instance, people's willingness to pay to avoid negative environmental impacts.

This literature review is part of a study whose objective was to investigate whether there were market failures outside the transport sector in New Zealand and, if so, whether these failures might lead to impacts from transport investments that were not captured elsewhere in the existing framework for transport appraisal. We were therefore primarily interested in impacts on traded sectors, such as productivity gains or expansion of employment.

We adopted what might be considered a narrow definition of economic impacts, excluding any non-market effect even though these might have a value to individuals. This meant, for instance, that we did not seek to investigate whether the valuation of non-work travel time saving was correct, but we did consider whether non-work travel time savings could have economic impacts that were currently not counted in appraisal in New Zealand (such as increased labour supply from commuting time savings).

We were also concerned mainly with the long-term equilibrium economic impacts and not short-term effects. This was appropriate, in particular because of the long time frame over which transport assessments are typically considered.

The rest of this chapter describes the potential types of economic impacts (as defined above) from a transport investment and which types are wider economic impacts – that is, additional to benefits already captured as part of conventional transport appraisal.

2.2 Direct economic impacts

The direct economic impacts of a transport scheme include those effects felt by providers and immediate users of the transport system. These impacts are nearly always captured in transport appraisal.

2.2.1 Journeys times and costs to business and freight

The principal economic impact of a transport improvement is the end-to-end journey time savings to freight drivers and business travellers. In the majority of cases, time spent travelling is time lost and reducing journey times will allow this time to be spent productively. The value placed on journey time savings is therefore the opportunity cost of the lost time – most often measured as gross hourly labour cost.

The exception to the above is where travellers are able to use some of the journey time productively, such as working on the train. In that case a more accurate measure of the economic impact of a journey time improvement is the difference between the opportunity cost of the lost time and the value of the productive time spent travelling. This impact is, however, rarely measured in appraisal.

For freight movements there can be additional gains from reducing the time goods are held up in transit. In particular for higher-value goods, reducing the amount of capital held in transit could mean economic efficiency gains. Improved reliability of transport can also unlock efficiencies in freight movements by, for example, permitting tighter scheduling and a smoother production process.

In addition, there may be fuel savings and other vehicle operating costs that will reduce resource costs to firms.

2.2.2 Journey comfort

Changes to other journey factors such as comfort and excess disutility of interchange and wait time (above the pure travel time) that impact on travellers do not cause economic impacts, apart from in those cases where they affect the productivity of the journey time.

2.2.3 Incidence of the direct impacts

The immediate indirect impact of time saved in the course of work is an increase in labour productivity. Firms may respond to this in various ways, depending on market conditions. They may lower prices and increase output, they may increase wages or profits or they may increase investment. Each of these responses will have a repercussion throughout the economy as the firms' customers benefit from lower input prices, suppliers benefit from higher demand, and workers receive higher incomes and owners receive higher profits. Similarly, individuals may respond to travel time savings in various ways, for instance by undertaking more face-to-face meetings. The important point is if there are no market failures outside the transport sector, the sum of the changes in final outcomes such as real rents, output, wages, prices and incomes will be identical to the sum of the direct impacts as measured in the appraisal.

2.3 Indirect impacts outside the transport sector

In addition to, or in some cases as a consequence of the incidence chain of effects from the direct impacts, there will be a range of indirect impact on the economy. Some of these will cause a redistribution or reallocation of resources; others may cause the entry or exit of firms. Some of the effects may enable yet more efficient use of resources, be it through economies of scale, through mitigating market failures or through affecting the output in markets that are imperfectly competitive. These are the effects we seek to identify and measure as wider economic impacts and can include:

- Economies of scale: improved transport can encourage increased concentration (agglomeration) or specialisation of economic activity thereby enabling increased efficiency from economies of scale.
- Mitigating existing market failures: market failures enabled by limitation on competition can be mitigated by improving accessibility and therefore cross-trade between spatial markets.
- Increased output in imperfectly competitive markets: if there are persistent externalities in other markets that are affected by a transport scheme, a reduction or increase in output can diminish or augment the cost of these externalities.
- Technology and knowledge transfer: transport's role is to connect people and places and increasing the interaction between economic actors can facilitate an increased transfer of knowledge.

All the potential wider economic impacts identified as part of this review fall into one or more of the above categories.

3 Review of literature on indirect impacts

3.1 The role of transport in the economy

The physical separation of different economic functions such as primary and secondary production, business and leisure activities, marketing and consumption is a fundamental aspect of a modern society. Consumers are widely dispersed from producers and in most industry sectors production is separated from where resources originate.

This separation comes at a cost. In New Zealand $14bn is spent annually on transport and communication, which is 11% of GDP[1]. This estimate does not capture the non-pecuniary costs of movement such as travel time. However, the fact the economy invests that amount of resources on transport is but one indicator of the vast economic benefits enabled by separation.

Separation in itself has benefits, for instance enabling residents to live in a nice suburb while working downtown and allowing polluting factories to locate away from farmland. But the main economic gains from separation are in fact specialisation and concentration. The separation of economic activities enables fewer actors to serve larger markets, enjoying economies of scale and exploiting comparative advantages. Separation also enables firms and workers to concentrate, deriving gains from agglomeration economies.

The important role of transport within the economy was realised many centuries ago. Adam Smith wrote in his seminal work *The wealth of nations* about how larger pin factories produced many more pins per worker than smaller ones and hence identified economies of scale from being able to serve a larger market. Marshall (1890) identified how concentration contributed to productivity through enabling firms to draw upon a larger pool of workers, thereby filling vacancies more quickly and employing workers better matched to their needs.

It is, however, only during the last 20 years that techniques have been developed that enable the quantification of transport's contribution to economic growth. And even this process has had mixed results.

This chapter reviews the state of the art methods for assessing the economic impacts of transport. They range from top-down, 'macro', approaches 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.

3.2 Incremental approaches

Bottom-up or micro approaches to identifying economic impacts of transport are typically partial equilibrium approaches. That is, they seek to quantify the impact of a specific effect in isolation from the rest of the economy, and the resulting gains are considered additional to the benefits captured elsewhere in the appraisal.

[1] Statistics NZ, GDP for transport and communication, 2009 values and prices.

3.2.1 Agglomeration

3.2.1.1 Description

Agglomeration refers to the co-location of economic activity in space. Industrial clusters and cities are both types of agglomerations. Firms and workers cluster because scale effects mean many activities are more efficiently undertaken and services more efficiently provided when concentrated.

It has long been recognised economies of scale of concentration exist. Marshall proposed in 1890 that producers within the same industry choose to locate in close proximity in order to support specialised local input providers, to induce labour market pooling, and to facilitate the spread of information (Marshall 1890). Later academics advanced the thinking behind agglomeration as part of the work on location theory, and embedded the theory of agglomeration within a general equilibrium framework that modelled the existence of a system of cities of different sizes and types (Henderson 1974; 1980; 1988).

The most recent advances in agglomeration have been on the empirical evidence of the existence and magnitude of agglomeration economies. An important focus has been not only on agglomeration as a way of explaining the existence of cities, but also on agglomeration externalities: the notion that firms' decisions about where to locate will affect the productivity of other firms. There is a clear interaction with transport here as improvements in accessibility can support agglomeration economies through two channels. First, a transport improvement can attract additional employment to urban areas where agglomeration economies are more important, thereby increasing productivity of existing firms (or reduce productivity where the opposite is the case). Second, as set out by Venables (2007), by reducing travel costs the effective catchment area of a city increases, facilitating the kind of interactions that drive agglomeration economies over a larger body of workers and firms.

3.2.1.2 Evidence

Rice et al (2006) examined the magnitude and geographical reach of agglomeration economies in the UK using a simulation model. They analysed regional differences in productivity controlling for differences in skills and sectoral composition and attempted to explain the residual variation using proximity to 'urban mass' as measured by journey times. They found a modest elasticity of productivity with respect to agglomeration (agglomeration elasticity) of 5%. They also found firms could benefit from proximity to other firms as far as 80 minutes away. They calculated that under their assumptions a 10% increase in the speed of all transport across the UK could deliver a productivity gain of 1.2%.

One of the most substantial contributions to the application of agglomeration assessment for transport has been the type of evidence developed by Graham (2007a; 2007b) and Maré and Graham (2009). These studies derived evidence on the relationship between 'effective density' and productivity. Effective density is in effect a measure of accessibility to employment that can be estimated at a local level with and without a transport improvement. The research developed a set of elasticities that helped convert the accessibility improvement from a project into a productivity gain from agglomeration. For New Zealand the elasticities varied between sectors, from around 0.032 for agriculture to 0.087 for finance and insurance with an economy average of 0.069. This means a 10% increase in employment accessibility across New Zealand would cause a 0.69% increase in national gross value added. The most recent evidence for the UK is very similar, ranging from 0.021 for manufacturing to 0.083 for producer services.

3.2.2 Competition

3.2.2.1 Description

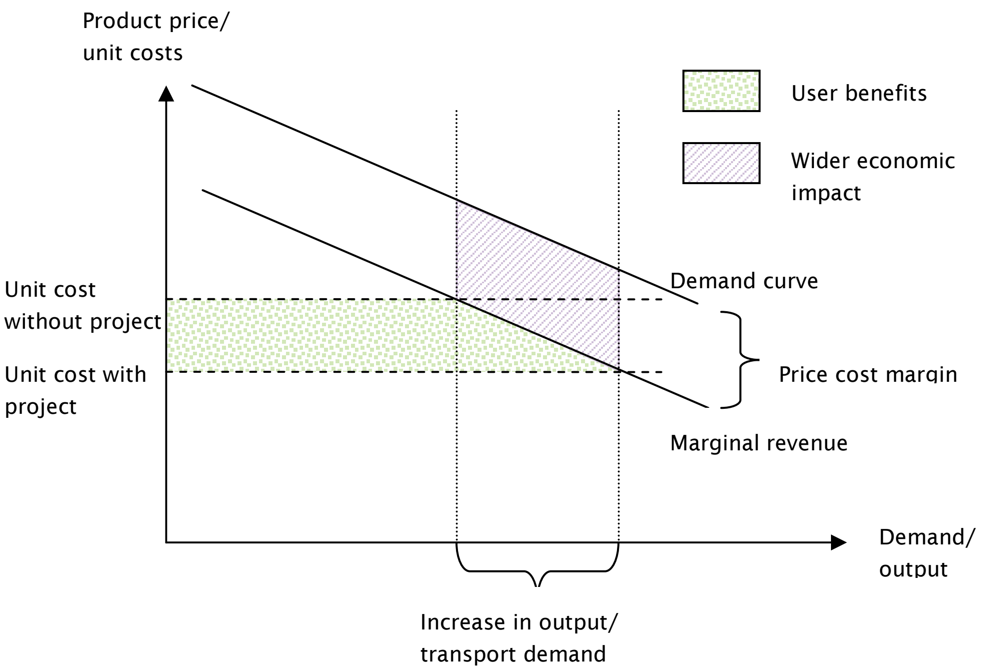
There is an intuitive and empirically verified relationship between the number of firms operating in a market and the fierceness of competition. Fiercer competition can drive down price cost margins and force a sector to minimise costs, improve management and to focus on delivering the goods and services that customers want. There are two potential reasons why improved transport can deliver economic gains by reducing the economic efficiency costs of imperfect competition.

Increased output where there are price cost margins

First, if a transport improvement drives down prices and demand therefore expands, there is a reduction in the societal 'dead-weight' loss that occurs when price cost margins exist. Hence output increases in imperfectly competitive sectors.

Figure 3.1 illustrates the situation of a reduction in transport costs to a firm or sector that is enjoying a price cost margin. The green area is the 'rule-of-a-half', expressing the time/cost savings to travellers quantified as part of conventional appraisal. However, the willingness to pay for the increased output, ie the demand curve, exceeds the internal cost to the firm/sector of producing this output. Since the valuation in appraisal of the improvement is derived from the saving in labour costs, the excess willingness to pay is not captured.

Figure 3.1 Wider economic impacts from imperfect competition



Source: DfT 2005

Under certain conditions there is a fixed relationship between the relative size of the purple and green areas. This relationship is dictated by the level of the price cost margin and the aggregate demand elasticity in the economy. Equation 3.1 demonstrates the wider economic benefit from the existence of a price cost margin equals x% of the user benefits to business travellers:

$$x = \frac{p-c}{p} \cdot \varepsilon D \qquad \text{(Equation 3.1)}$$

Where p is price, c is unit cost (and $(p\text{-}c)/c$ is the price cost margin), and εD is the aggregate demand elasticity.

Lack of competition

Second, lack of competition may cause inertia and complacency that can lead to inefficient management, and cost control and stiffer competition may put downward pressure on prices and hence force firms to tackle such inefficiencies. Importantly, markets for most products are defined geographically. It therefore seems natural to assume improved connectivity will increase competition by expanding the geographical size of markets to include more buyers and sellers, thereby delivering such efficiency gains. In this way, improved transport could mitigate existing market failures.

3.2.2.2 Evidence

Hausman and Sidak (2005) estimated the consumer benefits from the increased variation and price effects of a major supermarket entering the retail food market. They found the additional variety offered to local consumers was worth 20% of expenditure on food, while lower prices were worth about 5%. This suggests the economic benefits from competition can be substantial, and not just via reducing prices, but also from increasing variety and choice.

Glaeser et al (1992) used as a measure of competition the ratio of establishments per employee in a city for a given industry relative to the equivalent ratio for the entire US. They found an increase in this ratio was associated positively with growth. In a study encompassing the high-tech and machinery industries Henderson (2003) investigated the relationship between the average size of plants within each industry and county and plant productivity. Henderson found the number of plants within each industry in each county did positively affect productivity, whereas the average employment per plant did not. Rosenthal and Strange (2003) measured the number of new firm births as a function of the average number of establishments per worker within each industry and in other industries. In all six industries included in the analysis they found, as the number of establishments per worker increased in other industries, the number of firm births in the within each industry decreased. On the other hand, for five of the six industries, the average establishment size within each industry was positively associated with firm births (Rosenthal and Strange 2004, pp2141–2142).

Empirical work on the effects of transportation on competition tends to look at the effect of employment, plant size and the number of plants, both inside and outside the industry (Rosenthal and Strange 2004). Some evidence exists on the relationship between trade barriers and productivity, the former including the cost of transport. The European Commission (EC) (2003) found the introduction of the single market in the European Union in 1992 led to a 1.8% increase in the GDP of member states in 2002. It is of course impossible to judge how important increased competition was for this productivity gain.

Other empirical literature on transportation cost's effect on competition has focused on improved trade linkages between countries, and not the competitive impact on internal domestic trade. Thus, it is hard to draw definitive conclusions from the empirical evidence. Griffith et al (2006) found a reduction in trade barriers led to a reduction in firm price cost mark-ups. The 5% reduction in the tariff rates experienced by most EU countries over the 15 years to 2000 was found to have decreased mark-ups by 4.5%. DfT (2005) suggested a 70% to 100% reduction in travel costs would be required to have a similar effect. Bernard et al (2006) studied trade costs for US manufacturing industries and found evidence that firms in sectors with falling trade costs had higher productivity growth and higher firm death rates.

Transport investments might make markets more competitive but there remains the question of how uncompetitive they are at present. There is limited evidence they are significantly uncompetitive using price cost margins as an indicator[2]. Harris (1998) and Davies (1998) found average mark-ups in the UK

[2] Of course a fiercely competitive industry may still have high price cost margins (for instance because of high fixed costs) just as an uncompetitive sector may have low price cost margins (eg if poor management and cost control lead to inefficiencies). However, margins are nevertheless an indicator of the presence of poorly working markets.

manufacturing sector of between 15% and 30%, while findings by Gorg and Warzunski (2003) suggested between 0% and 15%. Other estimates of margins include Small (1997), who found average margins for service sectors typically ranged between 25% and 40%. Martins et al (1996) found significant mark-ups in most US manufacturing sectors, with most falling between 10% and 30%.

In the UK, DfT (2005) concluded the evidence on price cost margins gave rise to the potential for transport to raise economic efficiency by reducing production costs and hence increasing output. However it also found it was difficult to see how further improvements to the transport infrastructure in such a well connected and very densely populated country as the UK could have significant impacts on the fierceness of competition. It supported this view by also referring to the potential negative impacts of increased integration if it led to fewer sellers holding more market power.

In New Zealand, however, there are indeed concerns about how lack of integration between regions affects competition. The population density is a fraction of that of the UK and the economic geography is one of many small urban centres. McCann (2009) argued the consequences of this regional disparity were worsened by high spatial transaction costs, giving rise to small markets with a much higher potential for local monopolies to develop.

3.2.3 Labour supply

3.2.3.1 Description

For some individuals their labour supply decision, that is whether they seek to work or not (or, technically, how much to work), is sensitive to their take-home wages. They would be balancing the costs of working (loss of leisure time, child-care costs, transport costs etc) against the benefits (take-home pay). Hence, if the cost of working was lower, more people would be willing to work. Transport costs are one element of the cost of working.

If improved transport could encourage a net increase in the number of individuals who seek and find work there could be an increase in economic output from the increase in the labour force. This is important because the labour market features an important imperfection – labour taxation. The labour supply decisions themselves are internal to the individuals concerned, but, should a person decide to start working, the taxation paid on the gross income is a benefit to society the worker (or the firm) does not consider. Should a transport improvement encourage a net overall increase in labour supply, there would be wider economic impacts from increased taxation. This is another example of increasing output in imperfectly competitive markets.

3.2.3.2 Evidence

Despite a considerable body of research studying determinants of labour supply decisions, few studies have considered the role played by transport costs. Kolodziejczyk (2006) found there was a link between fixed costs of working and retirement age based on French data. Gonzalez (2008) found workers living further away from urban centres were likely to retire earlier, although this did not control for the possibility individuals change residential location in anticipation of retirement.

3.2.4 Employment redistribution and productivity differences

3.2.4.1 Description

There is considerable variation in productivity across regions and cities. There are various causes for this, most importantly differences in sectoral composition and workers' skills. However, some of the difference is caused by agglomeration economies. There may be other location-specific factors at play, such as access to ports or fertile land that contribute to the differences. In conclusion, some firms are more productive in some locations than in others because of the activities that already take place there and because of other features of the location (this is called productivity differentials in the UK guidance).

In such locations, typically CBDs in larger cities, workers' access to these high-productivity locations can be constrained by the time and cost of commuting there. If this is the case, a transport improvement could mean increased local labour supply, which would suppress wages and encourage further growth in employment.

Since activities taking place in these locations are more productive than if they were located elsewhere, unlocking growth by attracting more workers would mean a productivity dividend even if it caused no change in the structure of the overall economy. We can expect this dividend to be internal to workers and firms as they clearly do realise that activities taking place in such locations are more productive than elsewhere (otherwise why would firms in cities pay higher rents, wages and transport costs). But, as with the labour supply effect, there is an imperfection in the labour markets causing a wedge between private and social return to work. So if there is a net increase in output in this imperfectly competitive sector, the additional taxation paid on this additional output is an externality benefit not considered by individuals and therefore also not by conventional appraisal.

3.2.4.2 Evidence

Some studies have looked at the causes of differences in productivity across space. Rice et al (2006) found only about 40% of the variation in productivity across space could be explained by sectoral and occupational composition, leaving 60% to be explained by skills differences and other factors such as agglomeration. Blanchflower et al (2002) and ITS (2009) estimated the residual productivity differentials for UK districts, correcting for differences in sectoral and occupational differences and skill levels. The residual variation in productivity varied from about +/-30% of the national average, which suggests the potential for significant net productivity gains from the relocation of economic activity.

3.2.5 Inward investment

3.2.5.1 Description

Many governments and regions make significant efforts to attract foreign direct investment. Such inward investment is seen, at a regional level, as a means to increase activity levels and, at a national level, as a tool to generate productivity spillovers.

When foreign firms enter a market, they can positively affect the productivity of the domestic sector through various channels (see for instance Blomström et al 2000). The very presence of the new competitor may induce increased efforts by incumbent firms to compete and innovate, mitigating the impacts of less than perfect competition. Also, if the new entrant is more efficient, it may force the exit from the market of less efficient incumbents. Finally, interactions between the foreign company and incumbent firms may eventually result in the transfer of knowledge and working practices that enhance the productivity of the sector as a whole.

This is of interest for transport appraisal if it can be shown that transport improvement has the ability to influence the amount of inward investment, and particularly foreign direct investment (FDI), to a country or region. For instance, evidence shows (see below) that the quality of the transport infrastructure can be a key factor in firms' decisions about where to invest.

3.2.5.2 Evidence

Hubert and Pain (2001) found a 1% increase in output in foreign firms in the UK caused technical efficiency to grow by between 0.5% and 0.6%. Others have found little or no relationship when analysing panel data from various countries (see for instance Contessi and De Pace 2009). At best the evidence is mixed and more recent research has highlighted the possibility of a reverse effect, where FDI is a vehicle for multinational firms to gain access to domestic advantages (Wei 2003; Driffield and Love 2003).

Our search failed to find evidence on the relationship between FDI and productivity for New Zealand. Only recently the extensive panel data required for such empirical studies has been made available (Fabling et al 2008) and we understand there are studies at the working paper stage.

The link between transport infrastructure and FDI is even harder to document. The studies that have found clear evidence of a link tend to have looked at developing countries (see for instance Khadaroo and Seetanah 2008 for African countries; and Cheng and Kwan 2000 for China). Goodspeed et al (2007) and Kumar (2001) used cross sections of developed and developing countries and both found a relationship between public infrastructure investment and inflow of FDI, although neither was able to indicate what type of infrastructure was important.

It is likely in developed countries only certain types of investments would have the potential for instrumentally affecting FDI, such as access to international gateways. The *European cities monitor 2006*, a survey by real estate advisors Cushman & Wakefield, found 55% of executives interviewed thought transport links to other cities and international destinations were 'absolutely essential' for their choice of business location, the third highest-ranking indicator.

3.2.6 Gains from trade

3.2.6.1 Description

The contribution of international trade to economic growth is well established and documented in the literature. Crafts and Leunig (2005) argued the technological developments that caused the cost of communication to fall dramatically during last 200 years, through railroads, steam ships, aviation and communication technology, were instrumental in enabling the near explosion in international trade and the associate gains in wealth.

Trade enables economic growth through specialisation and comparative advantage. A key barrier to trade is the trade costs, part of which is the cost of transport. In theory, therefore, reducing the cost of shipping goods, even on the domestic leg of an international movement, should encourage increased trade, which in turn could lead to further economies of scale from specialisation.

3.2.6.2 Evidence

Our search did not find any direct empirical evidence on the potential for transport costs to increase productivity through reducing trade costs. McCann (2009) explained New Zealand's relative underperformance in productivity growth over the last decades in the context of the theory on new economic geography. Crafts and Leunig's submission to the Eddington study team (2005) provided the only example of how existing evidence could be used. By combining empirical evidence on the relationship between a reduction in trade costs and the trade as a proportion of GDP in a country (Limao and Venables 2001) with quantified findings on the impact of increasing trade on economic growth (Frankel and Romer 1999), they suggested a 5% reduction in trade costs could lead to economic growth of between 2.5% and 4.4%.

3.3 Top-down/macro approaches

3.3.1 Transport investment and GDP

3.3.1.1 Description

One of the recent strands of research into economic impacts of transport has considered how public investment can lead to increased output or productivity. Through looking at cross sections, time series or both, the research attempts to measure statistical impact of investment on economic growth at an aggregate level through a production model framework. Aschauer (1989) pioneered this approach by studying variations in transport investment and economic output across states in the USA and found a significant positive relationship. Other researchers highlighted concerns with Aschauer's approach, particularly citing the statistical problems in identifying the true causality: was productivity higher where there was more infrastructure investment or did more productive areas receive more investment? During the extensive debate that followed, Aschauer's approach was adapted and refined and studies correcting for the causality problem generally found much smaller elasticities. This approach was a 'catch-all' estimate of economic impacts of a project, capturing the net total of all positive and negative impacts. There was hence no need to attempt to identify the mechanisms through which the productivity gains appeared, nor to quantify each contributing effect separately (see Holl 2007).

3.3.1.2 Evidence

Earlier evidence suggested the elasticity of output to the stock of public capital was between 0.4 and 0.6 (Aschauer 1989). In more recent work a doubling of public capital investment has been found to lead to between 5% and 30% increase in productivity (see the review by Quinet and Vickerman 2004) which suggested a sustained 10% increase in public transport investment would have long-term impacts of between 0.7% and 3.7% of GDP. Other researchers have not found evidence of a significant impact on growth (see for instance Jiwattanakulpaisarn et al 2005; Stephanedes and Eagle 1986).

Lakshmanan (2010) pointed to these sharp differences in results in the literature, which often provided very different elasticities, even using sophisticated econometric approaches for the same or similar geographical areas, and hence questioned their reliability.

3.3.2 Property values

3.3.2.1 Description

Another top-down approach to measuring the economic gains from transport improvements is counting impacts on property values. It is intuitive that transport improvements have the potential for affecting land and property values, as long as the accessibility improvements of a project are valued by firms and residents.

In theory, if housing supply is relatively fixed (which may be a reasonable assumption for large urban areas), many of the economic impacts would be capitalised in property prices. Summing property revaluations across all affected areas would yield an estimate of economic benefits of the project, including any wider economic impacts that may arise.

3.3.2.2 Evidence

Gibbons and Machin (2003) applied a hedonic pricing model to consider the impacts on property prices caused by the introduction in 2000 of the London Jubilee Line metro extension. They found the improvement caused a 9% increase in property values within 5km of the line. Most of these occurred after the line was in operation, but values started to increase more than four years before. Using a similar approach, Agostini and Palmucci (2008) found property prices in Santiago responded significantly to the announcement of a Line 4 improvement, where properties within 200m of the future lines saw a 4.7% increase in value.

Grimes and Liang (2008) evaluated ex-post the land value impacts of the Northern Motorway Extension in Auckland using an econometric estimation of a spatial equilibrium model. They found discounted property value impacts to exceed the benefits calculated in the ex-ante appraisal.

3.4 Regional economic models

The above discussion has listed a range of approaches or frameworks for assessing the wider economic impacts of transport investments. A separate strand of appraisal is using economic models to assess economic impacts. These tools are sometimes used instead of cost-benefit analysis (CBA), although most commonly they are applied in addition to CBA to help identify a wider range of impacts or additional geographical detail.

3.4.1 Land-use/transport interaction (LUTI) models

LUTI models are a type of simulation model that treat in detail the factors affecting the location decisions of firms and households. Transport is explicitly modelled, either as an integrated transport module or by interactions with existing transport models. Changing transport costs will affect the accessibility to jobs, workers, and location of consumption and social value, which in turn will over time affect the location of firms and households. The latter will have feedbacks on transport costs (eg via congestion) which in turn will affect location decisions.

LUTI models typically take economic and demographic projections as inputs and predict the redistribution of these following a transport investment. Hence they are most appropriate for understanding the urban or regional economic impacts of a transport investment rather than the net contribution to the economic case for the investment from a national perspective.

3.4.2 Computable general equilibrium (CGE) models

CGE models are applied versions of the theory of general equilibrium developed by Arrow and Debeu in the 1950s. They represent the transaction made between economic agents such as firms, workers, households and government as well as interactions between two or more geographical areas. CGE models vary from simple two-sector, two-region models to highly complex multi-sector, multi-region applications (such as CGEurope, with more than 1000 zones and 100 sectors).

The attraction of CGE models is that they are highly consistent with accepted economic theories of how the economy works and are capable of representing equilibrium outcomes taking into account impacts across all markets. This is in contrast to partial equilibrium approaches, such as CBA, whose application requires often implausible assumptions about the functioning of other markets.

One of the main critiques of CGE models is that their strength, in being consistent with theory, is offset with the weakness of requiring detailed evidence of a large number of parameters, giving them a ‘black box’ nature (as argued by, for instance, Panagariya and Duttagupta 2001). A large number of transactions are modelled in a state of equilibrium (ie where all markets are clear – supply equals demand) and evidence is required on the relationship between all of these. This problem is solved in part by the approach of calibration of the model to an ‘equilibrium year’ for which data on transactions is available. But this leaves the question of whether any economy can be considered to be in equilibrium at any point in time.

Also, even a successful and satisfactory calibration will not alleviate the need for additional evidence and assumptions of the exact types of functional forms used to describe behaviour in the models. CGE models typically rely on ‘accepted’ parameter values derived from econometric studies and convenient functional forms. Sue Wing (2007), however, argued many of the perceived shortcomings of CGE modelling were caused by a failure in the literature to communicate the theoretical and practical foundations of this strand of modelling.

With regards to the application of CGE models for assessing the impacts of transport, the main obstacle was, until recently, their cursory treatment of the movement of goods and people. Recent applications of CGE have made advances by representing travel time as a negative impact on the utility and production functions of households and firms, and treating transport supply and demand interactively within the models (see for instance Sue Wing 2007).

3.4.3 Regional econometric models (REMs)

There is a wide range of REMs in application. Particularly in the USA, such models are applied in the transport context to understand the state or metropolitan level impacts on employment and output of infrastructure investments.

REMs typically consist of a set of econometric relationships based around a national macro-model that forecasts overall output and employment by sector in relation to variables such as interest rates, inflation and exchange rates. Depending on the type of area studied, trade may be a dependent or independent variable. The models then have regions as satellites to the national model, predicting regional employment and output growth for each sector as a function of the national outcome and various region-specific factors and policy levers, such as transport investment, investment conditions and land developments.

4 Overview of New Zealand and international practice

The assessment of the economic impacts of proposed transport investments is a part of the basis for deciding to go ahead with a given project, for prioritising of funding between different projects, and sometimes for evaluating in retrospect whether investments have been an effective use of public money. This is used by governments, transport agencies, and other public and private organisations, following official or unofficial guidance. Different countries have developed different guidance, with varying focus on the degree of detail.

This chapter briefly reviews existing practices of assessing wider economic impacts of transport investments in selected countries, including in New Zealand. We first consider the conventional assessment framework before identifying to what extent existing practices encapsulate wider economic impacts. We look at the UK in most detail, where the assessment of wider economic benefits is the most developed. We also consider the practices applied for assessing public transport investments in the USA. The appraisal framework adopted by the European Union is also reviewed, although it only sets out guidelines on 'best practice' rather than an absolute requirement for transport appraisal by member states. Finally we briefly consider some instructive applications in the Netherlands.

The information in this section comes from documented regulations and published administrative guidance, as well as previous literature reviews.

4.1 New Zealand

Economic efficiency is one of the three assessment factors considered in the funding assessment by the NZ Transport Agency (NZTA). The procedures to be used in the economic efficiency evaluation of activities submitted to the NZTA for funding are described in the *Economic evaluation manual* (EEM), published in January 2010. Volume 1 (EEM1) contains the basic concepts of economic efficiency evaluation in general, as well as specific evaluation procedures for road activities. Volume 2 includes procedures to be used for evaluating transport demand management proposals, travel behaviour change proposals, walking and cycling, transport services (including passenger and goods movements by rail, sea and road), private sector financing, toll road activities and parking measures.

Three types of benefit (or disbenefit) are considered in the economic evaluations of transport activities:

1. Benefits with monetary values derived from the marketplace, eg vehicle operating costs and the value of work travel time.
2. Benefits that have been given a standard monetary value, including the:
    a. statistical value of human life
    b. value of non-work travel time
    c. comfort value gained from sealing unsealed roads
    d. frustration reduction benefit from passing opportunities
    e. carbon dioxide reduction benefit.
3. 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, eg cultural, visual or ecological impact.

Only the first of the above three includes economic benefits as defined in this report. These include time savings for travellers during the course of paid employment, which are valued as the gross labour costs. The maximum values for congestion which may be added to these base values of time for transport users is also provided for work and non-work travel, and similarly for road category and time period.

Benefits of transport activities may accrue to both transport users and other parties. Disbenefits are treated as negative benefits. Furthermore, activities should be considered on a case-by-case basis to determine the appropriate level of data collection and analysis to apply.

The assessment can either be done in a simplified manner or as a full procedure, depending on the nature of the project. Simplified procedures can be used for road activities of capital cost below a threshold value or of a routine nature. These are presented for a selection of specific project types and condense an evaluation into a few pages.

The full procedures are used for economic efficiency evaluation when either more detailed analysis is required than is provided in the simplified procedures, or the limits specified for the simplified procedures are exceeded. The full procedures may be used for all types of land transport activities with appropriate adaptation. The benefits and costs considered in the evaluation should be adjusted or added to as appropriate to the activity type. The full evaluation must comply with the requirements for the particular type of activity.

Agglomeration benefits have been included relatively recently in economic assessments in New Zealand. Agglomeration economies describe the productive advantages that arise from the close spatial concentration of economic activity. The EEM operates with two types of agglomeration economies:

- Localisation economies: the efficiency gains that arise from the increased scale of a particular industry operating in close proximity. These economies are external to firms but internal to the industry.
- Urbanisation economies: the productive advantages that accrue to firms through location in large population centres, such as cities. These economies are external to the firm and the industry but internal to cities. Firms derive benefits from the scale of markets (including labour markets), from the proximity of market areas for inputs and outputs, and from good infrastructure and public service provision.

Weighted average agglomeration elasticities for different industry sectors in New Zealand are provided in the EEM1, based on empirical research. EEM1 states the required spatial concentration of economic activity for realising agglomeration benefits is only likely to occur in the major industrial and urban centres, and only large complex urban transport activities will provide the relevant conditions that justify an analysis of agglomeration benefits.

4.2 United Kingdom

The UK appraisal framework is based on the UK Department for Transport's (DfT) New Approach to Appraisal (NATA), released in 1998 and recently being updated (to be finalised in 2010). This framework aims to capture the full set of benefits society derives from a project in five areas, or goals as stated in the refreshed version: tackle climate change, support economic growth, promote equality of opportunity, improve quality of life and promote a healthy, natural environment and better safety, security and health. Within each of these areas there are a number of challenges, some of which are quantitative and some are qualitatively assessed.

DfT publishes and updates guidance to be used by consultants and agencies conducting appraisal and cost–benefit analysis of transport investments. The guidance is designed to allow DfT to make a standard comparison of transport investments across the country in a balanced way, providing a linkage to national goals and objectives. The government's transport appraisal guidance (www.dft.gov.uk/webtag) contains detailed requirements on model structure and recommendations about parameter values and economic variables. The accounting of benefits and costs is also subject to detailed guidance.

The main change introduced by NATA was an explicit multi-attribute analysis framework, which de-emphasised the CBA results to some extent, in order to consider other issues not easily included within a CBA. The core input to the appraisal, and to the economic assessment of time and cost savings to transport users, was estimated using dedicated transportation models. Other impacts, including accidents, emissions and health benefits were usually estimated on the basis of the model outputs. Yet others were assessed qualitatively.

The trend in refining NATA has been to seek to monetise a broader range of impacts, eg carbon savings, and to attempt to capture these through a more extensive CBA.

The assessment of wider economic development impacts includes two distinct elements. Depending on projects both, or one or none, can be required to be assessed. The first is 'regeneration', or supporting the economy of deprived areas, as measured by the change in unemployment within a 'regeneration area'. This is calculated through an analysis of how the economy operates and why it is in decline/stagnation with a special focus on accessibility. Formal guidance has existed for the assessment of regeneration benefits since 2003.

The second is 'wider impacts' (the new name for 'wider economic benefits'), for which guidance is in the final stages of development. An updated draft methodology was published by DfT in September 2009 (DfT 2009a). This methodology has been applied extensively over the last two years and consists of four of the elements described as incremental approaches in chapter 3:

- Agglomeration economies: these are assessed using the evidence produced by Graham and Youn Kim (2008) on the relationship between changes in effective density and productivity. Effective density is an employment accessibility measure calculated for the situation with and without an intervention based on official employment data and journey costs for work and commuting travel.
- Imperfect competition: the welfare impact from 'output change in imperfectly competitive markets' is estimated as a fixed proportion of total user benefits on business and freight journeys. The up-rate factor is currently estimated to be 10%[3]. The impacts are calculated for the whole modelled area based on the business user benefits identified in the traditional cost–benefit analysis.
- Labour supply: the additional value added to the economy due to a change in overall level of labour supply is calculated in three steps. First, estimation of the total commuting costs and travel time savings for workers commuting from a zone. Second, calculation of how the change in benefit from working will impact on the overall amount of labour supplied using 'return to work' elasticities. Third, the change in labour participation is multiplied by the wage of the marginal/less productive worker. The net wider impact is the taxation paid on the additional output.
- Move to more/less productive jobs: this can be calculated using a 'land-use transport interaction' model that predicts changes in employment location between areas. These changes can affect the

[3] 10% is based on Davies (1998) relationship between price cost margins, the elasticity of aggregated demand and the magnitude of the additional benefits occurring under imperfect competition. As Davies (1998) shows, the 'missing' user benefits are equal to a proportion of the conventionally measured benefits, where this proportion is the product of the average price cost marking in the economy and the aggregate demand elasticity. The discussion paper finds the average price cost margin to be 20% and the demand elasticity -0.5 and hence the missing benefits to equal 10%.

overall productivity of employment, and the effects are estimated using an index of productivity differentials for local authority districts.

Labour supply impacts and imperfect competition impacts are to be assessed for all projects with a scheme costing more than £20m, while the agglomeration assessment is only necessary if the scheme is near an economic centre or large employment area. The appraisal of the move to more/less productive jobs requires a land-use transport interaction model so is not a core requirement.

One of the first applications of the agglomeration analysis was for the Crossrail project in London, consisting of an underground east-west rail link connecting existing rail networks either side of the city. This was projected to deliver significant capacity and accessibility benefits to the capital, estimated to be worth about £12.8bn to transport users (net present value). Colin Buchanan and Volterra (2007) estimated these improvements would attract an additional 26,000 jobs to the CBD by 2026, delivering agglomeration benefits of around £3bn. Other studies have integrated the density-agglomeration relationship with transport and land-use models. Steer Davies Gleave (SDG) used an 'urban dynamic model'[4], to investigate three strategies for improving transport in the Yorkshire region:

1. Access to Leeds city centre
2. Improved transport between the urban areas
3. Increased access between Leeds and the Manchester Metropolitan Area.

The approach used a specification of the transport costs and agglomeration relationship as detailed by DfT. SDG estimated agglomeration could add from 12% to 25% to the direct benefits to travel times and costs.

4.3 USA

The Federal Transit Administration's (FTA) provides guidance and funding for a variety of public transport systems throughout the USA. Their New Starts and Small Starts programmes are the primary federal funding resource for capital investments in fixed guideway transit systems. The 2005 Safe Accountable Flexible Efficient Transportation Equity Act: a Legacy for Users (SAFETEA-LU) addresses the many challenges facing the transport system, such as improving safety, reducing traffic congestion and protecting the environment. SAFETA-LU identifies specific criteria which the FTA must consider in order to advance a New Start project through the project development process and enter it into a funding agreement. These include cost effectiveness, mobility improvements, land use, economic development, environmental benefits and operating efficiencies, in addition to local financial commitment.

However, until recently[5] economic development was not reported as a stand-alone criterion, but was included as an optional measure under the 'other factors' category, documented by project sponsors in a 'making the case' report to be submitted to the FTA. Specific reporting guidance was not provided, and the criterion was not required for the 2008 to 2010 financial year evaluation cycles because FTA wanted 'through the rulemaking process to work with the industry on the development of appropriate factors for measuring the economic development effects of candidate projects' (FTA 2007).

[4] A SDG developed land-use transport model, similar to other four-step or activity-based models.

[5] On 13 January 2010 the US Department of Transportation's FTA restored the statutorily prescribed process for recommending New Starts and Small Starts projects for discretionary federal funding assistance. This included removing the limitation to only recommend projects with a minimum 'medium' score on cost effectiveness imposed by the previous administration, and take into account all the project justification criteria as well as local financial commitment (as required by SAFETEA-LU sections 5309(d)).

Since January 2010, projects are to be assessed on all the SAFETU-LU criteria, with the following weightings: mobility improvements, cost effectiveness, land-use and economic development effects 20%; and environmental benefits and operating efficiencies 10%. Until FTA develops more robust measures, the rating of economic development effects will be based on two of the three sub-factors previously used to rate public transport supportive land use: public transport supportive plans and policies, and performance and impact of policies. These sub-factors, although separated into two separate measures, will be evaluated and rated as they were previously.

The economic development evaluation criteria are as follows:

- transit supportive plans and policies – includes the following factors:
  - growth management
  - transit supportive corridor policies
  - supportive zoning regulations near transit stations
  - tools to implement land-use policies
- performance and impacts of policies – includes the following factors:
  - performance of land-use policies
  - potential impact of transit projects on regional land use.

The FTA's (2008) *New starts and small starts evaluation and rating process* described a method and reporting requirements for a new, primary economic development criterion that would first apply to projects in the financial year 2011. This economic development would be assessed based on three criteria:

1 Developability of land near stations, documented through population and employment forecasts, tax assessment data, a build-out analysis of the total additional development that could be accommodated under existing or proposed zoning and a subjective market assessment by a local analyst.

2 The presence of transit-supportive plans and policies, documented through an inventory of relevant plans, policies and ordinances as well as a narrative description of potential barriers such as environmental contamination. Transit-supportive plans and policies are defined as those that support pedestrian mobility and accessibility, and include pedestrian network connectivity, building setbacks, parking design, requirements and regulations, the land-use mix, and residential and commercial densities.

3 Economic climate as documented through long-term metropolitan growth forecasts, recent growth in station area and project corridor property values, commercial and residential rents, and commercial vacancy rates.

However, following the recent policy change, FTA will now go through a 'rulemaking process' seeking to improve the measuring and quantifying of benefits provided by transit projects, including environmental, economic development, congestion relief and other social benefits.

In practice, the lack of clear prescriptive guidelines has lead to a piecemeal and somewhat uncoordinated set of approaches to assessing economic impacts of interventions and the same conceptual impacts are likely to be counted towards two or more of the assessment categories.

Also, the sheer geographical size of the USA also means the criterion applied in other countries of only capturing net national impacts, ie ensuring that negative impacts outside the study area are captured, is less applicable. Benefits are often assessed on a state or metropolitan level. This has meant regional economic modelling has had a much more important role to play as part of a public transport appraisal framework than in other territories considered as part of this review.

4.4 European Union

The European Union has proposed harmonised guidelines for project assessment for trans-national projects in Europe. This includes the provision of a consistent framework for monetary valuation based on the principles of welfare economics, contributing in the long run to consistency with transport costing. The guidelines were developed through the EC-funded research project Harmonised European Approaches for Transport Costing and Project Assessment (HEATCO 2006), which looked at the latest research results on the different aspects of transport project appraisal and on an analysis of existing practice in the EU countries and Switzerland.

For wider economic impacts of transport projects, HEATCO (2006) states 'in the presence of imperfect factor and/or goods markets, total final economic impacts are likely to exceed those impacts measured directly in the transport sector, ie there is additionality', and emphasises the importance of avoiding double counting in the CBA appraisal. The HEATCO report provides the following separation and description:

- Direct effects: effects on behavioural choice within the transport system (route choice, mode choice, departure time choice and destination choice) by users of that part of the network to which the initiative applies (eg the number of users of a newly planned road).
- Direct network effects: effects on behavioural choice within the transport system transferred by network flows to other users of the network who are not themselves users of the part of the network to which the initiative applies (eg the change in train use in the area where the new road is planned).
- Indirect effects: effects outside the transport market as the result of a transport initiative, typically including changes in output, employment and residential population at particular locations (eg households moving to a city because it has better connections to their work due to a new road).
- Indirect network effects: effects on the transport network of choices made in other markets (land and property markets, the labour market, product markets and the capital market), as a result of changes in generalised cost brought about by a transport initiative (eg the changed traffic flow within a city due to more households locating in the city because of a new road).

The HEATCO report states that the degree to which indirect effects are additional to direct effects differs widely in the literature, but the general consensus is the additional effects are significant. Bröcker et al (2004) found average indirect additional effects to add +20% to the conventionally measured user benefits for the trans-European networks. This was established as an average for the whole European study area, and did not include the effects of reducing imperfections in the labour market. Due to the high variability in the level of additional effects between different areas of Europe, the report recommends that indirect effects should be assessed for each location/project and not added as a fixed percentage to the final economic appraisal.

A survey[6] of the methods of assessment of indirect effects in transport appraisal in 26 European countries showed the most frequently considered indirect effects were the impacts on employment and state finances.

[6] By Odgaard et al (2005). Effects covered, regardless of the method for assessment used (multi-criteria assessment, cost–benefit analysis or quantitative measurement), include: land use, economic development, employment (short term and long term), cohesion (national and EU level), urbanisation, network effects, effects on state finances and equity.

Odgaard et al's report (2005) is concerned about the impact of market imperfection and argues this is best assessed through economic modelling, by incorporating market imperfections such as monopoly, monopsony, increasing returns to scale, externalities and information asymmetry as appropriate. For the best assessment it recommends to combine the advantages of different models rather than applying just one model, since existing models do not feature a standardised and complete inclusion of indirect effects.

If indirect effects are expected to be large, a spatially computable general equilibrium model (SCGE) is recommended. Alternative models can be used (like land-use transport interaction models, regional production function models, system dynamics models and macro-economic models), although these are claimed not to follow CBA accounting principles as naturally as SCGE models. In order to gain an understanding of indirect effects across borders, models need to operate at the European level. At the moment the only available SCGE model at the European level is the CGEurope model[7].

The European Commission recommends the following for the treatment of indirect effects:

- As a minimum, qualitative assessment should be used to provide an indication to the decision maker of the potential size of the additionalities. This assessment should be based on the findings of previous quantitative analyses undertaken in comparable contexts.
- An economic model, preferably a SCGE model, should be used to estimate indirect effects, where these are likely to be significant.

In the EC (2008) *Guide to cost-benefit analysis of investment projects* the assessment of wider impacts is mentioned briefly. It states 'there has been much debate as to whether there are wider economic benefits that are not captured in a traditional cost-benefit analysis', but concludes additional benefits might exist, although they are extremely variable and difficult to predict and are likely to be much less important than the direct transport benefits. Furthermore, the method of impact assessment is presented as a way to assess the wider economic impacts of a facility or an event/attraction on a target locality. Rather than as an alternative to CBA, economic impact analysis is recommended as a complementary tool.

4.5 The Netherlands

In the Netherlands, a standardised approach to CBA practice for infrastructure investments has been mandated by law since 2000, developed by the Dutch Ministries of Transport, Public Works and Water Management and Economic Affairs.

Annema et al (2007) investigated CBA practice through a benchmark system to measure the quality, transparency (ie accessibility for a non-expert reader), correctness, completeness and risk analysis of cost-benefit analyses conducted for 13 major infrastructure projects ranging in size from 300 million to 12 billion euros. Their evaluation found 10 out of 13 were inadequate in terms of transparency, 12 out of 13 were considered 'fairly complete', and only 6 out of 13 received positive marks for quality. The authors concluded that while the Dutch standardised CBA approach had improved ex-ante project evaluations and provided fairly complete information for policymakers, they suffered from a lack of quality in their methods and assumptions.

The Dutch cost-benefit assessment framework for new infrastructure projects does not currently include indirect economic benefits, but several Dutch transport economists argue this should be taken into account, as the conventional CBA of direct transport costs and benefits is based on the erroneous assumptions of a closed economy with perfect competition. This might underestimate or overestimate the total costs and benefits of a project.

[7] Institut für Regionalforschung, Kiel University

Among others, Oosterhaven and Elhorst (2008) at the University of Groningen recently looked at CBA under market imperfections. They undertook an integral evaluation of four Dutch magnetic levitation proposals, explicitly considering market imperfections and cross-border effects. The outcomes provided policy information on the interregional redistribution of employment and population, and on the national welfare effects of the projects. They also compared the results of an integral CBA with those of a traditional CBA of the direct transport effects only. Their conclusion was that where the ratio depended on the type of regions connected and the future conditions of the market economy, the additional economic benefits varied from –1% to +38% of the direct transport benefits due to market imperfections and cross-border effects. Finally, they concluded none of the suggested Maglev projects should be considered socially desirable.

However, it should be noted wages in the Netherlands are determined by national single-industry agreements, which are binding by law to all firms and workers throughout the country. In other words, sectoral wages are assumed to be equal throughout the country, and regional labour supply is assumed to constrain regional labour demand. This affects the benefit calculation since it means there are economic gains from redistributing employment away from dense urban areas where labour demand outstrips supply (because wages are not allowed to rise) to less dense locations where the imbalance is less severe or reversed. Projects that have the reverse effect of attracting additional jobs to the densest urban areas will hence have negative labour market effects.

5 Evaluation of the approaches

The guiding principles for an effective and successful methodology for assessing the wider economic impacts of transport should ensure it is:

- comprehensive and free from double counting, both internally as well as avoiding overlap with benefits captured within other parts of the appraisal
- robust and founded on sound economic theory
- supported by relevant evidence and data
- consistent with wider policy context.

The methodology should enable consistent, cost-effective and practical application. As far as possible the methods proposed should:

- be measurable, either directly or through a suitable proxy
- make use of existing data sources and provide evidence on parameters required for the assessment
- have regard for the availability of models or a realistic expectation of their development.

We keep these criteria in mind when discussing below the merits of the different approaches to assessing wider economic impacts.

5.1 Macro/top-down approaches

There are clear attractions with top-down approaches to assessing the wider economic impacts. It is hard to understand and model the exact interactions that lead to such wider economic impacts and both the production function approach and property value assessments avoid these complications by focusing on relatively easily measurable indicators such as investment or accessibility improvements and economic output. With modest investment the required evidence could be developed for New Zealand and provided to scheme appraisers together with a straightforward framework for assessing their impacts.

Despite these attractions the methods are not helpful in practical application for assessing the full range of benefits in transport appraisal. The production function approach raises concerns about identifying the true causal relationship between transport investment and economic performance, and the wide range of results in the literature adds to this concern. Furthermore, the effectiveness of individual projects will depend on so many scheme-specific factors that can never be taken fully into account within a general macro framework, leading Lakshmanan (2010) to refer to their 'black box' character.

Similarly, measuring impacts on property values has important limitations. First, if housing supply is not fully inelastic, then the economic gains will not be fully capitalised in prices. Rather, increased supply will mitigate some of the price impacts. Second, since we cannot say for certain all types of benefits are fully captured in prices, the approach results in an incomplete measure of economic gains. Third, the evidence derived is generally ex-post for particular investments. It is difficult to see how this can be generalised to allow for ex-ante assessment of benefits for projects of different types and different locations. Finally, benefits can often be spread over large geographical areas and, even if this is not the case, there will be negative impacts on property values in locations that become relatively less attractive compared with the areas directly affected by the improvement. The property value approach will most probably only be able to identify the gains within a limited distance from an improvement.

But more fundamentally, both of these approaches aim to capture all impacts of transport on the economy. It is hence difficult to see how such assessments can be combined within an appraisal framework where many of these impacts are already captured as time savings. The only solution for a consistent appraisal framework that avoids double counting will be to rely entirely on either the property value or production function approach to provide estimates of the full range of benefits from schemes, a role which neither approach is suited for.

5.2 Regional economic models

Regional economic models have their strength in providing an in-depth understanding of economic linkages. They can provide valuable information on sectoral and geographical impacts on employment, income, productivity and output from policy levers. Some models can also provide a general equilibrium assessment of economic impacts that avoids the concern about the partial equilibrium approach ignoring potentially important cross-market impacts.

However, a regional model for assessing the wider economic impacts of transport will need to:

- explicitly represent transport and the time and cost of movements
- have a detailed spatial disaggregation of the study area to allow for an explicit and realistic representation of a transport improvement
- incorporate the market imperfections that can cause wider economic impacts
- separately identify the economic impacts already implicitly measured as part of the traditional cost-benefit assessment, in order to avoid double counting.

Regional economic models tend to do some, but rarely all, of the above well. For instance REMs are strong at robustly incorporating observed economic interactions, but do not operate at a sufficient level of spatial disaggregation to allow transport to be represented realistically. Some CGE models, however, can now represent transport quite well, but are unable to provide estimates of the contribution to economic output of the direct benefits separate from the wider economic impacts. LUTI models are good at spatial detail and the representation of transport, but do not incorporate market imperfections.

Of course, existing regional economic models have not been designed for the purpose of assessing wider economic impacts. It would therefore be possible in theory to build a model for New Zealand with the explicit aim of doing all of the above well. However, the most advanced existing models have been developed over many years with significant resources dedicated to them. Building one for the purpose of complementing the transport assessment in New Zealand is likely to require even more resources.

5.3 Incremental approaches

As opposed to regional economic models, the incremental approaches to assessing wider economic impacts initially developed in the UK are designed for identifying each impact separately from benefits captured elsewhere in a CBA and for making the best use of information that is either typically already available as part of appraisal (eg transport model outputs) or readily available from published sources (eg employment and output by sector). The evidence and parameters required for the calculation of the wider economic impacts can be provided alongside the method for use by practitioners.

The approach effectively offers a menu of assessments, which allows each component to be included or excluded in appraisal guidelines in accordance with the strength and robustness of the theory and evidence underpinning each. Each component can be made compulsory, recommended or optional for different types and sizes of schemes, allowing a high degree of proportionality of the overall wider economic impacts assessment.

However, the fact that each impact is considered in isolation from the others, and from the conventional appraisal, means any feedback effects across the partial equilibriums will be ignored. For instance, increased productivity from agglomeration economies will most likely affect firm behaviour, such as location decisions and trip patterns and frequencies. Unlike some regional economic models, the partial equilibrium assessment framework is unable to capture these feedback effects.

Nevertheless, the high degree of consistency of this approach with the conventional appraisal (which, it should be noted, is also a partial equilibrium assessment), the support in theory and evidence and the relatively low resource requirement has led to the approach being implemented frequently in the UK (even though it is not yet a formal requirement). We have seen applications of elements of the incremental approach across the world, including England and Wales, Scotland, Ireland, Portugal, Spain, the USA, Australia and New Zealand.

5.4 Developing a methodology

As the guiding principles at the beginning of this chapter point out, evidential and theoretical support and practicality is not sufficient for a working methodology. We also need evidence on the variables and parameters needed for its application. Importantly, these need to reflect the economic reality in New Zealand.

This review has concentrated on identifying which mechanisms may cause wider economic impacts, the theory and evidence underlying these and the method being used to estimating them in practice. However, we here comment briefly on the variables and parameters required, potential approaches for estimating these and the availability of New Zealand specific evidence to enable the estimations.

5.4.1 Increased output where there are price cost margins

The UK methodology relies on economists understanding how imperfect markets operate. When analysing sectors or the economy as a whole, there are a different 'models' used to represent how firms compete and hence how they respond to changes in prices, costs or demand. Within a model there are defined relationships between the variables. For instance, under the commonly assumed model of 'monopolistic competition', a reduction in firms' costs from transport would pass-through to prices, encouraging increased demand and output.

There are generally two key parameters required to assess the potential wider impacts from increased output:

- Aggregate demand elasticities tell us how a change in price converts into increased output.
- Price cost margins tell us which proportion of the increased output is additional to benefits captured as part of conventional appraisal.

It is surprisingly hard to come across evidence on aggregate demand elasticities. The UK methodology relies on a consensus among a small group of academics that the appropriate elasticity is around -0.5. Our initial review has not returned any equivalent estimates (or even 'guesstimates') for New Zealand.

An alternative route, however, can be to search for income elasticities. Since an X% aggregate real price change is approximately equivalent to an X% aggregate real income growth, we may be able to use as proxies income elasticities (with the reverse sign), which are more readily available. For instance Dandie and Mercante (2007) review international evidence, including for New Zealand.

Evidence on price cost margins in New Zealand does exist in the literature (see for instance Creedy and Dixon 2000). Also, if the need is not to understand the cause or prevalence of price cost margins, but, as is the case here, to estimate their broad magnitude, evidence can be derived from national accounts. By comparing the differences between sectoral output to their costs (mainly labour costs, net capital formation and taxation), one can arrive at a broad estimate of margins. These results need to be interpreted carefully, but such an approach can offer a cross check of existing evidence in the literature and further insight into differences across sectors and, if the data permits, by region.

5.4.2 Lack of competition

Our review did not find any examples of methodologies for assessing specifically the impact of transport through intensification of competition. At best, such effects may be incorporated in some economic models, but without an explicit treatment.

This meant the stage 2 work needed in the first instance to concentrate on investigating the magnitude and causes of lack of competition in New Zealand. As reported above, McCann (2009) identified inadequate regional connectivity as a problem that might contribute to limiting the competitive pressures in the country.

5.4.3 Labour supply

For the labour supply a simple methodology exists in the UK, which can be transferred quite easily to New Zealand. In principle, the only data and parameters required are:

- employment
- average gross value added (GVA) per worker
- average tax component in labour related costs
- average earnings for new entrants
- labour supply elasticity.

The first three of the above are either publically accessible from Statistics NZ or easy to estimate based on readily available data. Evidence on average earnings for new entrants exists in studies using Statistics NZ's Linked Employer-Employee Database (LEED), for instance Maré and Hyslop (2008).

Evidence on labour supply elasticities in New Zealand also exists in the literature, see for instance Rankin (1990), Maloney (2000) and Kalb and Scutella (2003a).

The UK method is based on using an average national labour supply elasticity. However, evidence shows a significant difference in elasticities for different sub-groups of society. There is therefore scope to incorporate these in the method for New Zealand as far as the available evidence allows, in order to ensure regional variations are reflected.

5.4.4 Labour redistribution

The UK methodology for assessing the productivity gains from labour redistribution is very simple. However, the tough data requirements still mean it may not be feasible or desirable to introduce it as a requirement in appraisal. In particular, evidence is needed on the spatial redistribution effect on employment caused by a given transport scheme, robust estimates of which require a land-use model.

The methodology can still be developed and evidence on the required parameters identified. They include:

- productivity differences across space caused by location factors alone (called 'productivity index' in the UK guidance. Maré and Graham (2009) provide some evidence, but further work is required before we can say whether there is sufficient data to allow the UK methodology to be used
- average tax component in labour-related costs, which again can be sourced from data published by Statistics New Zealand.

5.4.5 Gains from trade and foreign direct investment

We have not found any explicit estimation of these benefits in the context of transport. Although the potential mechanisms are intuitive and plausible, further work will be required to determine whether there exists evidence for New Zealand that would enable these effects to be identified.

5.5 Summary of assessment

From our review we have found that the 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 CBA.

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 CBA benefits. For instance, the NZ Treasury model does not have a spatial disaggregation within New Zealand.

LUTI models can have a useful role in supporting the assessment of wider economic impacts by providing detailed evidence on the redistribution of employment. However, existing LUTI models in New Zealand, such as the Auckland Regional Transport Model (ATM2), do not offer a national coverage. Rather, they are focused on treating specific urban areas.

Developing regional economic models such as CGE or LUTI designed with the geographical detail and representation of transport adequate for the purpose of assessing wider economic impacts could be an attractive solution in the longer term. However, the scope for the study at hand is to develop a working methodology using tools and techniques that can be applied in the short to medium term.

From our review we therefore conclude that the most appropriate approach for introducing wider economic impacts in transport appraisal in New Zealand is to adapt the framework of incremental assessment developed in the UK. Although based on the UK framework, a suitable application for New Zealand would need to be based on New Zealand-specific data and evidence and tailored to the New Zealand economic context and existing appraisal framework. In the next chapter we present a confirmation of the scope for stage 2 of the project, which forms the departure point for the development of a full methodology.

6 Confirmation of the scope for stage 2

Our proposed method for this study recommended basing a framework for assessing wider economic impacts of transport investments in New Zealand on the framework already developed in the UK. We also proposed to identify other potential elements for inclusion where this was feasible within the budget and time frame of the project.

To this end, this literature review built an understanding of the full range of wider economic impacts that could follow transport improvements, and the potential methods for quantifying these. This allowed us to confirm, in principle, that the UK framework was appropriate for inclusion within the New Zealand appraisal method and to identify two additional potential areas for inclusion. We were also able to conclude that identifying wider economic impacts as independent and incremental elements was preferable to alternative approaches using economic models or macro/top-down assessments of impacts.

We recommended the focus of stage 2 of the project should be on researching and developing a framework that was envisaged to incorporate the following six elements (as described in chapter 3):

- mitigation of imperfect competition
- increased output in imperfectly competitive sectors
- increased labour supply
- productivity differentials from employment distribution
- increased inward/foreign direct investment
- increased international trade.

For each of these elements, stage 2 would:

- investigate whether New Zealand specific evidence supported the existence of the particular market failure and the potential for interaction with transport investments
- develop a methodology that enabled the assessment of the effect based on data and evidence readily available as part of appraisals, from published sources and/or parameters to be developed as part of the study
- develop the required New Zealand specific evidence on the parameters required for the application of the methodology.

PART 2: METHODOLOGY

7 Introduction to the methodology

In New Zealand, transport projects are appraised in a cost-benefit analysis (CBA) framework in which project impacts both positive and negative are converted into monetary units and summed to provide an estimate of the total value of the project to society.

This process is vital to the understanding of a project's total impact, as well as the distribution of impacts between different groups. It also provides a consistent process for the comparison of the effects of different schemes in terms of economic value and contribution to the core objectives of transport policy.

The NZTA describes the methodology of the approach in its *Economic evaluation manual* (NZTA 2010). The method includes the valuation of a wide variety of impacts across various types of transport projects. Table 7.1 shows the existing scheme benefit matrix indicating the different types of benefits attributable to each scheme type.

Table 7.1 NZ Transport Agency, scheme benefit matrix

	Road	Demand management	Services	Walking and cycling	Education, promotion and marketing	Parking and land use	Private sector financing and road tolls
Travel time cost savings	·	·	·	·	·	·	
Vehicle operating cost savings	·	·	·	·	·	·	
Accident cost savings	·	·		·	·	·	
Seal extension benefits	·						
Driver frustration benefits	·						
Risk reduction benefits	·	·	·		·		·
Vehicle emission benefits	·					·	
Other external benefits	·	·	·	·	·	·	·
Mode change benefits		·	·	·			
Walking and cycling health benefits		·		·	·		
Transport service user benefits			·			·	
Parking user cost savings		·			·	·	
National strategic factors	·	·	·		·		

Source: NZTA (2010)

The standard appraisal methodology is focused on savings in travel time, operating costs, accident costs and other more peripheral benefits using a set of software maintained by the NZTA.

These costs and benefits are valued using shadow pricing to adjust for the difference in the perceived market price and the true resource costs which often diverge because of taxes and subsidies. For example when an individual purchases a good in New Zealand they perceive the price as the resource cost + goods and services tax (GST); however, when the government purchases a good the price is merely the resource cost because indirect taxes are ultimately returned to its pocket. In New Zealand, the factor cost unit of account is used.[8]

The method 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 10 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[9].

7.1 Wider economic impacts

The importance of transport to economic growth and development is intuitively obvious, but quantifying the full effect of a specific project is difficult because of the complex interactions between transport demand, supply, employment, business formation and land use. The economic benefits of transport are realised in a variety of different ways including time savings, wider employment catchment areas and greater economic density, improved market access, higher land and property prices and greater labour pools to name but a few.

The wider economic impacts methodology developed in the UK by the DfT provided a step-change in the understanding and quantification of the economic benefits of transport, providing business case reviewers with a much better view of the full impacts of transport projects.

The theory of the wider economic impacts of transport supposes that schemes can produce benefits through five main effects that are additional to the standard approach to appraisal:

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

The inclusion of wider economic benefits in appraisal can significantly increase the economic valuation of a project. For example in an evaluation of the UK wider economic appraisal methodology, the DfT found that scheme wider economic benefits varied from 4% of conventional benefits for the South Yorkshire Bus subsidy to 44% for London’s Crossrail project.

In the following chapters we explain the latter four of the above effects and the economic theory that underlies them (agglomeration impacts have already been included in the EEM). We summarise the best available secondary evidence to implement the theory for New Zealand, and suggest some appropriate parameter values from evidence-based calculations.

Chapter 9 explains and examines the evidence for imperfect competition benefits and provides an estimate of the appropriate parameter values.

Chapter 10 explains and examines the evidence for improved competition benefits.

[8] This is merely a convention and the market price is an equally valid measure.

[9] Although the manual does briefly discuss the potential impacts of transport projects on economies of scale.

Chapter 11 explains and examines the evidence for labour supply impacts and provides an estimate of the appropriate parameter values.

Chapter 12 explains and examines the productivity differentials from job relocations.

The methodology employed to estimate each parameter is fully explained in each section. We also highlight any evidence gaps and suggest areas where additional primary research may be appropriate to improve the accuracy and scope of the wider impacts method for New Zealand.

Unless otherwise indicated all prices are quoted to a price base of June 2008 based on historical price information from the Bank of New Zealand.

8 Imperfect competition

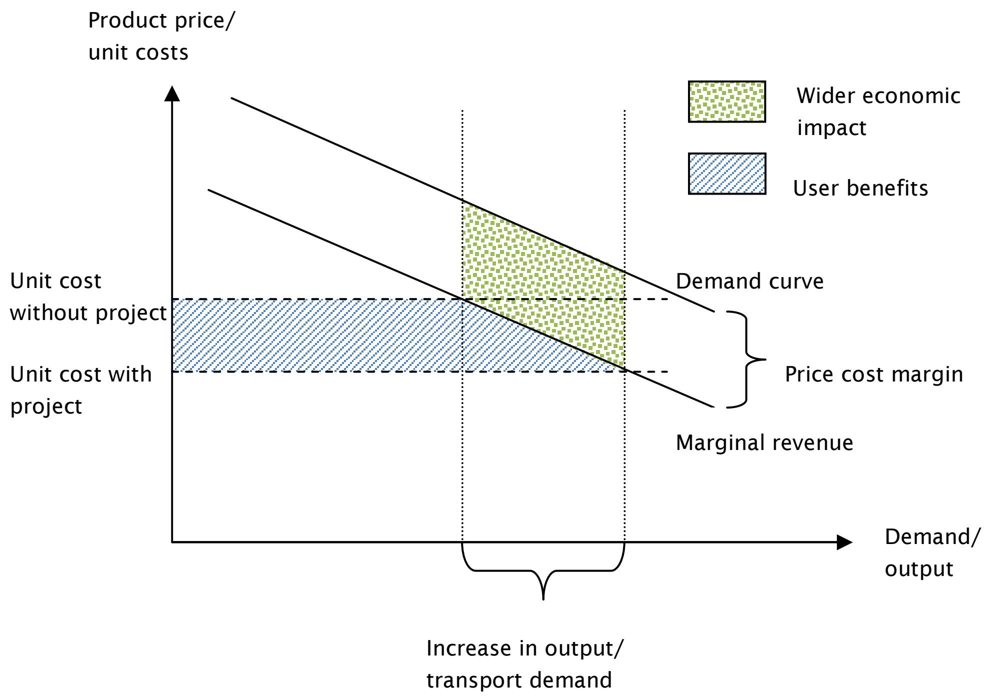
8.1 Description

The wider economic impact from imperfect competition can occur if a transport improvement causes output to increase in sectors where there are price cost margins.

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

However, if price cost margins exist, they, by definition, cause a wedge between the hourly gross labour costs and the market value of what is produced in that hour. Hence, where there are price cost margins, a transport-induced increase in output will cause a wider economic impact identical to the size of this wedge. Figure 8.1 illustrates the conventionally measured user benefits in light blue and the 'missing' benefit in light green.

Figure 8.1 Wider economic impacts from imperfect competition



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

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

However, the existence of imperfect competition means the increased output delivered by the project will lead to further gains, shown as a light green in the figure[10]. It is clear from the figure the magnitude of this wider economic impact is equal to the price cost margin multiplied by the increased output. However, the output increase from a given transport improvement would be difficult to measure directly.

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

$$IC = \left(\frac{PCM \cdot e}{PCM \cdot (e-1)}\right) = \frac{1}{n+1} \qquad \text{(Equation 8.1)}$$

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

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

8.2 Price cost margins in New Zealand

There is significant literature on price cost margins, but we have only discovered one paper that produces results for New Zealand. Boulhol (2005) estimated price cost margins for the manufacturing sectors in 18 countries. Table 8.1 A) shows average margins vary between countries from less than 10% in Norway and Sweden to close to 15% in New Zealand and Japan.

Table 8.1 B) shows the variations between sectors are more significant, from about 6% to nearly 16%. Note that these estimates ignore the service sectors where price cost margins are likely to be higher. For instance, the UK Department for Trade and Industry (reported in DfT 2005) found price cost margins across both manufacturing and services in the UK to be about 20%, which is double the result from Boulhol.

[10] This is conceptually similar to the resource cost correction in the transport market in the EEM, which accounts for the margin between market and resource prices created by taxes and duties. The wider economic impact from imperfect competition is, on the other hand, caused by the margin between resource prices and resource costs, so is entirely additional to the resource cost correction.

Table 8.1 Average price cost margins by nation and sector

A) All sectors, by country

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

B) All countries, by sector

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

Source: Boulhol (2005)

However, DTI's work ignored two elements: the cost of capital and the value appreciation of fixed capital. The relevant price cost margins for our purposes should be the margins in excess of 'normal' profits; that is, over and above what is required to give investors a normal rate of return. Hence the cost of capital should be included as a cost. Also, appreciations to the value of capital stock should be deducted from the cost base as it is a gain to the capital stock owner.

To supplement Bouhol's findings, we estimated average price cost margins for New Zealand based on national accounts data, similar to the DfT analysis. We have also included an assessment of both the cost of capital and the appreciation of asset values.

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

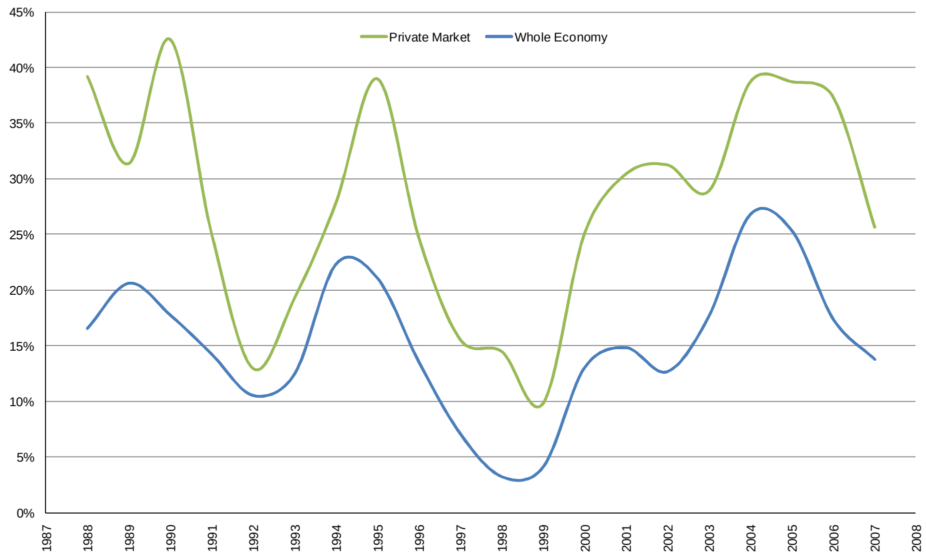
(Operating surplus – depreciation – capital costs + appreciation of the value of capital)/gross value added.

We have sourced national accounts data on gross operating surplus, depreciation, capital stocks and gross value added, all by sector and over time, from New Zealand national accounts. Estimates of the current weighted average cost of capital are based on PWC (2009), while historical data is sourced from Bao (2008).

The appreciation of the value of capital has been estimated from national and capital accounting data as the difference between nominal growth in capital stock and net investment.

Figure 8.2 shows our findings of the evolution of the price cost margins in New Zealand for the private sector and whole economy from 1988 to 2007. Clearly there is a substantial variation over the business cycle, but the average margins are around 25%–30% in the private sector market and 15%–20% across the whole economy.

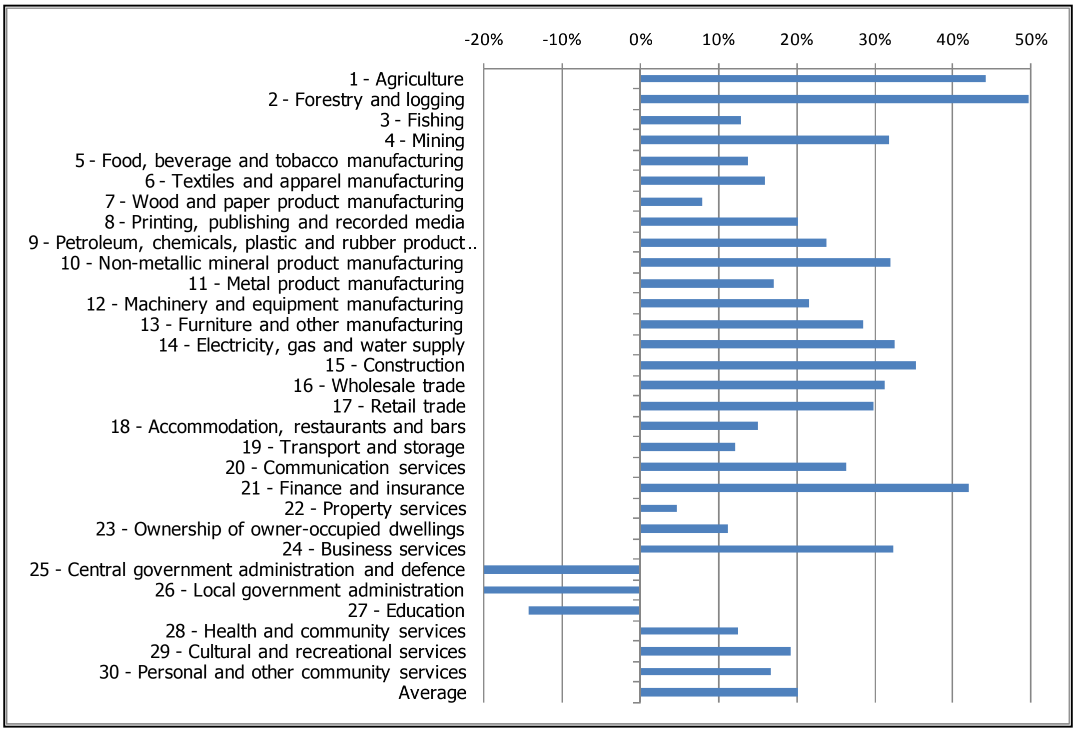
Figure 8.2 National price cost margins in New Zealand over time



Source: SDG analysis

Figure 8.3 shows the variation between sectors in average margins from 1988 to 2007. Again a substantial variation is evident. The largest margins are found in primary sectors, where typically a larger proportion of earnings are taken as operating surplus, and in finance and insurance. Negative margins are found in the public sector.

Figure 8.3 Price cost margins in New Zealand by sector



Source: SDG analysis

Despite the variation over time and across sectors, there are too many uncertainties and data constraints to attempt to apply sector or time-specific values as part of a wider economic impacts methodology. The most appropriate price cost margin is therefore the long-term, whole economy average across business cycles and sectors. We found this average for New Zealand to be 20%. This result is coincidentally identical to the price cost margin found by DfT (2005) to be the appropriate value for the UK.

8.3 Aggregate demand elasticity

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

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

Work for the UK Standing Advisory Committee for Trunk Road Assessments (SACTRA) (1998) suggested the most appropriate value for the UK was -0.5, based on an informal application of a Cournot-style economy (see appendix A for an explanation of Cournot competition).

Since none of this evidence is specific to New Zealand, we asked the NZ Treasury for evidence from their Treasury model. They provided a simulation run of a 0.45% increase in prices over two quarters, which led to a 0.25% reduction in consumption, implying an aggregate demand elasticity of just above -0.55. This seems to lend support to a value for New Zealand similar to SACTRA's finding in the UK.

Nevertheless, the existing evidence for an aggregate demand elasticity for New Zealand is not very robust, although there is another set of evidence that may be of help. The aggregate demand elasticity explains changes in total demand in an economy caused by changes in overall real prices. However, a change in overall real price levels is equivalent to the opposite change in real incomes. We may therefore be able to use income elasticities of demand as a proxy for price elasticities (with the opposite sign).

Pesaran et al (1997) estimated income elasticities for 15 OECD countries and found the cross-country value to be between 0.9 and 1. Specifically for New Zealand the estimate was 0.913. Szeto and Ryan (2009) described the empirical work underlying the consumption function in the NZ Treasury model, where they found the income elasticity to vary between 0.56 and 0.98 depending on the time period over which the relationship was estimated. In the model they applied a calibrated elasticity of 0.66.

To support this, the Treasury provided us with a simulation run: a 1.2% increase in private sector wages was found to lead to a 0.25% increase in consumption. Since the private sector wage bill is about 37% of total income in New Zealand, the wage increase is equivalent to 0.45%; we again get an elasticity just above 0.55.

Given the scarcity of established evidence and the wide range of estimates, it appears reasonable to adhere to the value the NZ Treasury has applied and found from simulations of their model. Their estimates imply aggregate demand elasticities of between -0.55 and -0.66, and we therefore recommend applying an aggregate demand elasticity of -0.6.

8.4 Application for the appraisal of wider economic impacts

As demonstrated in appendix A, the wider economic impacts from imperfect competition can be estimated as a fixed proportion of conventionally measured time and cost savings to in-work travel. The fixed proportion is equal to:

$$IC = \frac{pcm \cdot e}{pcm \cdot e - 1} = \frac{(0.2)\cdot(-0.6)}{(0.2)\cdot(-0.6)-1} = 0.107 \qquad \text{(Equation 8.2)}$$

This indicates that the wider economic impacts from imperfect competition, WEIIC, can be estimated as WEIIC = BUB x 0.117, where BUB is business user benefits, ie time and cost savings to in-work travel.

8.5 Average 'notional' number of firms in each market

As indicated above, the imperfect competition (*IC*) factor can also be calculated from the number of firms, (*n*), in each market. The *n* in this context refers to the number of identical sized suppliers. In reality suppliers are unlikely to be identically sized; however, we can use evidence on market concentration to estimate a 'number equivalent'.

This estimate is based on the Herfindahl[11] Index of concentration, which ranges from 0 for a perfectly dispersed competitive market to 1 for a single supplier. The Herfindahl 'number equivalent' is the reciprocal of the Herfindahl Index. So a market with a Herfindal Index of 0.2 is equivalent in concentration to a market with 1/0.2 = 5 equally sized suppliers.

There are no recent officially published statistics on the Herfindahl Index for New Zealand. However, there are some estimates in the literature. Pickford and Michelini (1985) found the index to vary by sector from 0.035 to 0.869 for 3-digit ANZIC[12] non-manufacturing sectors in New Zealand during the years 1977 to 1980, with an average of 0.223. This equates to a number equivalent of 4.5.

However, Davies (1998) argued the appropriate level of analysis was at the 4-digit level since this more detailed segmentation was more closely aligned to individual markets. There are on average between two and three 4-digit sub-sectors within each 3-digit sector. Recognising that some suppliers may operate in more than one of the sub-sectors, Davies (1998) suggested 3-digit segmentation would underestimate the number equivalent by a factor of about 2[13]. So a corrected estimate from Pickford and Michelini (1985) would be about nine firms. This equates to an imperfect competition factor of about 0.11, very close to our initial estimate.

Iyer et al (2009) found the index to be 0.14 for domestic firms and about 0.3 for multinational firms within the manufacturing sector. With the Davies-correction, this is equivalent to between 7 and 14 firms within each market, or an imperfect competition factor of 0.07 and 0.13.

Although the evidence is relatively sparse, the alternative firm concentration approach of estimating the IC factor yields results that strongly supports the finding of a factor of 0.107.

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[11] The Herfindahl Index is a measure of the number and relative importance of firms in a given industry. It is frequently used as a measure of competition in a market by regulatory authorities. It is defined as the sum of the square of the market share of the 50 largest firms in a sector where market share is expressed as a fraction of the total market value. An index of 1 represents a monopolistic market, an index of 0 represents a perfectly competitive market.

[12] Australian and New Zealand Standard Industrial Classification

[13] If a 3-digit sector has two 4-digit sub-sectors and no supplier serving both sub-sectors, then estimating the number equivalent based on 3-digit data will underestimate the number of suppliers with a factor of exactly 2.

8.6 Summary

Based on the best available evidence we estimate a 20% aggregate price cost margin for the New Zealand economy and an aggregate demand elasticity of -0.6. Academic research also indicates a Herfindahl index of around 0.223 which implies an average of around nine firms per ANZIC 4-digit sub-sector.

This evidence leads us to recommend that NZTA use our estimate from first principles that imperfect competition benefits can be estimated as a direct 10.7% uplift on business user benefits.

Table 8.2 Recommended parameter values for imperfect competition benefits

TParameter	Description	Value
εad	Aggregate demand elasticity	-0.6
pcm	Price cost margin	20%
τ	Ratio of imperfect competition benefits to business user benefits	0.107

9 Increased competition

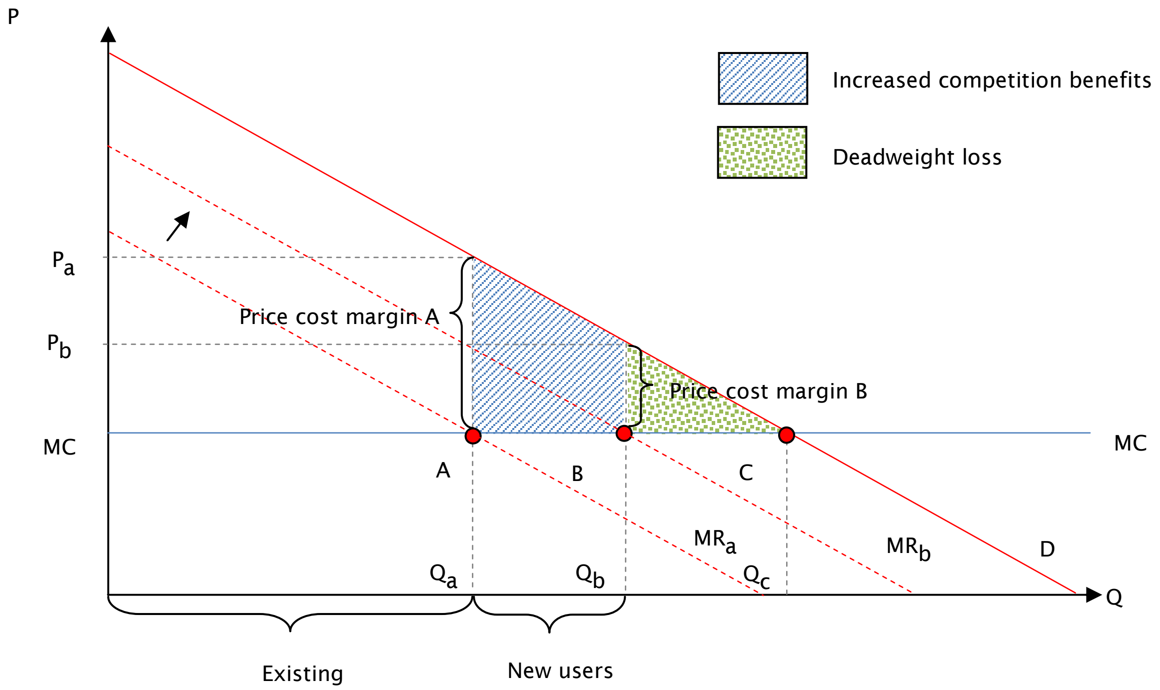
9.1 Description

As described in chapter 8, the presence of a price cost margin in an economy provides conditional evidence of imperfect market competition and the greater the margin the greater the level of market failure and welfare losses relative to the perfectly competitive optimum position.

Increasing the levels of competition in an economy therefore produces an additional economic benefit by pushing the economy toward its optimum position and reducing the overall deadweight loss to society by increasing output and reducing price, and eroding market power from monopoly, oligopoly and other forms of market failure.

If a price cost margin exists, not only will the assumption of a perfectly competitive economy misrepresent the true level of user benefits attributable to a reduction in marginal cost (imperfect competition benefits) but there is also potential for a project to improve the level of competition in the economy by reducing the magnitude of the price cost margin and directly increase welfare. The effect is shown in figure 9.1.

Figure 9.1 Increased competition benefits



The figure shows a situation where market imperfections cause prices to deviate from marginal revenue (MR) so that price is set above marginal cost (MC), and the economy is set at point A with price P_a and quantity Q_a. The price cost margin is therefore equal to (P_a-MC).

If the competitiveness of the market was improved in some way, the ability of each firm to control the price would diminish and the price cost margin would fall, for example from (P_a-MC) to (P_b-MC), the market would then move to point B, and output would increase from Q_a to Q_b with economic benefits equivalent to the blue shaded area. Note the marginal cost does not change.

Although visually similar to figure 9.1, this effect is additional to imperfect competition benefits, which correct the standard benefit calculation in the presence of imperfect completion (with a fixed price cost margin). Increased competition benefits capture the impact of a reduced price cost margin.

Therefore if a transport scheme increases the levels of competition in an economy it will deliver an additional set of economic benefits by reducing the amount of deadweight loss caused by price deviating from marginal cost. In theory this process could occur through several economic linkages described in the next section.

9.2 Spatial market power

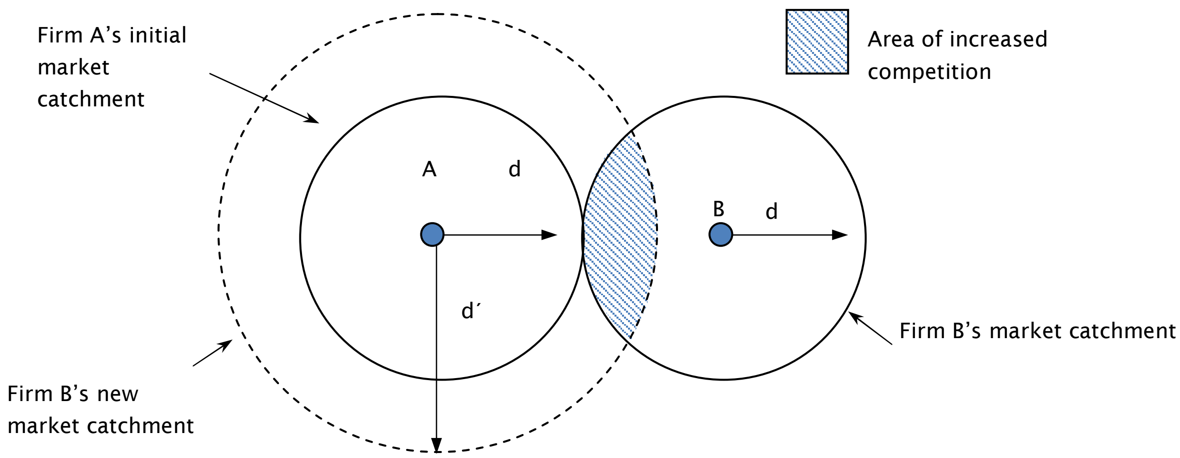
A key concept in the importance of transport and market performance is the idea of spatial market power and that market power can be directly related to transport costs and accessibility. For example at an aggregate level the retail market is broadly competitive, with many shops selling similar products to many consumers, with no significant economies of scale, information asymmetries and no significant market power apparent at the broad industry level.

However, in reality transport costs do produce market frictions and this means consumers are effectively limited to several shops in a local area, which compete as much on distance from the consumer as on the price of products sold. (Transport costs are particularly important for markets where transport costs are high relative to the overall cost of the product such as in logistics and retail).

Where transport access costs between businesses are high this results in a spatial oligopoly which can increase market power for firms with isolated catchments and can produce an uncompetitive outcome with higher costs and poorer service.

By reducing the transport costs of consumers and firms, a transport improvement effectively widens the market catchment area and thereby increases the level of competition in a given economy; this reduces market power and brings the market closer to the perfectly competitive outcome. The effect is illustrated in figure 9.2.

Figure 9.2 Spatial market power



This shows two identical firms A and B, both with catchment radii equal to d, just in contact at the margin. Although the firms are part of a broadly competitive market at the aggregate level, the consumers within each catchment area effectively face a limited spatial monopoly (or some degree of market power) because of high transaction costs which deter consumers from using the firm at a greater distance.

A transport investment increases the catchment radius of firm A from d to d' and this expands the catchment so that consumers in the blue shaded area are now within the catchments of both firms, and thus market overlap erodes the spatial monopoly and increases competition producing welfare gains through directly reducing the average price cost margin of both firms A and B because they are now in direct competition over a portion of the total market which effectively moves from monopoly to duopoly.

While this is a highly stylised example, in principle it is clear to see how and in what context transport investments could produce significant economic benefits through increased competition and reducing spatial market power and directly reducing the Herfindahl Index for a given market. Such effects could be apparent through for example connecting an island to the mainland, or bridging a river between two towns.

The effect is most likely to impact on industries where transport and time costs are an important component of overall cost. These include firms that transport bulky or heavy items over long distances, or conversely must attract customers over long distances, such as in retail, food and drink, logistics, construction, agriculture mining and tourism sectors. In industries where the movement of goods or the attraction of footfall is less important such as in finance and business services, professional services and some parts of manufacturing, transport costs are not likely to be an important factor in market competitiveness.

Furthermore, different industries operate over very different scales from the corner shop serving a network of local streets to the accountants or lawyers serving the local town to the consultancy firm serving international clients. Therefore the actual impact of transport accessibility on aggregate market competition is highly variable over different markets.

9.3 Other effects

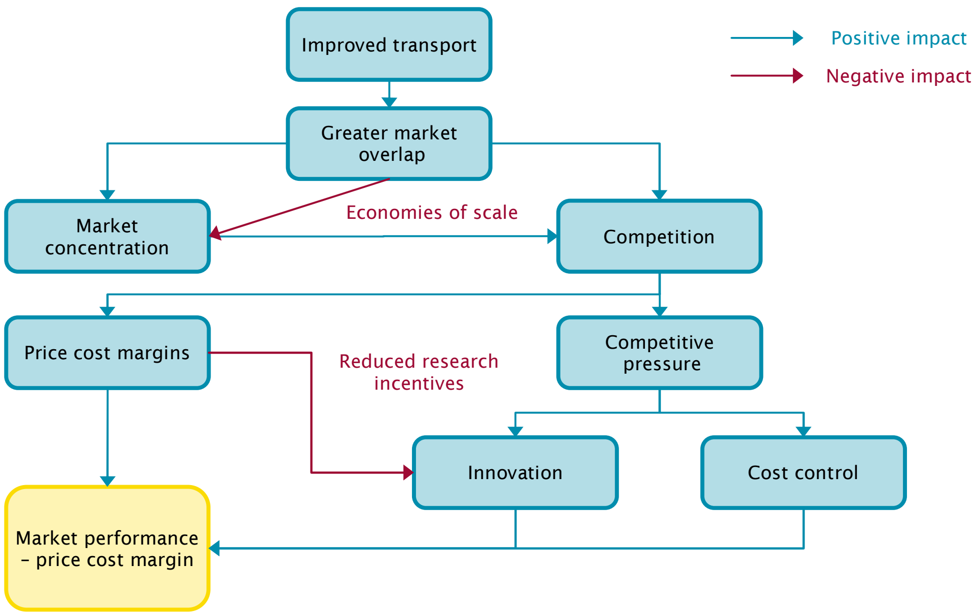
Although transport can increase the competitiveness of markets through reducing effective distance, this can have other impacts. By increasing the spatial reach of each firm, transport projects can:

- as discussed above, increase market overlap leading to more intense competition between firms, reducing monopoly rents and encouraging increased innovation and cost control (either directly through existing firms or through 'creative destruction' of inefficient firms[14])
- decrease firm concentration if there are economies of scale, which will reduce average production costs but also potentially reduce competition
- discourage innovation by eroding monopoly rents.

A flow chart of these processes is shown in figure 9.3.

[14] New more efficient firms replacing exiting, less efficient firms.

Figure 9.3 How transport improves market competition



The figure shows that reducing transport costs initially results in greater market overlap as more businesses become accessible to more consumers. This directly increases competition between firms and can produce welfare gains through greater competition, lower price cost margins and greater competitive pressure which then lead to more innovation and greater cost control increasing market efficiency and welfare.

A secondary effect of increasing market overlap is the impact on firm concentration. Higher firm concentration produces benefits through agglomeration and increased consumer choice, but the impact of a transport project can actually be negative if there are economies of scale in a market.

The presence of economies of scale means that larger firms develop a cost advantage that allows them to eliminate competition through lower prices. Hence in the presence of economies of scale the expansion of a catchment area for a firm has the potential to increase its market power at the expense of a smaller rival.

This effect is demonstrated in the new economic geography literature, for example Krugman (1991) shows how manufacturing industries exploit economies of scale and agglomeration to show how reductions in transport costs encourage some industries to concentrate in core centres at the expense of regional hinterlands and smaller towns.

This impact is clearly apparent in the grocery market where, as people have become more mobile through increased car ownership, the catchment areas of supermarkets have effectively expanded dramatically. As a result more consumers choose to shop at the supermarkets because of lower costs and convenience and smaller shops are driven out of the market. This has a direct cost in reducing the level of choice for the consumer, but the effect is not necessarily a sign of market failure in that large firms such as supermarkets have lower costs and are therefore more efficient. However competition, concentration and market variety is clearly reduced which has potential impacts on cost control and innovation. In addition there is actually an increased risk of market power developing which is a clear negative impact.

Furthermore, there are some important reasons why a price cost margin is not always an indicator of market failure. High sunk costs for example mean some market power is required for private companies to break even when providing a good or service; the marginal cost price of rail for example is not normally enough to cover the fixed costs of track building and maintenance. Similarly in terms of increasing innovation it is necessary to grant legal monopolies to innovators through the patent system so that companies can recoup the high research and development costs involved in new developments through monopoly profits, at least for a limited time.

Therefore, reducing transport costs between areas has an ambiguous effect on competition. The presence and strength of these effects is further complicated because different markets are more or less sensitive to each particular factor. The competitiveness of some industries may be very closely linked to transport costs, while for other markets these effects may be negligible so the aggregate effect from an appraisal point of view is difficult to determine.

9.4 Evidence for increased competition effects

Unfortunately direct empirical evidence for the effect is largely unavailable. However, we can draw some conclusions from research into the effect of removing or reducing trade barriers which are widely understood to generate positive impacts on competition between nations and could be considered a loose proxy for increases in transport accessibility on a major scale.

For example Griffith and Harrison (2004) in examining the trade tariffs between EU members found a 5% reduction in the mean tariff rate was associated with a 4.5% reduction in the domestic mark up of a firm. Assuming transport costs make up between 5% and 7% of total costs to the firm this implies a similar result could only be achieved by reductions in transport costs of between 70% and 100%.

Furthermore the EC (2003) found between 1992 and 2002 the single market had increased total European GDP by 1.8%, although this was the result of many factors, not just improved transport links or a reduction in trade barriers.

Such indirect evidence is indicative of the potential effect of transport; however, there are clearly problems in comparing the effects of international trade liberalisation between nations and transport projects within them which means this is not suitable evidence to apply in an appraisal.

Another persuasive reason why transport projects may not have a significant effect on the level of competition is that most developed economies are already regulated by competition authorities whose role is to minimise market power and ensure market efficiency through, for example, franchise arrangements, preventing anti-competitive acquisitions, controlling price and firm behaviour and removing barriers to entry and exit. If strong spatial monopoles do exist we could anticipate they would be identified and ameliorated by regulatory authorities so transport impacts are not likely to be material[15].

Additionally part of this body of economic theory suggests, even in industries where market failure is likely to be a problem, firms will act in a near optimal manner if barriers to market entry and exit are sufficiently low so as to deter the realisation of market power. This essentially means, even in the presence of a spatial monopoly, firms will behave in an optimal manner if barriers to entry are low because any super normal profits or market power will act as a signal and encourage new firms to enter into the market at lower cost, removing all profits for the incumbent. Hence where spatial monopolies do exist they are unlikely to be severe where there are no barriers to entry or exit.

[15] Armstrong and Sappington (2005) provide an overview of the latest economic regulation theory.

9.5 Summary

We conclude that, while there are clear intuitive and theoretical reasons why a transport investment could increase levels of competition in some markets, there is very little suitable empirical evidence to estimate the effect at an aggregate level in appraisal.

Furthermore there are some strong reasons to suspect in developed nations with fully formed transport networks, and well-regulated markets, the competitive impacts of transport schemes will be small and only occur to a significant degree in isolated areas where market access is difficult.

We therefore do not recommend the quantification of this wider economic impact in general appraisal. However, New Zealand is a small and relatively remote economy where access can be particularly constrained for some locations. It may be that scheme promoters would want to consider developing their own evidence for an effect in cases where:

- a scheme generates a major improvement in accessibility for the study area
- there is evidence of a lack of competition in some or all sectors of the local economy
- the impact of the scheme on levels of competition and the price cost margin can be fully quantified
- the economic value of this reduction can be measured.

10 Labour supply

10.1 Description

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 commuters are the main beneficiaries, and it is clear the travel to work experience is a key factor in the labour market decisions of workers and can often be a significant deterrent for those not in employment.

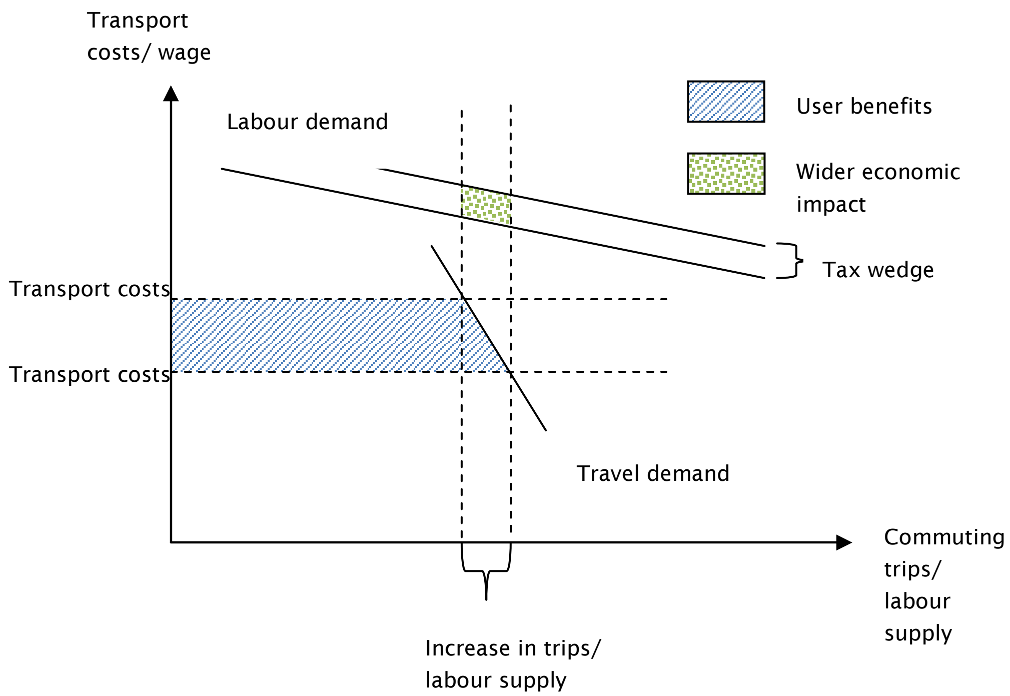
Reduced time and cost of commuting can enable easier access to work and increased separation between places of work and places of residence. In either case, it is natural to assume a reduction in the perceived cost of working can induce more people to work than would otherwise be the case. This could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

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

However there are some important externalities in labour supply decisions, the main one being increased tax revenue. Since individuals make their labour supply decisions based on the returns to work net of income tax and other forgone benefits, there is a wedge between societal and private gains from a person working. This wedge is neglected in transport appraisal, so if it can be shown 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 10.1 illustrates the presence of the tax externality (the 'tax wedge') on labour supply. A reduction in travel costs increases the number of trips and the labour supply. Increased labour supply increases the levels of income and tax, which is a direct social benefit.

Figure 10.1 Wider economic impacts from increased labour supply



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

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

The following sections discuss how existing evidence can enable such an assessment.

10.2 Transport and labour supply

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

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

The links between travel time and labour supply are therefore complex and potentially contradictory between different segments of the labour market. The UK DfT's guidelines on assessing wider economic impacts conclude there is insufficient evidence to support an assessment of how time savings in travel to work can impact on hours worked for existing workers.

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

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

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

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

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

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

We are more interested in the impacts of travel times on participation rates and, as we demonstrate in appendix B, treating a commuting time saving as a change in the fixed cost of working or in the wage rate is much less problematic than when considering the direct change.

The following section formalises the theoretical relationship between commuting time savings and the labour participation rate.

10.3 Formalising the relationship between commuting time and labour participation

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

$$\frac{\partial E}{E} = \frac{\partial w}{w} \cdot e \qquad \text{(Equation 10.1)}$$

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

Since we can consider the value of a commuting time saving as a change in net wage, we can write:

$$\frac{\partial E}{E} = \frac{V^C\partial t/_{(1-\tau^l)}}{w} \cdot e = \frac{V^c\partial t}{w(1-\tau^l)} \cdot e \qquad \text{(Equation 10.2)}$$

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

The additional output from increased employment is the average GDP per worker for the new entrants, GDP_W^E, times the additional employment, *dE*, so:

$$\partial GDP = \partial E \cdot GDP_W^E = \frac{V^c\delta t}{w(1-\tau^l)} \cdot e \cdot E \cdot GDP_W^E \qquad \text{(Equation 10.3)}$$

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

$$\partial GDP = \frac{CV^c\partial t}{w(1-\tau^l)} \cdot e \cdot GDP_W^E \qquad \text{(Equation 10.4)}$$

Where *C* is the number of commuters. The tax take on this additional output, τ^{LS}, is the wider economic impact from increased labour supply:

$$WEI^{LS} = \frac{CV^c\partial t}{w(1-\tau^l)} \cdot e \cdot GDP_W^E \cdot \tau^{LS} \qquad \text{(Equation 10.5)}$$

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

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

In the next section we review and discuss the availability of data and evidence for each of these parameters for New Zealand.

10.4 Data and evidence for labour supply impacts

10.4.1 Commuting time savings (CV^Cdt)

The value of commuting time savings are usually available, or can at least be estimated, from transport model outputs. The disaggregation varies, but they are usually available by origin – destination and by mode which should allow the calculation of the level of time savings for labour market zone.

Standard values of time by time period and road type can be found in the EEM1 (table A4.1), for example for a car driver the value of time varies from $23.85 per hour to $6.90 per hour for work and non-work modes (2002 values and prices).

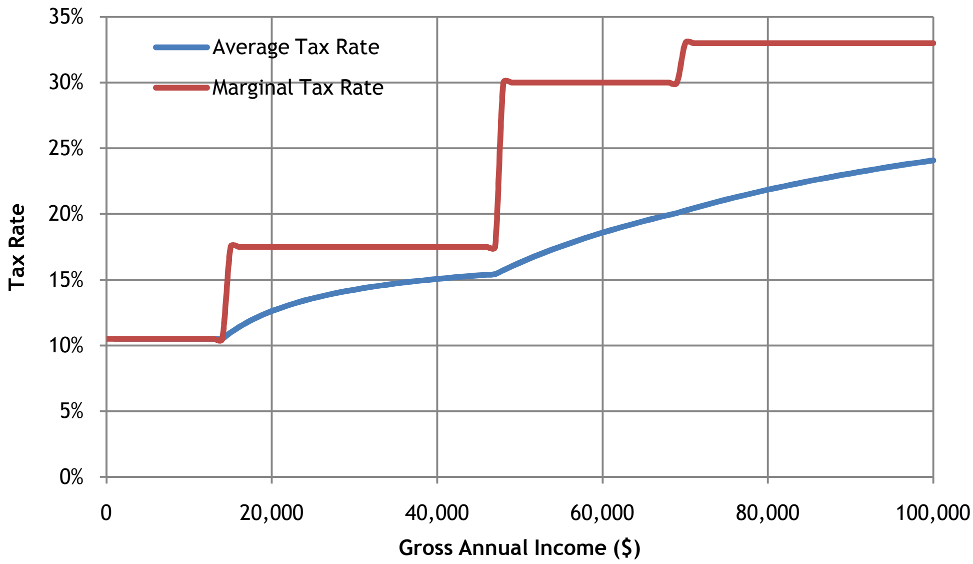
10.4.2 Average earnings (*w*)

Earnings data is available at a range of disaggregation from Statistics NZ, including by region, workplace area, sex, sector and income band. Together with employment data, this allows for the estimation of earnings based on any combination of the above disaggregation. In June 2009, the average wage in New Zealand across all employed persons was $43,800[16].

10.4.3 Average tax rate on labour income (t^L)

Income tax in New Zealand is a progressive proportion of income based on marginal tax bands. From October 2010 the tax rate within each band runs from 12.5% to 35% in four income steps. For any given level of income, the average 'headline' tax rate can therefore easily be calculated as shown in the figure below.

Figure 10.2 Marginal and average tax rates in New Zealand



The figure shows a gradual increase in the average rate of tax on increasing levels of income with a significant marginal step for individuals earning over $46,000 per year.

10.4.4 The elasticity of labour participation with respect to wage (*e*)

Dandie and Mercante (2007) conducted a comprehensive review of labour market elasticities focusing on Australia, but also considering New Zealand, the UK and Canada which they regarded as comparable economies. They found studies for labour market participation elasticities were fairly rare with most focused on portions of the labour market such as married women who were a group of particular interest in terms of increasing labour market participation because they tended to have the lowest participation rate.

There is relatively little evidence for labour market participation elasticities in New Zealand. One of the few studies we have found (Kalb 2003a) developed labour supply and participation elasticities with respect to wages for New Zealand workers by age and demographic group. The average elasticity of participation with respect to wages was found to be about 0.2 for married men and single parents, 0.3 for married women and around 0.6 for single men and women.

In comparison, for Australia, Kidd and Ferko (2001) estimated an elasticity of participation with respect to wages of between 0.11 and 1.20 for women and men, while Kalb et al (2007) found elasticities of between 0.15 for married men and 0.41 for lone parents in Australia.

[16] NZ Income Survey June 2009 showed a mean monthly wage income of $718 across all people in employment.

Kalb (2003a) only provided disaggregated estimates by demographic group. We required an aggregate figure and so in order to use the research we had to create a weighted average upon the existing categories of those not in employment.

Data from the New Zealand labour force survey showed that of those not in employment 39% were men and 61% were women, while the 2006 census revealed that of the total population of marriageable age 61% were partnered and 39% were not partnered. From these figures we can infer the proportion of those not in employment from each category.

Table 10.1 Labour market participation elasticity by sex and marital status

	Married men	Married women	Single men	Single women	Sole parents
Labour participation elasticity	0.2	0.3	0.6	0.6	0.2
% of non-employed	23.8%	37.2%	15.2%	23.8%	-

Source: Kalb (2003a), NZ Labour Force Survey, NZ Census 2006

If we assume new entrants to the labour market are evenly distributed from this pool of individuals so that all groups are equally sensitive to changes in wages, the weighted average participation elasticity can be estimated based on these proportions. From these figures we estimate the weighted average participation elasticity with respect to wages is around 0.4.

10.4.5 Average output per worker for new entrants

Evidence on output per worker can be estimated based on data from New Zealand's national accounts. This data is available in a range of disaggregation including by sector and location.

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

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

There is significant evidence for this effect. Gregg et al (1999) examined the UK Labour Force Survey and found new entrants had earnings 31% below the average of existing workers. For New Zealand, Kalb and Scutella (2003b) used data from the Statistics NZ Household Economic Survey from 1991 to 2001 to establish how employees' detailed characteristics determined differences in wages and used this evidence to predict wages for non-employed individuals. Table 10.2 sets out their findings for wage differentials by sex and marital status.

Table 10.2 Estimates of hourly wage by employment, sex and marital status (1995 values, 2008 prices)

	Married men	Married women	Single men	Single women	Sole parents
All non-employed	15.08	13.60	12.10	11.87	16.27
All employed	22.43	18.40	16.85	16.70	17.22
Non-employed wage differential	32.8%	26.1%	28.2%	28.9%	5.6%

Source: Kalb and Scutella (2003b) table 4

They found the predicted wages for those not in employment were between 33% and 6% lower than for those in employment (married men and sole parents respectively).

Using these figures in conjunction with the categorical proportions of those not in employment from table 10.1 we can estimate the weighted average of the non-employed wage differential is equal to 29%.

There is more supporting evidence for the presence of a productivity differential for new entrants from academic studies. For example Maré and Hyslop (2008) examined Statistics NZ's Linked Employer-Employee Database (LEED) using a longitudinal survey of earnings of new entrants and found new entrants to the labour market from 1999 to 2007 earned 19% less than the average wage. The authors attributed 60% of this effect to the tendency of new entrants to enter industries with lower average wages, and the remainder to the taking of lower paid positions within those industries.

Bryant et al (2004) used the data generated by Kalb (2003b) and adjusted it based on the average number of hours worked by age category to find the productivity differential varied from 13% to 32% for age groups 15 to 19 and 60 to 64 respectively.

Based on the range of possible differentials we believe Maré and Hyslop's (2008) finding of a 19% wage differential for new employees provides a representative and robust evidence-based estimate well within the range of the various other studies considered and using the latest data of the studies considered. Adjusting average productivity for new workers downwards by this value provides a conservative estimate of the lower productivity of new entrants to the labour market.

10.5 Tax take on increased labour supply (t^{LS})

10.5.1 Income tax and contributions

An important economic impact of increasing the participation rate is the effect on tax revenues, a clear positive externality of higher employment caused by the divergence of net and gross income known as the 'tax wedge'.

In order to estimate the impact of increases in the participation rate on the tax take we need to understand two factors:

- the relationship between income and the total tax wedge
- the average income of new entrants.

The basic relationship between tax and income is determined by the marginal income tax rates and other employment-related payments deducted from an individual's wages. These include income tax, payments to the Accident Compensation Corporation (ACC), GST and increases in business tax attributable to higher employment.

Employees and employers contribute to ACC funds at the rate of 2.5% and 1.47% of earnings respectively. In 2009 the average annual wage for people in New Zealand was $43,800[17] per year. Based on the 19% productivity differential we estimate new entrants to the labour market earn on average $35,500[18] (or $34,800 in 2008 prices).

Thus for the average employee the total employer contribution is around $550 per year, while for a new entrant the total employer ACC contribution is around $440 per year.

Table 10.3 shows the marginal income tax rates in New Zealand from October 2010, including the ACC charges which contribute to health and social spending.

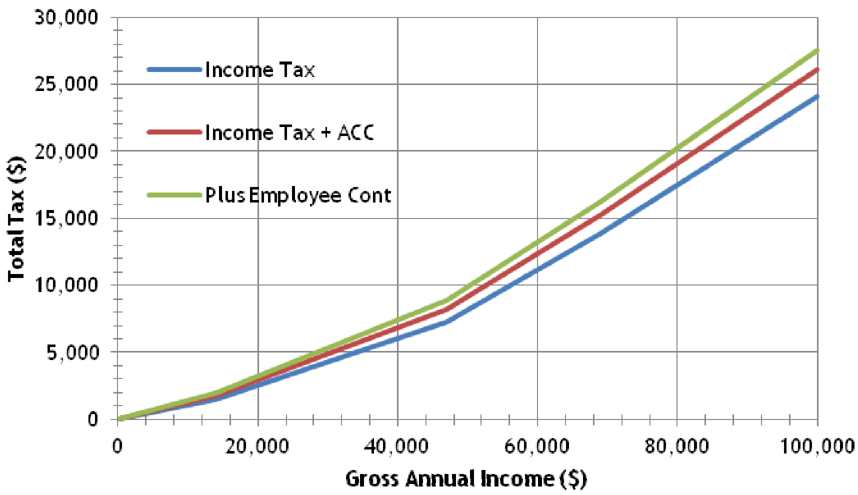
Table 10.3 Marginal tax rates on earnings

Taxable income ($)	PAYE rate for every $1 of taxable income (excluding ACC earners' levy)	PAYE rate for every $1 of taxable income (including ACC earners' levy)	PAYE rate for every $1 of taxable income (including ACC + employer contributions)
0–14,000	10.5%	12.5%	13.97%
14001–48,000	17.5%	19.5%	20.97%
48,001–70,000	30.0%	32.0%	33.47%
70,000+	33.0%	35.0%	36.47%
Undeclared	45.0%	47.0%	48.47%

Source: NZ Inland Revenue

Figure 10.3 graphs this relationship on a continuous basis showing the total income tax and ACC levy generated by every level of income between $0 and $100,000.

Figure 10.3 Income tax and ACC on earnings



Based on this relationship and our estimate of the average earnings of new entrants in 2009 we can estimate that on average each new entrant generates $5100 in income tax and $700 in ACC levy per year, and employers contribute an additional $515 in ACC levy per year.

[17] NZ Income Survey June 2009 showed a mean monthly wage income of $718 across all people in employment.

[18] We assume here the 19% productivity differential translates to a 19% wage differential.

10.5.2 Goods and services tax

This basic tax-pay relationship is complicated by other system features which affect the link between an individual's earnings and tax contribution. These features include GST and taxes on additional profits.

Because individuals in employment have higher incomes they also purchase more goods and services meaning tax income from GST increases with higher employment. In October 2010 GST in New Zealand increased from 12.5% to 15%. GST is applied to all goods and services except rental payments and financial products.

Table 10.4 shows a table of average expenditure by income group and an estimate of total GST at 12.5% and 15% based on the proportions of spending on liable goods and services by income from the NZ Household Economic Survey.

Table 10.4 Total annual spending and estimates of GST by wage income group (2007 values, 2008 prices)

Wage income group	Total spending	Total GST (@12.5%)	Estimated total GST (@15%)
All income groups	$49,722	$2070	$2484
Under $17,600	$19,698	$820	$984
$17,600 to $25,799	$23,046	$959	$1151
$25,800 to $33,399	$30,898	$1286	$1543
$33,400 to $44,899	$37,497	$1561	$1873
$44,900 to $55,799	$41,777	$1739	$2087
$55,800 to $67,999	$48,599	$2023	$2428
$68,000 to $80,899	$53,799	$2239	$2687
$80,900 to $98,799	$65,749	$2737	$3284
$98,800 to $131,299	$78,536	$3269	$3923
$131,300 and over	$97,864	$4074	$4889

Source: Statistics NZ Household Economic Survey 2008

The table shows that across all income groups, the average spending is around $50,000 per year and the GST bill is around $2400 per year for the average person. (Note average spending is higher than average wages in part because total income also includes transfer payments, and returns from investment in property and shares).

For new entrants we have estimated the average wage is around $35,500 per year. Assuming a new entrant moves from the lowest income category to the $33,400 to $44,899 category, spending increases on average from $19,600 to $37,500 and this generates an additional $18,800 spending per year, and an additional $900 per year in GST.

10.5.3 Corporate tax

The final element of the tax wedge is the business tax collected on the additional profit generated by each employee. Total New Zealand government income in 2009 was $79bn with $14.2bn of this attributed to business taxes. On a per-employee basis this is equivalent to $6543 per year in tax; however, we must adjust this figure to take account of the marginal impact of an additional employee on a company's profits (rather than the average value), and this requires several steps.

First, workers who join the public sector do not usually generate any new business tax revenue. In June 2010 there was a total of 544,000 employees in the public sector (characterised as public administration and safety, education and training, and healthcare and social assistance). This is equivalent to 25% of the current total workforce.[19]

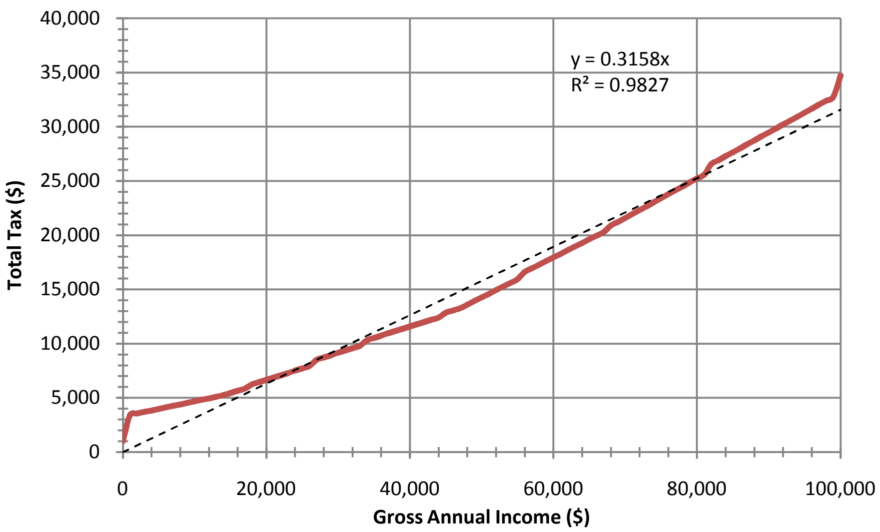
Furthermore the direct effect of an additional employee on business profit is hard to estimate because revenue and costs are often impossible to fully allocate between capital and labour inputs, and the marginal change in profit from a new employee is much less than the average tax income per employee because this omits the value of capital inputs which are assumed to remain constant.

A standard approach to this issue is to assume the output and profit elasticity of labour input is proportional to its share of GDP so each new employee on average generates revenue proportional to wages in line with the overall returns to labour in the economy.

For New Zealand, total GDP in 2009 was $184bn, with total wages accounting for 44%, operating surpluses (profits) accounting for another 44% and the remainder from taxes and subsidies. Based on these figures we can then assume employees generate 44% of total GVA, and therefore the total taxation generated by employment is around $6.25bn. This is equivalent to $3800 per private sector employee, and $2800 across all employees. Using the latter figure and adjusting for the 19% lower productivity of new entrants we estimate the average business tax generated by each new employee is around $2300 per year.

Based on direct impacts on income tax, ACC contributions and indirect effects on increased GST spending and business taxes we can estimate an overall general wage – tax relationship as shown in figure 10.4.

Figure 10.4 Income tax, ACC and GST contributions by income



As indicated by the dashed line in the figure this relationship is well approximated by considering the total tax wedge as equivalent to 32% of total wages for any given level of income.[20]

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[19] Statistics New Zealand Labour Force Survey, June 2010.

[20] The R^2 value for this relationship explains over 98% of the variation of the tax income relationship and is therefore a good approximation. Statistically speaking, the 32% linear coefficient estimate has a standard error of 0.0207 and a t stat of 152.21 meaning it is a very likely to be a valid estimate of the true relationship.

In summary therefore, from first principles and based on an assumed average wage of new entrants of $35,500 per year we estimate that on average every additional new entrant to the labour market generates a net positive externality of $9500 per year. This is equivalent to 26% of the total increase in labour supply.

The full breakdown of the externality for each new entrant by tax component is shown in table 10.5.

Table 10.5 New entrant tax wedge breakdown (2009 values, 2008 prices)

Tax element	Average value for each new entrant
Income tax	$5006
Employee ACC	$687
GST (additional payments)	$883
Employer ACC	$505
Additional business tax	$2257
Total	$9339

In order to benchmark our findings, we can compare our results with the OECD's (2009) comprehensive review of international labour market tax in their series, *Taxing wages 2008*, which estimates the size of the tax wedge for most major nations including New Zealand. The international figures are shown below in table 10.6.

Table 10.6 International tax wedges for single individuals

Country	Total tax wedge (as a % of labour costs, for a single individual) 2008	Country	Total tax wedge
Belgium	56.0	Spain	37.8
Hungary	54.1	Norway	37.7
Germany	52	Portugal	37.6
France	49.3	Luxembourg	35.9
Austria	48.8	UK	32.8
Italy	46.5	Canada	31.3
Netherlands	45.0	USA	30.1
Sweden	44.6	Japan	29.5
Finland	43.5	Switzerland	29.5
Czech Republic	43.4	Iceland	28.3
Greece	42.4	Australia	26.9
Denmark	41.2	Ireland	22.9
Turkey	39.7	New Zealand	21.2
Poland	39.7	Korea	20.3
Slovak Republic	38.9	Mexico	15.1

Source: OECD (2009) *Taxing wages 2008*

The OECD report defines the tax wedge as income tax plus employee and employer social security contributions minus cash transfers (but omits corporate taxes). The report compares the tax wedge of various countries including New Zealand which at 21.2% of labour costs actually has the third lowest tax wedge of the countries included in the study. Based on our estimate of the average income of new entrants the OECD tax wedge infers an average externality of $7526 per new entrant per year.

This is around 20% lower than our estimate; however, this can be explained to some extent by the fact that the OECD did not consider the effects of increased labour participation on business taxes.

Excluding this impact our estimate falls to $7215, slightly lower than the OECD estimate, and again this can be explained in part by the reductions in tax rates effective from October 2010 not being taken into account by the OECD work.

We believe our estimate is a more reliable and transparent indicator because it is estimated across all individuals (as opposed to married and single individuals), includes the new tax changes as well as taking account of more up-to-date statistics on employment and earnings.

It is also worth pointing out higher rates of participation have other potentially important positive externalities. For example individuals who enter employment tend to directly increase their rates of physical activity through work, which in turn has positive impacts on physical and mental health. Similarly, higher rates of employment are associated with lower crime rates.

Such benefits have not been included in this analysis because of the difficulty in formalising the relationship between such disparate variables, but these impacts are likely to be important secondary economic benefits which can be seen as a small potential upside.

10.6 Summary

Based on our analysis of tax, income and spending data in New Zealand and research into labour market impacts and commuting times we find 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 recommend an elasticity of labour participation with respect to wages of 0.4.

We estimate 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 likely to generate around $9k in additional tax revenue.

Analysis of the tax system shows 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 the lower productivity and spending of new entrants we estimate a 26% tax wedge for this group. The recommended values are summarised in table 10.7.

Table 10.7 Recommended parameter values for labour market impacts

Parameter	Description	Values
τ^{L}	Indirect tax parameter (to convert gross to net earnings)	32%
ε^{ls}	The elasticity of labour participation with respect to wages	0.4
τ^{LS}	The tax take on increased labour supply.	26%

11 Productivity differentials from job relocations

11.1 Description

By increasing urban accessibility, transport schemes can encourage firms and individuals to change their employment location as the accessibility of some areas improves and reduces the costs of commuting to a new location. This effect can produce an additional economic benefit neglected in standard appraisal.

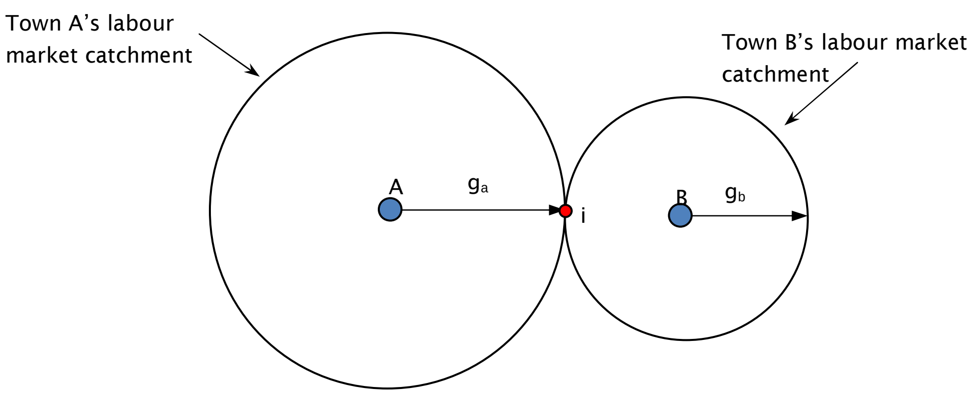
Similar to the effect on the participation rate, this benefit is related to the presence of the tax wedge as a positive externality of the individual's labour supply decisions. By encouraging individuals to relocate to more productive areas (for higher wages), transport schemes create economic benefits by increasing an individual's output and the associated tax income. Conversely, schemes that encourage moves to less productive areas reduce economic benefits because tax revenue is lost.

11.2 Job relocation

To illustrate this impact, consider two towns A and B. Each town has a labour market paying wages w_a and w_b respectively and recruits labour from the population in its immediate hinterlands. Town A is larger and because of agglomeration benefits its productivity and average wages are higher.

Individuals can choose to work in either location, and the choice is dependent on the net wage and generalised cost of commuting between the two locations. The level of tax paid to the government has no impact on the decision and is a positive externality. Figure 11.1 shows the situation graphically.

Figure 11.1 Labour market catchments



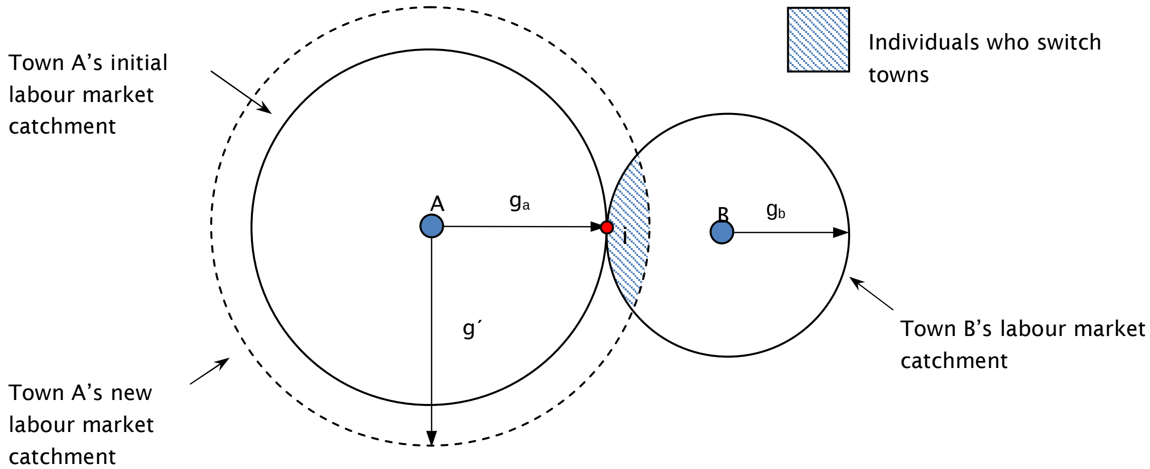
The figure shows the two towns A and B. The two circles represent the boundary of the catchment areas of each town, where g_a and g_b are the commuting times to the town from the boundary of the catchment areas. The catchment area of town A is larger than town B because its wages are higher and therefore people are willing to commute further to work there, offsetting the commuting time cost against the net wage gain.

Point i represents a point of indifference where the increased wages in town A are entirely offset by the higher travel time relative to town B. Therefore all individuals within the left circle work in town A, and those in the right circle work in town B.

All individuals pay a tax on their income proportional to their wage (the tax wedge). Because individuals in town A earn higher wages than in town B they pay more tax. While employment in both towns has a positive social benefit, employment in town A is socially more beneficial than in town B, and so an individual who switches from working in town B to town A generates an economic benefit.

If we consider the effect of a transport project which improves the accessibility of town A, the generalised cost of working there is reduced, and the boundary of the catchment area between towns A and B shifts right. The effect is shown in figure 11.2.

Figure 11.2 Job relocations



The figure shows a change in accessibility reduces the generalised cost of commuting to town A relative to town B and so shifts the catchment boundary outward so that individuals in the shaded area change their employment decision and begin working in town A. These individuals earn higher wages and pay more in tax generating an economic benefit.

11.3 Formalising the relationship between productivity differentials

The individual chooses to locate by maximising his or her happiness (U_i) which is directly proportional to total wages w_x minus the generalised cost of commuting to work g_x, where g_x is a function of time and distance between home and work locations.

$$Max\ U_I = w_x - \tau(w_x) - g_x = w_x(1-\tau) - g_x \quad \text{(Equation 11.1)}$$

Where x is a vector of all possible work locations (A and B in this case), τ is the average tax rate on wages, and g_x is the generalised cost of travelling to each location.

Initially for some individuals at the boundary of town A's catchment area:

$$w_a > w_b\ and = g_a > g_b \quad \text{(Equation 11.2)}$$

so that:

$$w_a(1-\tau) - g_a < w_b(1-\tau) - g_b \quad \text{(Equation 11.3)}$$

So that the individuals choose to work in town B paying tax τw_b. A new transport project reduces the generalised cost of accessing town A to g'_a so that:

$$w_a(1-\tau) - g'_a > w_b(1-\tau) - g_b \quad \text{(Equation 11.4)}$$

Thus the individual changes his or her work location from town B to town A and wages increase from w_b to w_a. The time saving component of this change is captured in standard appraisal techniques using the rule of a half, but what is omitted is the benefit from the increases in tax revenue. As a result of the changes in employment location the total tax take increases and we can write that the external benefit (*πi*) generated by the switching individual *i* as:

$$\pi_i = w_a(\tau) - w_b(\tau) = (w_a - w_b)(\tau) \quad \text{(Equation 11.5)}$$

At a macroeconomic level and for the purposes of economic appraisal we can assume the change in wages for individuals changing locations will be proportional to the productivity differential of the two areas, and thus we can rewrite the equation multiplied by the total change in employment across all locations so that:

$$\Pi = \frac{GDP^f}{W^f} \cdot \sum_{ij}(E^a_{if} - E^b_{if}) \cdot P_i \cdot \tau \quad \text{(Equation 11.6)}$$

Where Π is the total economic benefit, *GDP/W* is the average output per worker, *E* denotes total employment in zone *i* for the base (b) and alternative (a) scenarios across *f* forecast years. *P* is the relative productivity differential between zone *i* and the national average.

The operationalisation of this assessment requires evidence on each of the parameters and variables. We discuss the requirements in the following section and then follow with a summary of our initial data and evidence review:

11.4 Data and evidence for productivity differentials methodology

11.4.1 GDP per worker (*GDP/W*) by forecast year

Average output per worker can be established from national accounts and labour force data from Statistics NZ. Forecast data of economic and population growth is also required.

11.4.2 Employment by zone (*E*), scenario and forecast year

Total employment forecasts are required across all geographical zones in the study area in both the base and the do minimum case, for all forecast years. The base case can be established from several sources depending on the spatial focus of the study. The labour force survey, national census and LEED survey are the main potential sources. Estimating the changes in employment from the forecast year will require a land-use interaction (LUTI) model.

11.4.3 LUTI models

A LUTI model is required to understand the impacts of a transport scheme on employment location. There are various types of model, each with different inputs and processes. LUTI models tend to be a significant investment in terms of the needs for validation and calibration on individual study areas. These models are too complex to discuss here in detail, but they are an important part of the wider economic impact methodology and need to be considered as part of the general approach to transport modelling taken for a given scheme.

11.4.4 Relative productivity by zone (*P*)

This is very difficult to determine accurately as pure location productivity differentials are difficult to determine without considering the variation due to the relative characteristics of individual regions in terms of socio economic, industrial and occupational structures.

We can infer something about the relative differentials from the average wages across the regions.

Table 11.1 shows the regional variation of income for full-time employed persons for 2008.

Table 11.1 Median weekly income $ (June 2009 values, 2008 prices)

Regional council area	2009
Northland	$687
Auckland	$771
Waikato	$707
Bay of Plenty	$660
Gisborne/Hawke's Bay	$707
Taranaki	$736
Manawatu-Wanganui	$687
Wellington	$791
Nelson/Tasman/Marlborough/West Coast	$687
Canterbury	$716
Otago	$716
Southland	$682
Total	**$742**

Source: NZ Income Survey 2009

The table shows that on average employees in Wellington earned the highest wages at $791 per week while people in the Bay of Plenty earned the least at $660 per week (similar statistical data exists for the territorial authorities although they are too numerous to list here).

Unfortunately it is not possible to attribute these differentials to pure location productivity alone as a significant proportion of the variance is likely to be due to differences in individuals' skills, sector and occupations apparent within the different regions, which are not dependent on location.

NZIER (2004) for example examined New Zealand's regional economies finding significant variance in wages by sector. The report found per capita GDP varied from 83% of national per capita GDP for Northland, to 114% in Wellington, and concluded that Auckland and Wellington had the highest level of economic performance based on almost all measures including wages, even after controlling for differences in population attributes.

Kalb (2003a) examined these issues using an econometric model to take account of regional differences in industry and skills to estimate pure productivity effects for New Zealand regions between 1991 and 2001. The findings are shown in table 11.2.

Table 11.2 Regional productivity differentials

Region	Productivity differential (relative to Auckland)
Auckland	0.00%
North Island (north)	-8.01%
North Island (central)	-10.44%
Wellington	4.32%
Canterbury	-8.23%
South Island	-8.71%

Source: Kalb (2003a)

The report confirmed Wellington and Auckland were the most productive regions while the central North Island region was the least productive. This variation pointed to the presence of agglomeration benefits and suggested people and businesses were more productive in the major urban areas. In comparison in the UK these effects were estimated at a district level by Johnson et al (2008) using an econometric model to account for the various non-location differences in district productivity. In their study they found pure location productivity differentials varied from +30% of the national average for the city of London to -30% for West Devon.

11.4.5 Average tax take (*t*)

As discussed in the labour market participation effects section, the average tax take on job relocations is dependent on the tax wedge which is proportional to the marginal rate of taxation for people in employment. In this case, however, we are considering the relocation of existing employees rather than new entrants to the labour market, and so the appropriate externality is proportional only to the change in wage multiplied by the average tax wedge.

In the labour market section we estimated the tax wedge to be approximately 32% of total wages, therefore the value of tax take on changes in income is equal to 32% of the total change in income.

11.5 Summary

Job relocation benefits are likely to be a source of significant benefit to transport projects. Based on the existing evidence, we conclude that each relocation to a more productive area will generate a tax benefit equal to about 32% of the total increase in income. This estimate is based on the approximate linear relationship between gross annual income and total tax paid as shown in figure 10.4.

Table 11.3 Recommended parameter values for job relocation benefits

Parameter	Description	Values
τ_{Lm}	The tax take on the move to more productive jobs	32%

However, while there is evidence of productivity differentials taking account of personnel and industry characteristics at a regional level, at a local geography 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 a regional level. The effect is likely to be much more significant at a territorial authority level for which pure productivity differentials are not available.

Wage data at territorial authority level can serve as a rough proxy for productivity differentials but 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. Addressing this issue should be an area for further research to improve the accuracy of the benefit estimate in appraisal.

PART 3: CASE STUDY EVALUATION: THE ADDITIONAL WAITEMATA HARBOUR CROSSING

12 Introduction to Part 3

12.1 Background

The NZ Transport Agency (NZTA) commissioned Steer Davies Gleave to develop a wider economic impacts appraisal methodology for New Zealand based on existing practical approaches and the latest academic evidence.

The study involved a review of the economic theory underlying wider economic impacts and the estimation and calculation of key economic parameters based on the best available statistics, economic research and evidence for New Zealand. The review is now Part 2 of this report and contains an explanation of the theoretical justification and practical quantification for wider economic impacts and a description of the best data and evidence for their estimation currently available in New Zealand.

The study also required a demonstration of the methodology for a case study project. The proposed additional Waitemata Harbour crossing (AWHC) was selected for this. Part 3 describes the practical process, method and outcome of applying the New Zealand wider economic impacts methodology to this project.

12.2 The additional Waitemata Harbour crossing[21]

The existing Auckland Harbour Bridge is a critical transport link for the Auckland region. The road bridge presently handles over 168,000 vehicle crossings per day, and population and economic growth means demand is expected to increase by 22% by 2041. Such growth in demand is likely to cause, without intervention, a significant increase in delay and congestion on the exiting crossing.

In order to mitigate this, an additional crossing over the harbour has been proposed in the form of the AWHC. Once built, this new crossing will be one of New Zealand's largest-ever infrastructure projects.

The preliminary business case for the project (NZTA 2010a) highlights that the benefits of the project are expected to include:

- reduced congestion and improved access across the harbour linking the North Shore to Auckland CBD and beyond
- the provision of an additional transport route to the existing Auckland Harbour Bridge increasing transport capacity, providing a backup in the event either route is blocked
- improving opportunities for all modes of transport including commercial and general road traffic, public transport, and walking and cycling across the harbour
- a more effective transport network that supports greater economic growth in the region.

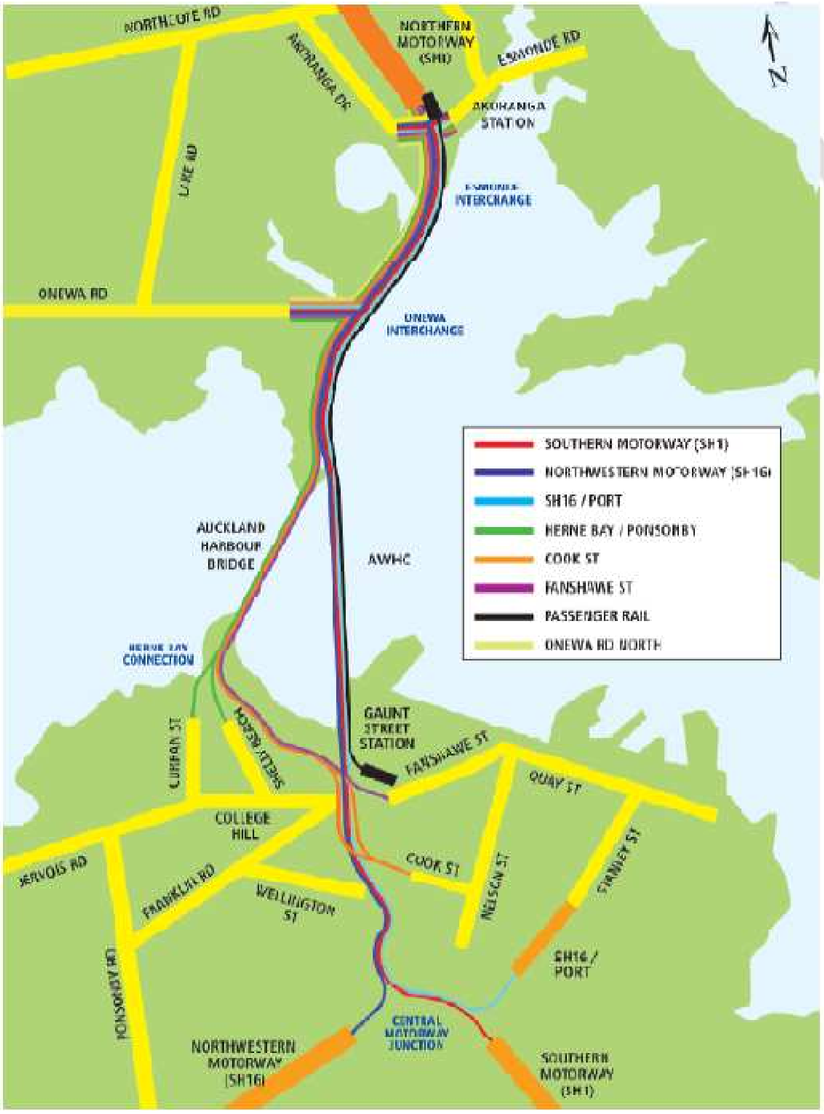
The project has the potential to significantly improve the accessibility, reliability and journey time of cross harbour trips for both road and public transport modes in an area of high-density population and

[21] Project website: www.nzta.govt.nz/network/projects/project.html?ID=13

economic activity. The project therefore provides an excellent case study for the estimation of wider economic impacts in this report.

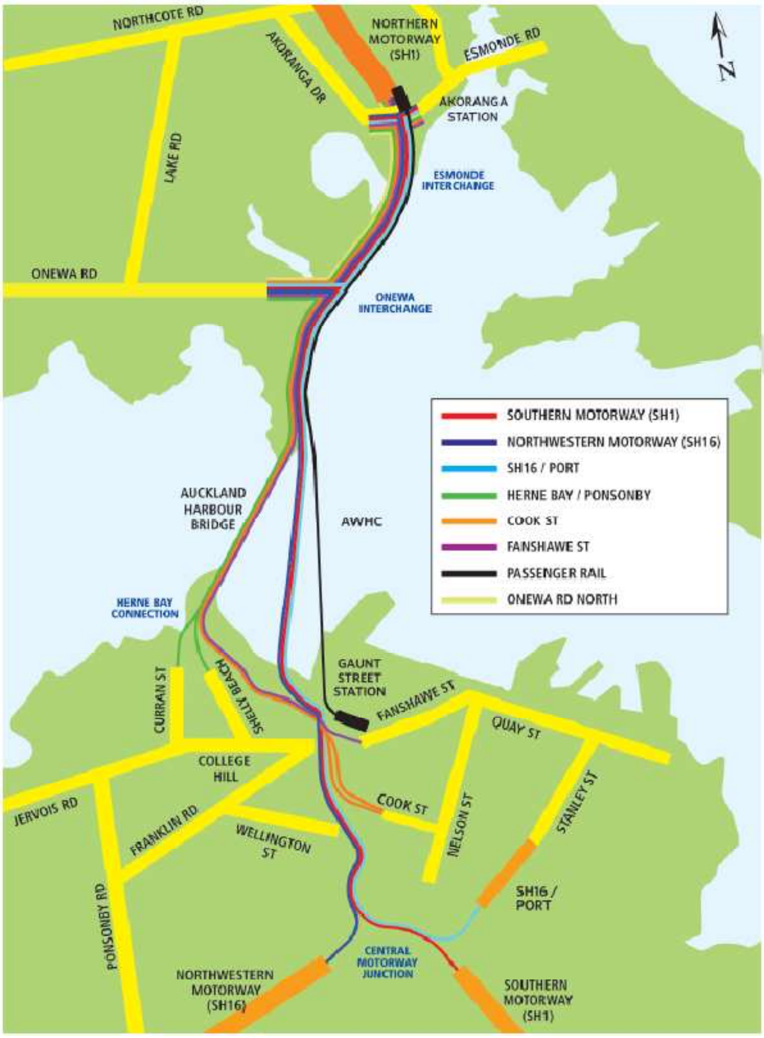
The project is included in the New Zealand 2010 National Infrastructure Plan and is currently in the planning and evaluation stages. The current plan upon which this study is based, takes the form of either a bridge or a tunnel with three lanes of traffic in each direction, and two separate single track rail links. The tunnel and bridge route alignment options are shown in figures 12.1 and 12.2.

Figure 12.1 Waitemata Harbour crossing tunnel alignment option



Source: NZTA 2010a

Figure 12.2 Waitemata Harbour crossing bridge alignment option



Source: NZTA 2010a

There are some substantial differences between the two options, including the approach alignments, visual and environmental impacts, and costs in particular. Table 12.1 provides a summary of the relative option costs.

Table 12.1 Net present value of costs ($m, 2010)

Cost type	Tunnel option	Bridge option
Total capital costs	3100	2200
Land acquisition	190	170
Operating and maintenance	160	40
Risk adjustment	840	830
Total	**4290**	**3260**

Source: NZTA 2010a

Despite the differences in cost, the two options are expected to have identical levels of capacity and in transport modelling terms they have been treated as the same scenario. For this reason this report will only conduct a single wider economic impacts assessment representative of both options.

The rest of Part 3 is structured as follows:

- Chapters 13 and 14 provide an overview of the modelling process in terms of the key inputs, processes and outputs required to conduct a wider economic impacts assessment.
- Chapter 15 provides a description and explanation of the process of estimating agglomeration impacts including the results of the case study.
- Chapter 16 provides a description and explanation of the process of estimating imperfect competition impacts including the results of the Waitemata case study.
- Chapter 17 provides a description and explanation of the process of estimating labour supply impacts including the results of the case study.
- Chapter 18 provides a description and explanation of the process of estimating the move to more productive jobs impact.
- Chapter 19 provides a summary of the case study wider economic impacts evaluation.

In the following chapters we explain how we have calculated the wider economic impacts for the Waitemata Harbour crossing including detailed equations, results and outputs. The method, equations and data sources and inputs used to estimate the impact are described in Part 2 of this report.

13 Wider economic impacts model overview

13.1 Background to wider economic impacts

The importance of transport to economic growth and development is intuitively obvious, but quantifying the full effect of a specific project is difficult because of the complex interactions between transport demand, supply, employment, business formation and land use. The economic benefits of transport are realised in a variety of different ways including through time savings, wider employment catchment areas, greater economic density, improved market access, higher land and property prices and greater labour pools to name but a few.

The wider economic impacts methodology developed in the UK by the DfT provided a step change in the understanding and quantification of the economic benefits of transport, giving business case reviewers a much more developed view of the full impacts of a transport project.

The theory of the wider economic impacts of transport supposes schemes can produce benefits through five main effects that are additional to the standard cost-benefit analysis approach to appraisal:

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

The inclusion of wider economic benefits in appraisal can significantly alter the economic valuation of a project. For example, in an evaluation of the UK wider economic appraisal methodology, the DfT found scheme wider economic impacts varied from 5% of conventional benefits for the South Yorkshire Bus subsidy to 56% for London's Crossrail project.

To provide a benchmark of the wider economic impacts for other projects we provide a summary of examples for existing assessments in table 13.1. The examples are from the UK unless otherwise stated.

Table 13.1 Wider economic impact project examples

Type of scheme	Location	Scheme	Agglom-eration	Imperfect competition	Labour market	Total additionality
Rail	Major city	Crossrail, London	24%	4%	28%	56%
HSR	Interurban	HSL London Birmingham	44%	8%	0%*	52%
Road	Conurbation	Leeds to Bradford Improved Highways Connections	30%	6%	5%	41%
Road	Conurbation	Leeds Urban Area Highway Improvements	31%	5%	3%	39%
Mixed	Major city	Melbourne East West Road and Rail Package (Australia)	22%	2%	6%	30%
Rail	Major city	Airtrack, London – Heathrow	26%	2%	1%*	29%
Road	Interurban	Leeds to Sheffield Highways Improvements	24%	6%	-2%	28%
HSR	Interurban	HSL Lisbon Porto (Portugal)	18%	8%	0%*	26%
HSR	Interurban	HSL Y-Line London – Manchester and Leeds	18%	7%	0%*	25%
Bus	Conurbation	Leeds to Bradford PT Improvements	18%	3%	2%	23%
HSR	Interurban	HSL London – Scotland (West Coast)	14%	8%	0%*	22%
Rail	Major city	Cross River Rail, Brisbane (Australia)	16%	0%	5%*	21%
Road	Interurban	A46 Interurban Road, East Midlands Region	13%	6%	1%*	20%
Mixed	Conurbation	Victoria Transport Plan Package (Australia)	17%	1%	1%	19%
Bus	Urban	Intra Leeds Bus Fare Reduction and Frequency	13%	2%	2%	18%
Road	Interurban	M6 Shoulder, West Midlands Region	11%	5%	0%*	17%
Rail	Major city	Melbourne East West Rail Package (Australia)	14%	1%	2%	16%
PT	Conurbation	Leeds Urban Area Major PT Investment	11%	3%	2%	16%
Bus	Area wide	West Yorkshire Bus Fares and Frequency	10%	2%	2%	15%
Bus	Area wide	South and West Yorkshire Bus Fares and Frequency	8%	3%	2%	12%
Bus	Area wide	South Yorkshire Bus Fares and Frequency	3%	3%	0%	5%

The table shows that in other (mainly UK) case studies wider economic impact benefits have been estimated at between 5% and 56% of standard economic benefits with agglomeration benefits accounting for the largest component followed by labour market impacts and imperfect competition benefits. Part of the variation in impact can be explained by an evolving methodology: an identical approach has not been used for all examples. For instance, for some schemes the labour market impact only includes the wider impact from increased labour supply, and not from the productivity gains from job relocation (indicated with an asterisk in the table).

The relative size of wider economic impact benefits varies depending on the type of project and the economic context of the area. Wider economic impacts tend to be highest where agglomeration effects are strongest and the impact on economic density, commuting costs and business benefits are high. For this reason projects which focus on urban areas with higher concentrations of service businesses and employees tend to see higher wider economic impacts (relative to conventional benefits) than less dense rural areas with more dispersed primary industries. Furthermore, projects that tend to benefit business and commuter travel, as opposed to non-work related journeys, also deliver larger uplifts to the conventionally measured benefits. On average across the example projects, agglomeration benefits generated an uplift of around 18% on standard economic benefits, labour market impacts around 4% and imperfect competition benefits around 3%. Overall the average uplift was around 25%.

From these project examples it is apparent major city and inter urban projects that generate large time savings for businesses and commuters in particular tend to generate larger wider economic impacts than small-scale rural projects. For example the London Crossrail project is expected to generate an additional 56% wider economic impacts uplift, while the South Yorkshire Bus Fares and Frequency project is only expected to generate an additional 5% wider economic impacts uplift.

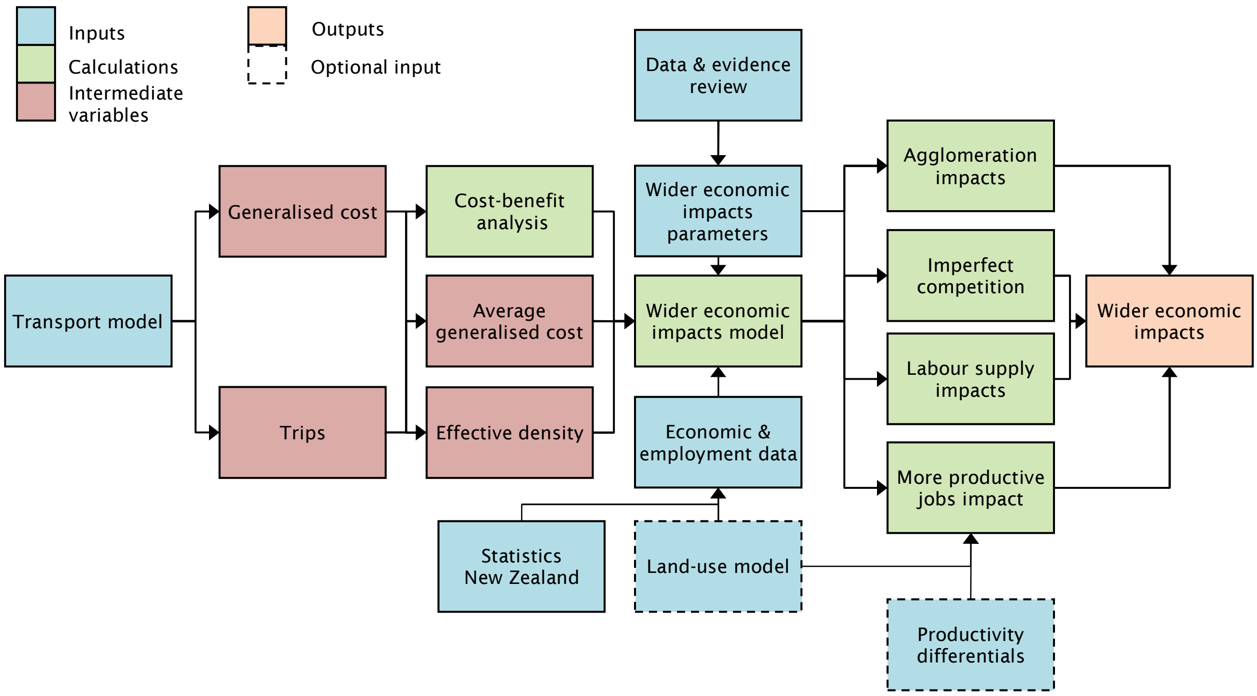
13.2 Wider economic impacts calculation overview

The wider economic impacts estimation methodology has been designed to use standard transport models and economic data. The process requires multiple calculations based on key parameters and inputs. These inputs are used in four separate calculations, including:

- imperfect competition impacts
- labour supply impacts
- agglomeration impacts
- more productive jobs impacts.

This section provides a general overview of the process and method used to estimate wider economic impacts in New Zealand before going into the specific results for the AWHC case study project in the latter sections. Figure 13.1 shows an overview of the wider economic impacts calculation process.

Figure 13.1 Wider economic impacts model overview



The methodology and equations used in this report are based on the UK's DfT wider economic impacts methodology as outlined in the Transport Analysis Guidance, Unit 3.5.14 document (DfT 2009a). The methodology has been fully adapted in this study for application in New Zealand.

13.3 Inputs

The calculation of wider economic impacts requires three key inputs: transport demand and cost data, economic and employment data, and wider economic impacts parameter values. Most of these inputs are obtained from transport models and published national statistics. However, the wider economic impacts parameters are sourced from the evidence derived as part of this project and are presented in Part 2 of this report.

13.3.1 Transport model

The wider economic impacts methodology is designed to make use of transport model outputs normally already available from the modelling work underlying any major business case for which wider economic impacts are normally considered. The data required includes trip numbers, journey times and generalised costs for the base and intervention scenarios across one or more future modelled years. The data must be segmented by origin and destination zone, mode and journey purpose (including business, commuting and other trip purposes) and should represent trips across the average day.

13.3.2 Economic and employment data

The estimation of wider economic impacts also requires some information on economic variables including employment and gross domestic product per worker by sector, forecast year and zone. In practice it can be difficult to obtain estimates in such detail beyond national or regional estimates and therefore it is often necessary to derive these factors using proxy data available at a more detailed spatial level.

Employment data can be obtained from national data sources such as Statistics NZ[22], which holds census and labour force survey data and can provide reliable and detailed information on employment over time and at a range of geographies. Where available, employment data should be provided by industrial sector.

13.3.3 Land-use models and productivity differentials

Where available, a land-use model should be used to provide different projections for employment for both 'do minimum' (DM) and 'do something (DS – called 'option' in the EEM) scenarios for each forecast year. This allows changes in employment origins and destinations to be estimated, which in turn can be used to estimate the impact of the move to more productive jobs.

Estimating this impact also requires information on pure productivity differentials between different areas to reflect the change in productivity of an individual changing work location. Although some estimates do exist of productivity differentials between New Zealand regions (see Maré 2008), our view is that the evidence is not sufficiently robust for this impact to be assessed. In particular, the existing evidence does not correct for the contribution to spatial productivity differentials from differences in skills and capital intensity.

13.3.4 Wider economic impacts parameters

There are several parameters used in the wider economic impacts models to calculate the impact of transport investment upon the four separate components. These parameters enter the model in several ways and include:

- the ratio of imperfect competition benefits to business user benefits
- an indirect tax parameter (to convert gross to net earnings)
- an estimate of the elasticity of labour participation with respect to real wages
- an estimate of the tax take on increased labour supply.

The specific value and function of each of these parameters is explained in chapter 16.

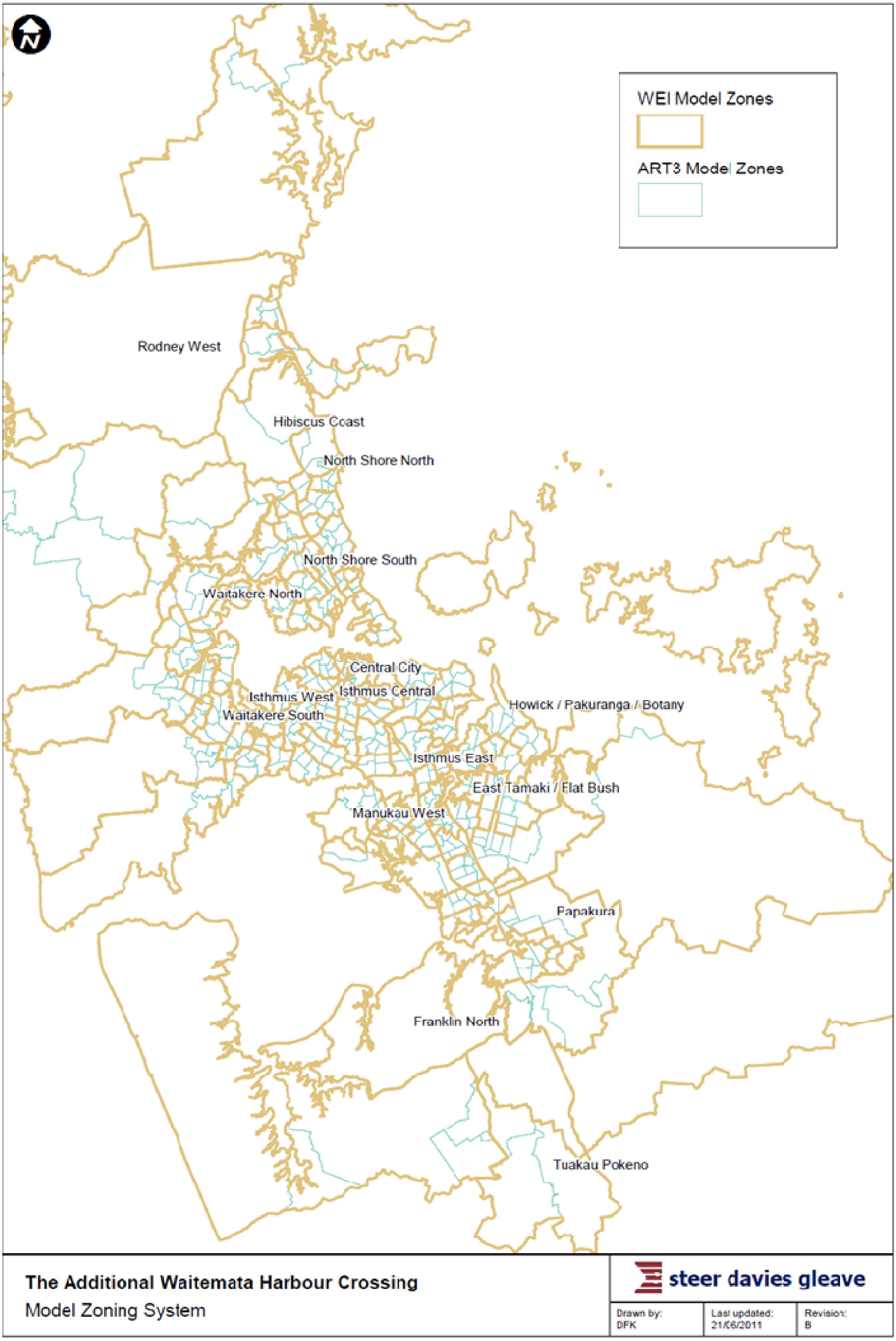
13.3.5 Zoning system

The zoning system used in the wider economic impacts model must be designed to ensure consistency between the various model inputs. On one hand, a more detailed zoning system will allow the assessment to make use of and reflect detailed differences between areas. On the other hand, the transport model, employment data and other economic variables such as productivity differentials and GDP per worker need to be based on the same boundaries, which limits the level of detail that can be achieved.

In practice, therefore, a compromise needs to be struck between making use of detailed model data and zones and the detail at which economic data is available or can be estimated reliably. This will often require the aggregation of model inputs into a 'common denominator' zoning system. As long as care is taken to apply the aggregating procedure correctly (see chapter 15, the loss of detail will not lead to any systematic errors or differences in the calculation of wider economic impacts. Figure 13.2 shows the correspondence between the transport model and the wider economic impacts model used in this study.

[22] Statistics NZ website: www.stats.govt.nz/

Figure 13.2 Model zone system



In addition, the assessment of agglomeration benefits requires the zoning system to extend to the full geographical area where a significant amount of trips are being made to and from the study area. In practice this means the system needs to cover the whole of New Zealand. Transport models, however, typically do not have such an extensive coverage and the wider economic impacts approach often requires estimates to be made of the average cost of travel between the study area and the rest of the country. This can be done by representing the rest of New Zealand by a single external zone.

In New Zealand the smallest statistical unit is the meshblock. This unit is typically aggregated up into area units, territorial authorities and regional council areas for which statistics on employment and other economic variables are collected. The actual boundaries used do not matter as long as all inputs use a consistent boundary, although clearly a more dense zoning system will provide more accurate and detailed results all else being equal.

13.4 Intermediate variables

In order to calculate the wider economic impacts, the calculation of two intermediate variables is required: the average generalised cost and effective density. These variables are used in several calculations in the wider economic impacts model including agglomeration and labour supply impact calculations.

Average generalised cost is a measure of the average cost of accessing one zone from another, weighted across all modes and journey purposes. The variable is used to estimate effective density and agglomeration and labour supply impacts.

Effective density is a measure of the ‘mass’ of the economic activity accessible to an area. It is calculated by estimating the average generalised cost from the origin zone to economic activity in other areas, the latter measured in the form of jobs. Effective density is used in conjunction with agglomeration elasticities to estimate the agglomeration impacts of changes in generalised costs between zones.

The application of calculations for intermediate variables and agglomeration impacts for the Waitemata Harbour project is explained in the following chapters.

14 Model inputs

14.1 Transport model

In order to assess the impacts of the project, a transport modelling exercise was undertaken by Sinclair Knight Merz (SKM) using the Auckland Regional Transport model (ART3) to test the impact and effects of the crossing options.

The transport model consisted of 512 model zones covering the entire Auckland region. For the purpose of the assessment of wider economic impacts the model outputs were aggregated to 110 larger zones for which economic and employment data was available or could be estimated with some confidence.

Although ART3 is segmented by time period and several distinct user classes, these were aggregated to the segmentation required by the wider economic impacts assessment, namely total daily trips and average journey times and costs for three modes (public transport, car and heavy commercial vehicles) and three journey purposes (business, commuting and other). This definition produced seven distinct user classes. Table 14.1 provides a summary of the modes, purposes and years used within the model.

Table 14.1 Transport model definitions

Modes (m)	Journey purposes (p)	Model years (t)
Car	Home-based work (HBW) (commuting)	2026
Public transport (PT)	Employer business (EB)	2041
Heavy commercial vehicles (HCVs)	Other	
	HCV (HCV mode only)	

The outputs obtained from the model included estimates of the average number of daily trips, journey times and out-of-pocket costs between each origin (i) and destination (j) zone by mode and trip purpose for the two forecast years and for each of the ‘do minimum’ (DM) and ‘do something’ (DS) scenarios.

14.1.1 Model scripts

The variables in the model equations used a variety of scripts to represent particular types or instances of a given variable. Table 14.2 provides an explanation of each of the model scripts used in the equations.

Table 14.2 Variable scripts

Script	Description	Values
I	Origin zone	1–110
J	Destination zone	1–110
S	Scenario	Alternative (A), base (B)[23]
F	Forecast year	2026, 2041
M	Mode	Car (C), public transport (PT), HCV, slow
P	Journey purpose	Commuting (HBW), business (EB), other, HCV
K	Industrial sector	See table 14.4

[23] Base and alternative were used interchangeably with ‘DM’ and ‘DS’.

14.1.2 Values of time

The estimates of trip cost and time are combined to produce an estimate of generalised cost using values of time supplied by SKM. Table 14.3 shows the values of time used to convert journey times into generalised cost for each journey purpose.

Table 14.3 Values of time ($/hour)

Year	2011
Work (EB) trips)	33.8
Commute (HBW trips)	10.98
Other trips	11.76
HCV trips	26.33

Source: SKM file note

14.2 Economic and employment data

14.2.1 Employment

Employment data was supplied by SKM for each of the model zones using outputs from the Auckland Regional Transport land use model (ART2.3) for the two forecast years and across 14 industrial sectors.

Table 14.4 shows the total employment figures used in the model.

Table 14.4 Total model employment

Sector	2026	2041
Industrial	102,323	122,858
Business services	193,881	235,788
Wholesale trade	92,602	115,137
Retail trade	195,392	228,040
Central government admin and defence	16,333	19,156
Pre-school and primary education	13,358	14,178
Secondary education	24,753	32,433
Tertiary education	41,994	46,022
Hospitals	19,720	17,932
Medical practices	9369	8520
Public services	14,004	13,152
Agriculture	16,390	17,648
Utilities	23,830	23,095
Construction	17,155	19,616
Total	**781,103**	**913,573**

Source: ASP3.2 model (SKM)

The data shows that overall employment is expected to increase by around 31% between 2026 and 2041.

14.2.2 GDP per worker

In order to estimate GDP per worker by year and across each zone, we have used the latest available estimates of regional GDP from Statistics NZ for 2003 (Statistics NZ 2006) in combination with historical employment data to estimate the average regional GDP per worker in 2003.

Table 14.5 Regional GDP ($NZ nominal)

Region	2000	2001	2002	2003
Northland	2787	3106	3370	3243
Auckland	**39,518**	**40,277**	**43,301**	**47,689**
Waikato	8930	10,119	11,087	10,598
Bay of Plenty	5721	6134	6551	6689
Gisborne	916	960	1001	1031
Hawke's Bay	3569	3839	4122	4318
Taranaki	3743	4600	4678	4414
Manawatu-Wanganui	4847	5201	5557	5594
Wellington	16,790	17,046	18,283	19,286
Total North Island	**86,820**	**91,281**	**97,951**	**102,863**
Tasman/Nelson	1943	2080	2282	2343
Marlborough	955	1045	1161	1193
West Coast	662	755	804	779
Canterbury	12,538	13,237	14,195	15,074
Otago	4344	4683	5127	5411
Southland	2434	2861	3120	3023
Total South Island	**22,875**	**24,661**	**26,688**	**27,824**
Gross domestic product	**109,696**	**115,941**	**124,639**	**130,687**

Source: Statistics NZ 2006

In order to estimate the equivalent figures for 2010 we used evidence on growth in GDP per worker from Statistics NZ for New Zealand as a whole.

In order to produce estimates of GDP per worker by zone we adjusted the Auckland-wide estimate of GDP per worker by sector to reflect variations in wages by sector between our zones. Average GDP per worker was then estimated by attributing regional GDP to each zone based on its wage income and dividing by its levels of employment.

14.3 Wider economic impacts parameters

Part 2 of this report summarised the review of economic research and evidence on the New Zealand economy and the estimate of the key WEB parameters. A summary of the values is shown in table 14.6.

Table 14.6 Wider economic impacts parameter values

Parameter	Description	Value
I	Ratio of imperfect competition benefits to business user benefits	0.107
ε^{ad}	Aggregate demand elasticity	-0.6
pcm	Price cost margin	20%
τ^{L}	Indirect tax parameter (to convert gross to net earnings)	32%
ε^{ls}	The elasticity of labour participation with respect to wages	0.4
τ^{LS}	The tax take on increased labour supply	26%

15 Agglomeration impacts

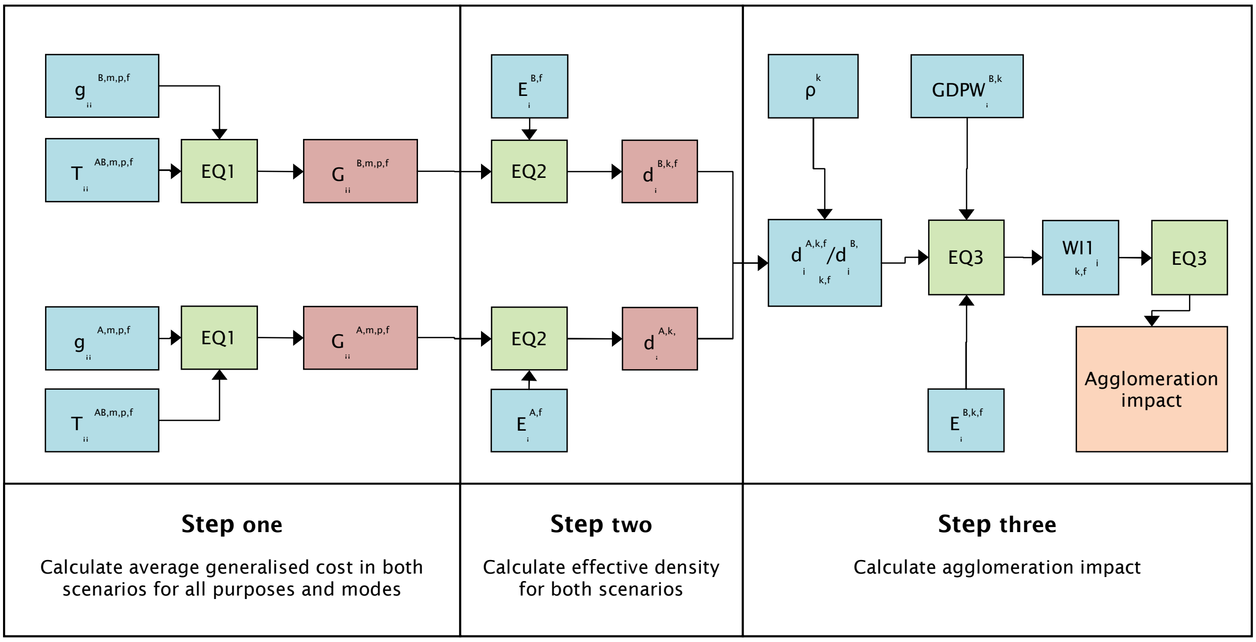
15.1 Description

Agglomeration economies refer to productivity gains enjoyed by firms located in areas of dense economic activity. Transport investments reduce the costs of travelling between locations and hence increase the effective economic density of an area by reducing the transport costs between businesses and employees. As a consequence, such improvements may deliver increases in the productivity of these firms and employees through several processes including:

- greater business interactions and networking opportunities, involving sharing of knowledge
- more efficient labour markets
- more efficient input and output markets.

The process for estimating agglomeration impacts is outlined in figure 15.1.

Figure 15.1 Agglomeration benefits calculation



Adapted from DfT (2009)

The figure shows agglomeration impacts are calculated in three steps using four equations.

1. The first step is the calculation of average generalised costs.
2. The second step is the calculation of effective density.
3. The final step is the calculation of the agglomeration impact.

The variables used in each process are described and explained in table 15.1.

Table 15.1 Agglomeration variable descriptions

Variable	Description
$g_{ij}^{S,m,p,f}$	Generalised cost for mode (m), purpose (p), forecast year (f), and scenario (S), between origin zone (i) and destination zone (j).
HBW	The total number of trips for mode (m), purpose (p) and forecast year (f), between origin zone (i) and destination zone (j) and summed across the two scenarios ('do minimum' and 'do something').
$G_{ij}^{S,m,p,f}$	The average generalised cost across modes (m), purposes (p), forecast year (f), and scenario (S), between origin zone (i) and destination zone (j).
$E_j^{S,f}$	Total employment in destination zone (j), scenario (S) and forecast year (f).
$d_i^{S,k,f}$	The effective density of zone (i) by sector (k), forecast year (f) and scenario (S).
ρ^k	The elasticity of productivity with respect to effective density for sector (k).
$GDPW_i^{B,k,f}$	Gross domestic product per worker by sector (k), forecast year (f), zone (i) in the do minimum scenario.
$WI1_i^{k,f}$	Agglomeration impact by sector (k), forecast year (f) and zone (i).

15.2 Average generalised cost

The average generalised cost of travel is calculated by averaging the generalised cost of travel across all modes or journey purpose (or both). The formal equation for the calculation is shown in equation 15.1. Note that the number of trips is used for weighting purposes only and the same weight must be used for each scenario. It is recommended that the trip-weights used are the sums of the DM and DS scenarios (denoted by the 'AB' superscripts).

$$G_{ij}^{S,m,f} = \frac{\sum_p g_{ij}^{S,m,p,f} \cdot T_{ij}^{AB,m,p,f}}{\sum_p T_{ij}^{AB,m,p,f}} \quad \text{(Equation 15.1)}$$

15.3 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 for the calculation is shown in equation 15.2.

$$d_i^{S,k,f} = \sum_{j,m} \frac{E_j^{s,f}}{(g_{ij}^{S,m,f})} \quad \text{(Equation 15.2)}$$

15.4 Agglomeration impacts

Once average generalised cost and effective density have been calculated the agglomeration impact can be estimated by calculating the change in effective density between the DM and DS scenarios. The formal equations for the calculation are shown in equations 15.3 and 15.4.

$$WI1_i^{k,f} = \left[\left(\frac{d_i^{A,k,f}}{d_i^{B,k,f}}\right)^{\rho^k} - 1\right] GDPW_i^{B,k,f} \cdot E_i^{B,k,f} \quad \text{(Equation 15.3)}$$

$$Agglomeration\ impact = \sum_{i,k} WI1_i^{k,f} \quad \text{(Equation 15.4)}$$

15.5 Key parameters

The calculation of agglomeration impacts is dependent on the agglomeration elasticity (ρ^k), 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.

Table 15.2 provides a summary of the agglomeration elasticities estimated by sector for New Zealand by the NZTA. 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 15.2 Agglomeration parameters

Productivity with respect to effective density (agglomeration elasticity)	Value
Agriculture forestry and fishing	0.032
Mining	0.035
Electricity, gas water and waste services	0.035
Manufacturing	0.061
Construction	0.056
Wholesale trade	0.086
Retail trade	0.086
Accommodation and food services	0.056
Transport postal and warehousing	0.057
Information, media and telecommunications	0.068
Finance and insurance services	0.087
Professional, scientific and technical services	0.087
Public administration and safety	0.087
Rental, hiring and real estate services	0.087
Education and training	0.076
Health care and social assistance	0.083
Arts and recreational services	0.053
All industries	0.065

Source: NZTA *Economic evaluation manual* (Volume one), section A 10.2

15.6 Results

The transport model shows the effect of the crossing on the average generalised cost of travel in the region. The model results show the intervention is expected to cause the average trip cost across all modes and journey purposes to fall by $0.03 per day in 2026 and $0.06 per day in 2041. The equivalent figures for each user class are shown in tables 15.3 and 15.4 for 2026 and 2041 respectively.

Table 15.3 2026 average generalised costs (2010 prices)

Cost per trip ($ per day)	HBW car	HBW pt	EB car	EB pt	Other car	Other pt	HCV	Average
DM	6.07	18.29	12.68	43.50	3.74	20.24	13.35	5.98
DS	6.03	18.28	12.59	43.19	3.72	20.07	13.33	5.95
Saving per trip	0.04	0.01	0.09	0.31	0.02	0.17	0.02	0.03

Table 15.4 2041 average generalised costs (2010 prices)

Cost per trip ($ per day)	HBW car	HBW pt	EB car	EB pt	Other car	Other pt	HCV	Average
DM	6.95	19.40	13.60	44.46	3.92	20.71	14.63	6.52
DS	6.92	19.13	13.50	43.39	3.91	20.27	14.57	6.49
Saving per trip	0.03	0.27	0.09	1.07	0.02	0.44	0.06	0.04

The reduction in generalised cost reduces the costs of business to business interaction and improves access to labour increasing the effective density of the zones in the model by an average of 0.8% in 2026 and 1.2% in 2041. The change % in effective density by model sector is shown in table 15.5.

Table 15.5 Change in effective density by sector

Sector	Zone	% increase in effective density	
		2026	2041
Rodney	1 to 11	0.60%	0.84%
North Shore north	12 to 19	1.02%	1.51%
North Shore south west	20 to 25	2.04%	2.58%
North Shore south east	26 to 29	1.83%	2.13%
Waitakere north	30 to 34	0.37%	0.48%
Waitakere central	35 to 38	0.17%	0.29%
Waitakere south	39 to 43	0.13%	0.13%
Auckland CBD	44 to 45	0.19%	0.47%
Auckland inner	46 to 54	0.05%	0.16%
Auckland west	55 to 60	0.08%	0.22%
Auckland south west	61 to 64	0.06%	0.13%
Auckland south east	65 to 69	0.10%	0.13%
Auckland east	70 to 76	0.11%	0.12%
Howick/Papakura	78 to 81	0.15%	0.18%
East Tamaki	82 to 88	0.14%	0.15%
Mangere/Otahuhu	89 to 98	0.19%	0.26%
Manukau central	96 to 98	0.18%	0.23%
Manurewa	99 to 101	0.15%	0.23%
Papakura	102 to105	0.14%	0.17%
Franklin	106 to 109	0.11%	0.14%
Total		**0.40%**	**0.54%**

The greatest change occurs in North Shore, Rodney, Waitakere and in the CBD. The increase in effective density generates significant agglomeration benefits by reducing the cost of business interactions.

The effect is to generate increase in employee productivity based on the sectoral composition of each of the zones in the model. Figures 15.2 and 15.3 plot the productivity impacts per worker in 2026 and 2041 on zonal maps.

Figure 15.2 Agglomeration impacts per worker 2026

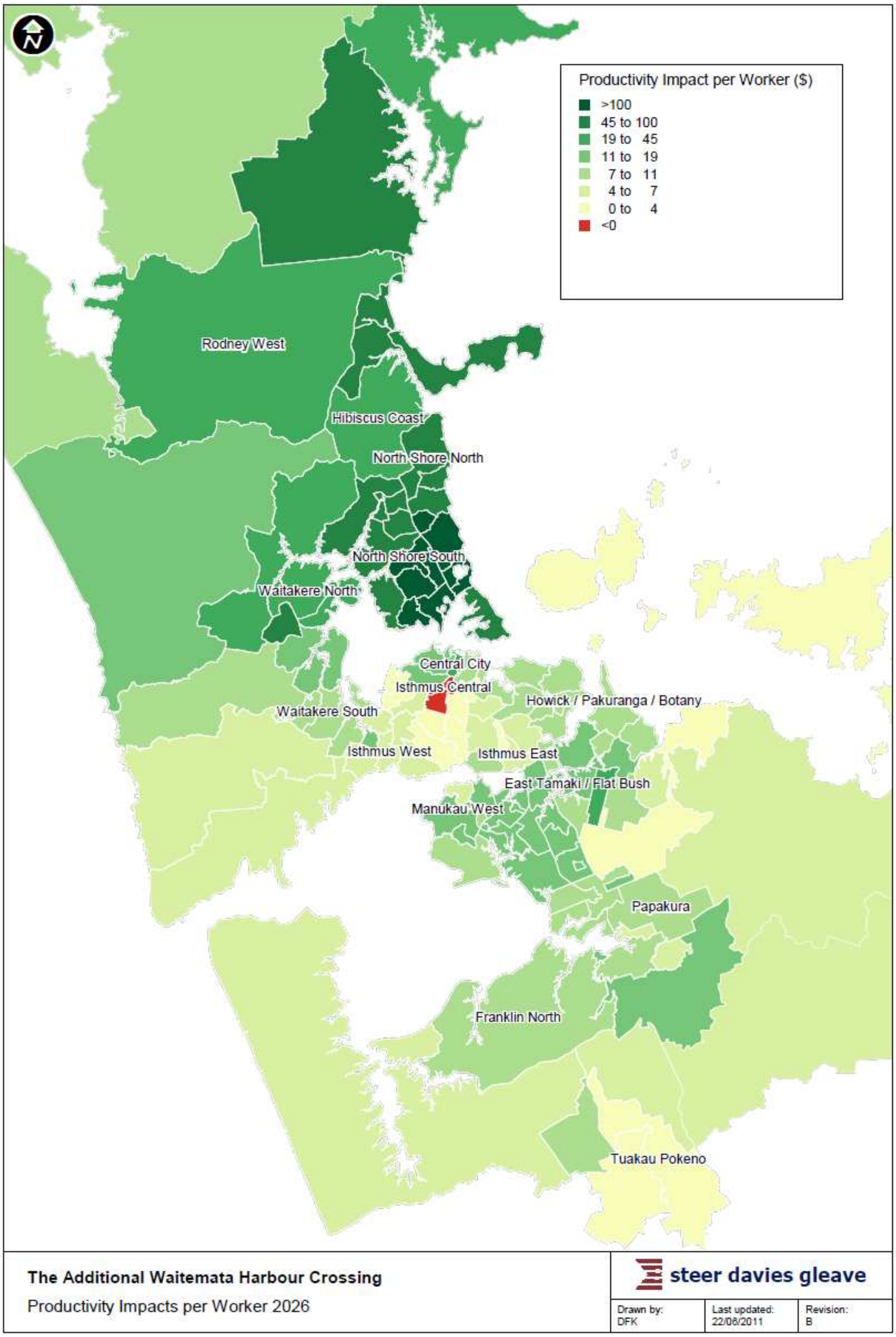
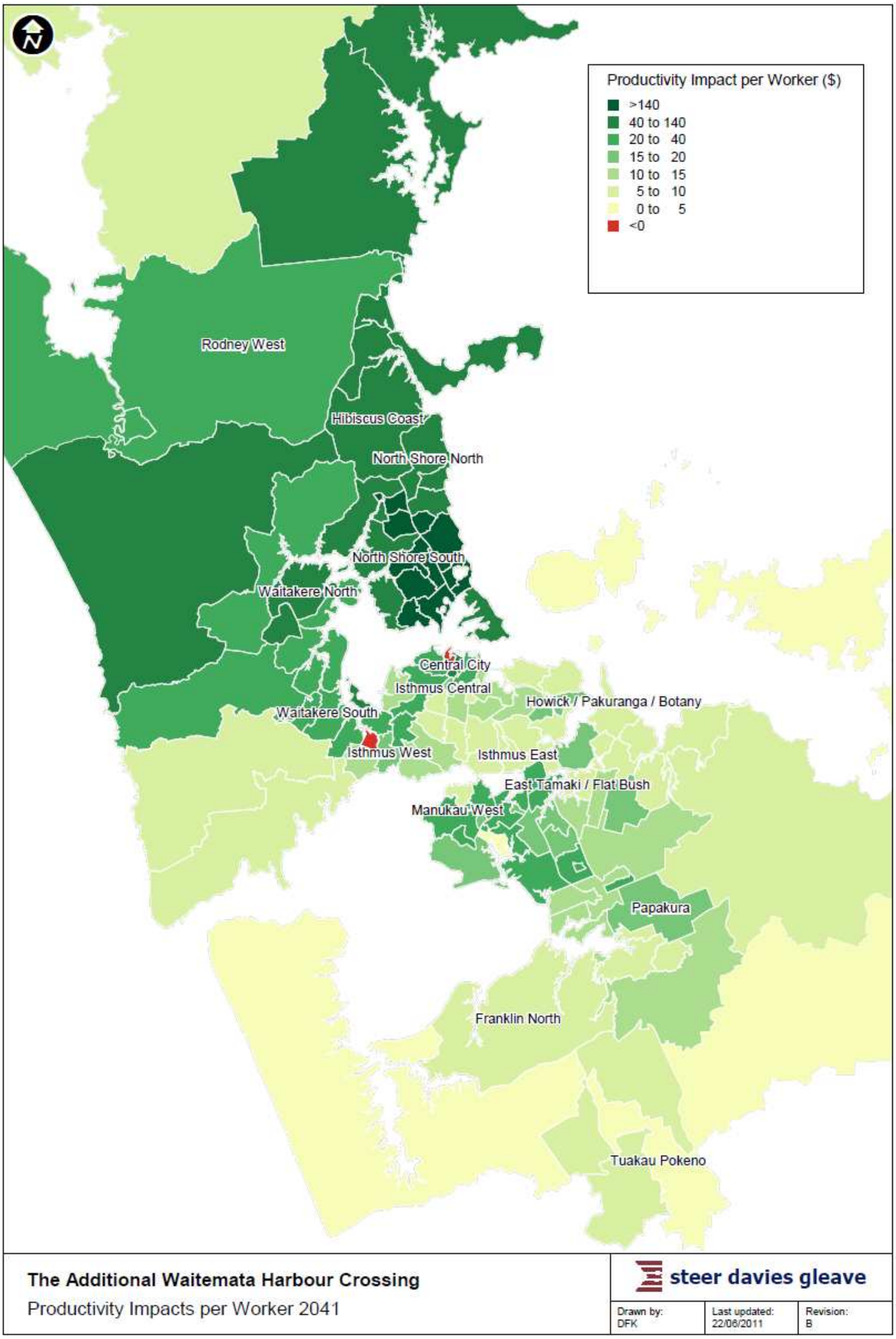


Figure 15.3 Agglomeration impacts per worker 2041



The results show that the North Shore, and particularly the areas around the AWHC, are likely to see significant increase in productivity per worker. Significant impacts on worker productivity are also seen in the peripheral areas to the north of Auckland, where the increase in accessibility to the centre is improved. However, the low employment density in these locations means they contribute relatively modestly to the total productivity gain.

A couple of zones in the central isthmus see a very small negative impact on agglomeration. Table 15.6 provides a breakdown of the agglomeration impact by territorial authority.

Table 15.6 Agglomeration benefits (NZ$ 2010 prices, current values)

Sector	Zones	Agglomeration impacts	
		2026	**2041**
Rodney	1 to 11	1,534,481	2,384,029
North Shore north	12 to 19	3,297,931	4,855,979
North Shore south west	20 to 25	3,376,419	4,388,745
North Shore south east	26 to 29	4,522,176	6,278,941
Waitakere north	30 to 34	495,373	943,232
Waitakere central	35 to 38	247,219	506,227
Waitakere south	39 to 43	391,733	-437,303
Auckland CBD	44 to 45	1,446,897	4,890,305
Auckland inner	46 to 54	387,271	1,038,762
Auckland west	55 to 60	129,779	464,983
Auckland south west	61 to 64	37,499	123,427
Auckland south east	65 to 69	348,836	457,416
Auckland east	70 to 76	267,795	373,170
Howick/Papakura	78 to 81	123,744	150,067
East Tamaki	82 to 88	424,203	344,140
Mangere/Otahuhu	89 to 98	328,069	531,852
Manukau central	96 to 98	472,711	619,299
Manurewa	99 to 101	34,566	52,716
Papakura	102 to105	125,194	275,364
Franklin	106 to 109	136,174	187,362
Total		**18,128,070**	**28,428,714**

The table shows the greatest benefit occurs to the North Shore areas followed by Auckland CBD. This pattern of impacts broadly reflects the location and access corridor of the AWHC. Auckland CBD has double the employment of the other areas on average so although the agglomeration impact per worker is actually relatively moderate, the overall agglomeration impacts is high.

Overall agglomeration impacts will generate economic benefits equivalent to $18.1m per year in 2026 and $28.4m per year in 2041. The net present value (NPV) of the impacts is equal to $72m, equivalent to 22.3% of the NPV of user benefits of the project.

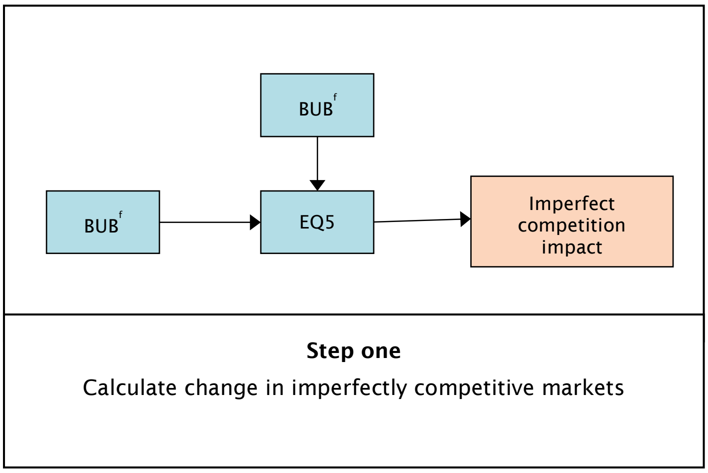
16 Imperfect competition impacts

16.1 Description

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

It can be shown that the level of underestimation in appraisal is directly proportional to the price cost margin in the economy[24] and this can be corrected by multiplying the business user benefits of a project by a fixed factor (a more detailed explanation of the theory is provided in Part 2 of this report). Figure 16.1 provides a diagram of the process.

Figure 16.1 Imperfect competition benefits calculation



Adapted from DfT (2009)

Imperfect competition benefits are calculated through a simple multiplication of business user benefits by an uplift factor (ι) proportional to the level of imperfect competition in the economy. Business user benefits are calculated from a standard cost-benefit analysis by aggregating the benefits attributable to business and freight user classes. Table 16.1 provides a description of each of the variables shown in the figure above.

Table 16.1 Imperfect competition parameters

Variable	Description
BUB^f	Total business user benefits, including freight by forecast year (f)
ι	Imperfect competition parameter

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

$$Imperfect\ Competition\ Impact = \sum_{f} \iota \cdot Business\ User\ Benefits^{f} \qquad \text{(Equation 16.1)}$$

[24] The price cost margin is a direct indicator of competition with a zero price cost margin representing a perfectly competitive market.

16.2 Results

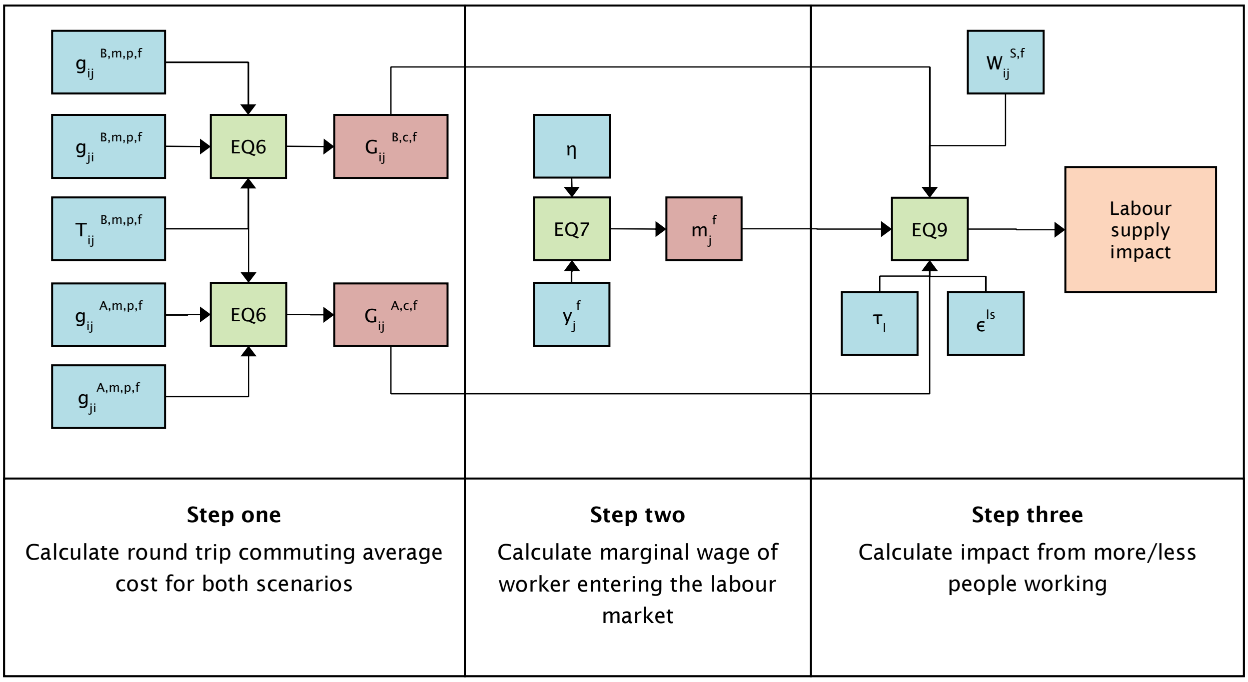
Business user benefits will be worth $24.7m per year in 2026 and $51.2m per year in 2041. The imperfect benefit parameter for New Zealand has been estimated at 0.107 meaning that imperfect competition benefits will be equal to $2.6m in 2026 and $5.5m in 2041. In total, imperfect competition impacts are worth $13m in overall net present value, equal to 4% of the standard cost-benefit valuation of the project.

17 Labour market impacts

17.1 Description

Transport projects have the potential to generate positive labour market impacts through reducing the costs of accessing employment and increasing an individual's income and time budgets. This can lead to an increase in employment as more people choose to either work longer or enter (or remain) in the labour force. The process for estimating labour market impacts is shown in figure 17.1.

Figure 17.1 Labour supply impacts calculation



Adapted from DfT (2009)

The figure shows that labour supply impacts are calculated in three steps:

1 The first step is the calculation of the round trip commuting cost in the DM and DS scenarios.

2 The second step is the calculation of the marginal wage of a worker entering or leaving the labour market.

3 The final step is the calculation of the impact of changes in labour supply on tax income.

The variables used in the calculation are explained in table 17.1.

Table 17.1 Labour supply impact variable descriptions

Variable	Description
$g_{ij}^{S,m,p,f}$	Generalised cost for mode (m), purpose (p), forecast year (f), and scenario (S), between origin zone (i) and destination zone (j)
$T_{ij}^{B,m,p,f}$	The total number of annual home to work trips for mode (m), purpose (p), forecast year (f), between home zone (i) and work zone (j) in the do minimum scenario. (Also known as the 'home to work' matrix in the base (B) case
$G_{ij}^{S,c,f}$	The average generalised cost across mode (m), commuting purpose (c), forecast year (f), and scenario (S), between origin zone (i) and destination zone (j)
η	The productivity of marginal labour market entrants relative to the average
y_i^f	Gross mean residence based earnings in zone i
m_i^f	Gross mean residence based GSP per worker in zone i
$W_{ij}^{S,f}$	The number of workers commuting from zone i to zone j in scenario (S) and forecast year (f)
τ	Factor to convert gross to net earnings
t^{LS}	Tax take on increased labour supply
ε^{ls}	The elasticity of labour supply with respect to effective (real) wages

17.1.1 Commuting costs

In order to calculate the impact of a transport project on the labour market the model requires an estimate of the change in commuting costs for workers living in zone *i* and working in zone *j*. This is achieved by first calculating for each scenario the total annual commuting costs for each origin-destination pair (ie home to work from *i* to *j* and work to home from *j* to *i*), averaged across all modes. The formal equation is shown in equation 17.1.

$$G_{ij}^{S,c,f} = \frac{\sum_m (g_{ij}^{S,m,c,f} + g_{ji}^{S,m,c,f}) \cdot T_{ij}^{B,m,c,f}}{\sum_m T_{ij}^{B,m,c,f}} \qquad \text{(Equation 17.1)}$$

Next, the total annual commuting cost savings for workers living in zone *i* is calculated by multiplying the change in commuting cost for each destination by the number of commuters and summing:

$$dG_i^f = \sum_j W_{ij}^{S,f} (G_{ij}^{A,c,f} - G_{ij}^{B,c,f}) \qquad \text{(Equation 17.2)}$$

17.2 Labour supply response

The labour supply response can now be 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 17.3.

$$dE_i = \varepsilon^{ls} \frac{1}{y_i(1-\tau_l)} dG_i^f \qquad \text{(Equation 17.3)}$$

17.3 Gross labour supply impact

The increased output from the increased labour supply impact is estimated using the equation shown in equation 17.4.

$$LS\ Impact = \sum_i dE_i \eta m_i \qquad \text{(Equation 17.4)}$$

The equation shows the labour supply impact is a product of the increased labour supply and the net productivity per worker for new entrants.

17.4 Net labour supply impact

Finally, the wider economic impact from increased labour supply is the proportion of the additional output taken in taxation:

$$WEI\ from\ increased\ Labour\ Supply = LS\ Impact\ x\ t^{LS} \quad \text{(Equation 17.5)}$$

17.5 Results

As a result of the project, average commuting costs across all zones are expected to fall. Overall the largest savings are for residents in the areas closest to the bridge including the North Shore and Waitakere sectors. There are some sectors where commuting costs are expected to increase slightly including Franklin and Mangere/Otahuhu.

Overall the project is expected to reduce commuting costs by around $35m in 2026 and $70m in 2041. Table 17.2 shows the total annual commuting cost saving for each model sector in 2026 and 2041.

Table 17.2 Total reductions in commuting cost by sector (NZ$ 2010 prices, current values)

Sector	Zones	Total reduction in commuting costs	
		2026	2041
Rodney	1 to 11	4,796,046	11,506,793
North Shore north	12 to 19	6,766,793	15,018,689
North Shore south west	20 to 25	9,311,447	16,253,838
North Shore south east	26 to 29	8,546,790	15,690,323
Waitakere north	30 to 34	3,147,946	6,559,768
Waitakere central	35 to 38	605,547	1,587,974
Waitakere south	39 to 43	557,348	1,146,187
Auckland CBD	44 to 45	299,433	821,242
Auckland inner	46 to 54	1,130,878	2,570,063
Auckland west	55 to 60	553,880	1,271,152
Auckland south west	61 to 64	291,302	499,513
Auckland south east	65 to 69	92,590	117,962
Auckland east	70 to 76	462,768	693,083
Howick/Papakura	78 to 81	-230,947	-272,692
East Tamaki	82 to 88	-691,514	-1,173,676
Mangere/Otahuhu	89 to 98	-114,649	-229,081
Manukau central	96 to 98	-161,610	-97,303
Manurewa	99 to 101	-156,140	-267,830
Papakura	102 to105	-182,797	-702,291
Franklin	106 to 110	64,699	-290,805
Total		**35,089,810**	**70,702,909**

The effect of this reduction is to increase the attractiveness of working, meaning that more individuals enter the labour force, or remain for longer. Figures 17.2 and 17.3 plot the impacts on labour supply across the model zones in 2026 and 2041.

Figure 17.2 Increase in labour supply 2026

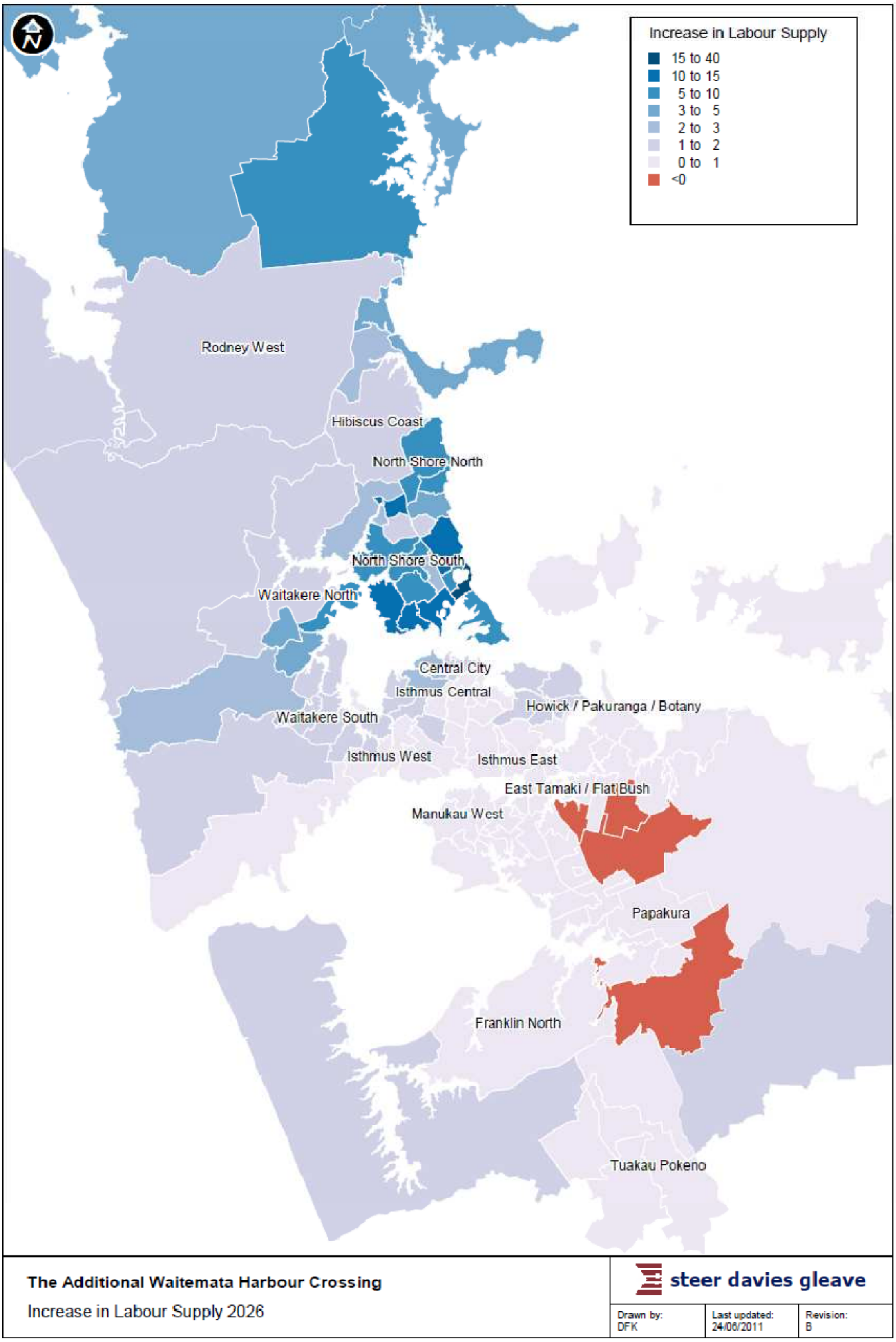
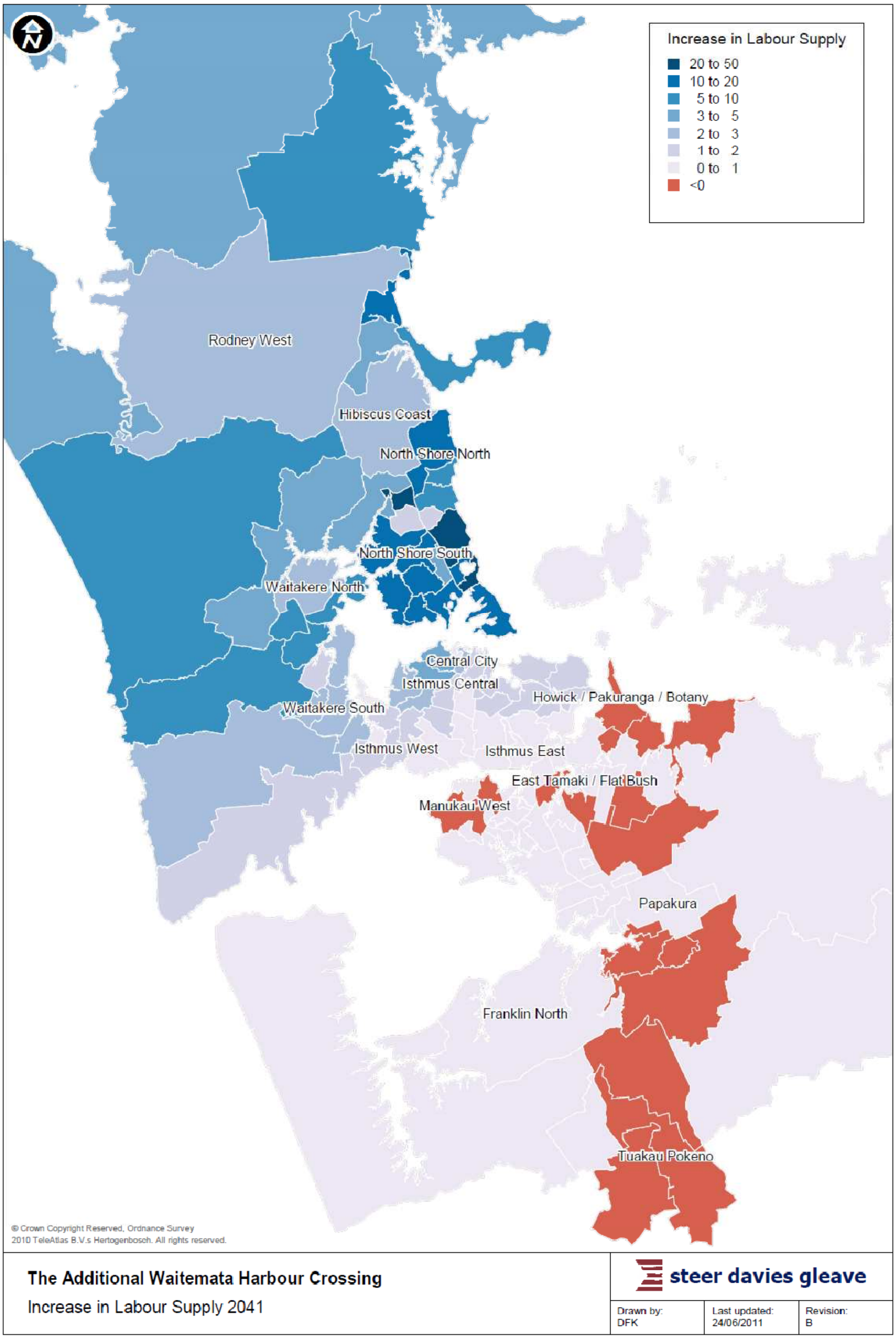


Figure 17.3 Increase in labour supply 2041



The figures show the labour market impacts are focused on the northern side of the harbour, particularly around the North Shore areas. Table 17.3 provides estimates of the number of new workers entering the labour supply in each territorial area based on reductions in commuting costs and the labour supply elasticity. Overall the new crossing could generate additional employment of 134 in 2026 and 271 in 2041.

Table 17.3 Increase in employment

Sector	Zones	Increase in employment	
		2026	**2041**
Rodney	1 to 11	41	102
North Shore north	12 to 19	60	135
North Shore south west	20 to 25	94	141
North Shore south east	26 to 29	30	135
Waitakere north	30 to 34	9	57
Waitakere central	35 to 38	3	14
Waitakere south	39 to 43	7	10
Auckland CBD	44 to 45	1	7
Auckland inner	46 to 54	6	22
Auckland west	55 to 60	1	11
Auckland south west	61 to 64	3	4
Auckland South East	65 to 69	-2	1
Auckland east	70 to 76	-6	6
Howick/Papakura	78 to 81	0	-2
East Tamaki	82 to 88	-3	-10
Mangere/Otahuhu	89 to 98	0	-2
Manukau central	96 to 98	0	-1
Manurewa	99 to 101	0	-2
Papakura	102 to105	0	-6
Franklin	106 to 110	0	-3
Total		**245**	**618**

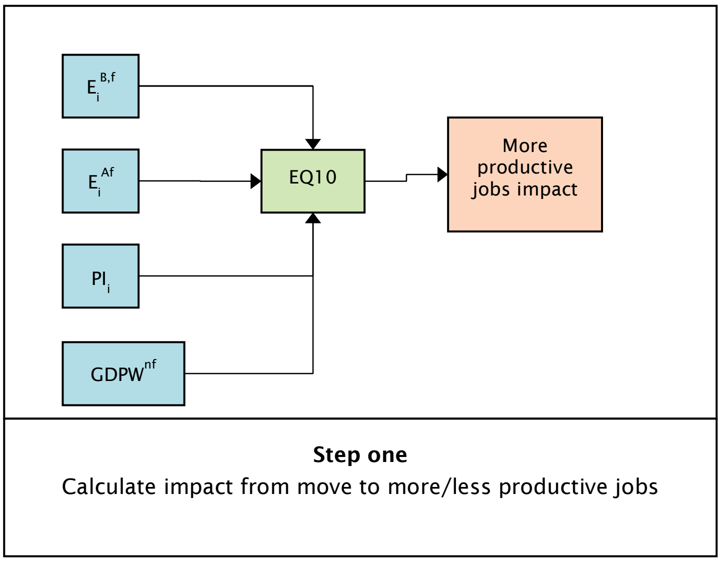
In turn the increase in employment is likely to generate an additional economic impact from increasing the tax income base. The tax payments of the new entrants are adjusted to take account of lower productivity. Overall, the increase in employment is likely to lead to an increased tax take of $4.4m per year in 2026, and $9.2m in 2041, which equates to an average of 6.7% uplift over time savings.

18 Impacts of more productive jobs

18.1 Description

Very large transport projects have the potential to radically alter land use and personnel travel choices and behaviour. One possible impact, particularly for large projects over the long term is that people choose to change their home or work locations. This can generate an economic impact if individuals choose to relocate to locations of higher productivity and thereby increase their wages and tax contribution. Figure 18.1 provides an overview of the impact calculation.

Figure 18.1 More productive Jobs calculation



Adapted from DfT (2009)

The figure shows the calculation is made using a comparison of DM and DS employment estimates, in combination with information about pure relative locational productivity and GDP per worker to estimate the change in tax revenue associated with different transport options. Table 18.1 provides a description of each variable.

Table 18.1 More productive jobs impact variable descriptions

Variable	Description
$E_i^{B,f}$	Total employment in zone (i), scenario (B), and forecast year (f).
$E_i^{A,f}$	Total employment in zone (i), scenario (B), and forecast year (f).
PI_i	An index of productivity in each zone (i).
t^{LP}	Average tax take on increased labour productivity
$GDPW^{nf}$	National GDP per worker by forecast year (f).

The estimation of the impact of the move to more productive jobs is shown in equation 18.1.

$$More\ productive\ jobs\ impact = GDPW^{N,f} \cdot \sum_i (E_i^{A,f} - E_i^{B,f}) \cdot PI_i \qquad \text{(Equation 18.1)}$$

The estimation of the impact of more productive jobs requires a land-use model to assess the impacts of transport interventions on home and employment location choices. It also requires an estimate of the true productivity differentials across geographical zones taking account of individual characteristics and sector employment – that is, productivity differentials caused by differences in location and not differences in sectoral composition, skills or capital intensity. Some estimates exists, but they are either at a too aggregate spatial level (see table 18.2) or do not correct for differences in skills and capital intensity (see table 18.3).

Table 18.2 Regional productivity differentials

Region	Productivity differential (relative to Auckland)
Auckland	0.00%
North Island (north)	-8.01%
North Island (central)	-10.44%
Wellington	4.32%
Canterbury	-8.23%
South Island	-8.71%

Source: Kalb (2003a)

Table 18.3 Auckland productivity differentials

Region	Productivity differential (relative to non -Auckland)
Auckland CBD	172%
Auckland city	139%
Auckland urban area	36%
Auckland region	25%

Source: Maré (2008)

18.2 Results

It is possible the project will cause some changes in home and location choices that could result in individuals moving between regions and even to more productive areas within Auckland. However the regional impacts are likely to be very minor and without accurate information on productivity differentials at a sub-regional level it was not possible to estimate the impact for this study.

19 Summary

Overall the wider economic impacts of the AWHC project are likely to be worth around $106.6m in net present value (2010 prices). This represents a 33.1% uplift on the standard cost-benefit analysis of the project, placing the scheme near the top end of the example wider economic impacts projects listed in table 13.1.

Table 19.1 shows a summary of the wider economic impacts for each modelled year, and across the full 30-year appraisal period.

Table 19.1 Wider economic impacts summary table ($, 2010 prices, current prices)

	User benefits[25]	Agglomeration	Labour supply	Imperfect competition	Total WEI	WEI uprate %
2026	83.8	18.1	4.4	2.6	25.2	30.0%
2041	127.6	28.4	9.2	5.5	43.1	33.8%
NPV	322.4	72.0	21.7	13.0	106.6	33.1%

Agglomeration impacts account for the largest component wider impacts for the project with a total $72m impact in net present value, which is equivalent to a 22.3% uplift on the standard valuation. Labour supply impacts are the next most significant impact at $21.7m net present value (6.7% uplift) and finally imperfect competition impacts are worth $13m net present value (4% uplift).

The agglomeration impact is slightly higher than average for other transport investments. This is not surprising given the significant increase in connectivity for locations in the proximity of the crossing to Auckland's CBD and the North Shore. Put simply, agglomeration is driven by an improvement in connectivity to locations of dense economic activity, while user benefits are the product of a connectivity improvement and the number of travellers enjoying this improvement. Hence, projects that deliver a significant improvement in access to employment centres will tend to deliver larger agglomeration gains in proportion to user benefits.

Labour supply impacts and imperfect competition impacts are of a similar magnitude to those found in other studies.

Overall the impact of the bridge is focused on the areas of high population and employment density located close to the crossing corridor. Figure 19.1 plots the spatial impact of the wider economic impacts, while table 19.2 shows a breakdown of the impact by territorial authority.

[25] A slight discrepancy from the reported benefit in the AWHC business case of $329m occurs because of averaging errors.

Figure 19.1 Total wider economic impacts by modelled zone in 2026

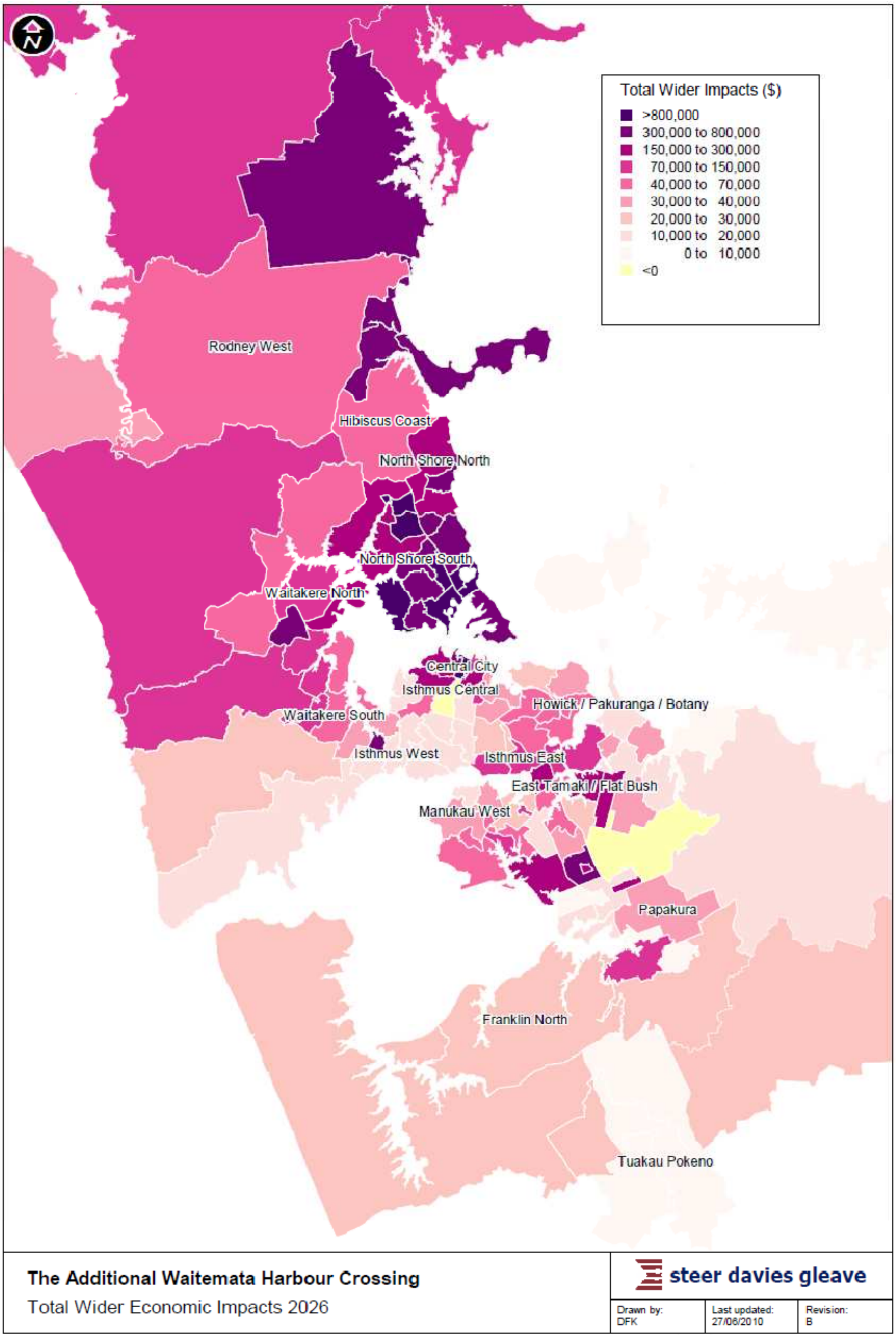


Table 19.2 Wider economic impacts by sector (NZ$, 2010 prices, current values)

Sector	Zones	WEI	
		2026	**2041**
Rodney	1 to 11	2,132,618	3,880,634
North Shore north	12 to 19	4,141,848	6,809,927
North Shore south west	20 to 25	4,537,692	6,504,788
North Shore south east	26 to 29	5,588,084	8,319,007
Waitakere north	30 to 34	887,967	1,796,045
Waitakere central	35 to 38	322,740	712,871
Waitakere south	39 to 43	461,243	-288,006
Auckland CBD	44 to 45	1,484,241	4,997,117
Auckland inner	46 to 54	528,307	1,372,779
Auckland west	55 to 60	198,856	630,503
Auckland south west	61 to 64	73,828	188,455
Auckland south east	65 to 69	360,383	472,760
Auckland east	70 to 76	325,509	463,268
Howick/Papakura	78 to 81	94,941	114,612
East Tamaki	82 to 88	337,961	191,369
Mangere/Otahuhu	89 to 98	313,771	502,060
Manukau central	96 to 98	452,555	606,646
Manurewa	99 to 101	15,093	17,881
Papakura	102 to105	102,397	184,131
Franklin	106 to 110	144,243	149,520
Total		**22,504,277**	**37,626,366**

Overall the North Shore sectors see the greatest economic benefit. All sectors see a positive impact, except for a slight negative in Waitakere south in 2041. The impacts on more distant and rural sectors such as Franklin and Papakura are relatively small.

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Appendix A: Technical proof for the imperfect competition uprate factor

A.1 Conventional cost-benefit analysis

A.1.1 The perfectly competitive model

In standard cost-benefit analysis and appraisal the economy is generalised as a perfectly competitive market. This market structure has the following characteristics:

- many small identical suppliers
- many small identical consumers
- zero barriers to entry or exit
- perfect information
- homogenous products
- costless transactions
- all firms are independent and seek to maximise profit.

These assumptions result in a market structure that is unique in several ways. Because firms are small relative to the overall market, an individual firm's output has a negligible impact on the overall level of aggregate supply and so monopoly power is zero.

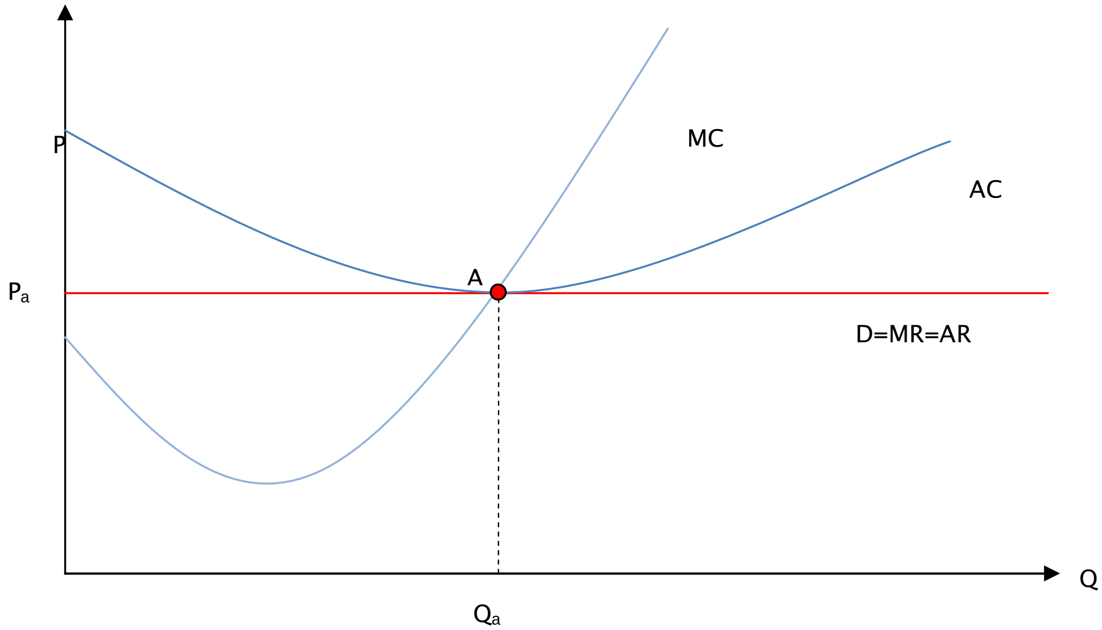
Furthermore, perfect information, costless transactions and homogenous products mean price is the only determinant of demand and so, profit maximising firms will continually undercut one another to gain market share until price equals marginal cost and any additional output results in a loss.

In the short term firms can gain a profit if demand is sufficiently high so that marginal cost is above average cost at the point of output, but in the long run, because barriers to entry (and exit) are zero new firms will enter the market absorbing excess demand and reducing the demand of each firm to a level at which marginal cost equals average cost, eliminating super normal profits and making additional market entry non-profitable.

In the long run, these conditions result in a welfare optimising market where price is equal to both marginal and average cost, and markets are efficient in both allocation and production, because output is priced so the benefit of the marginal unit is equal to the marginal cost, and market density is optimised to fully exploit economies of scale.

The output of the firm in a perfectly competitive market in the long term is shown graphically in figure A.1.

Figure A.1 The perfectly competitive firm in the long run



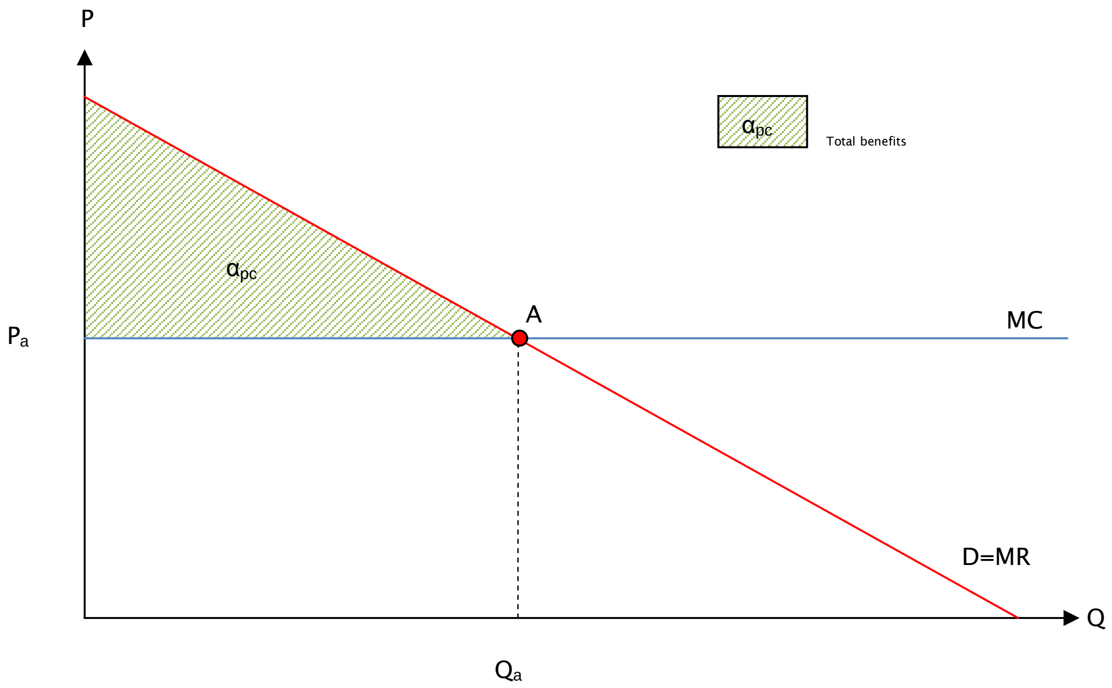
Because there is no monopoly power, the demand curve is perfectly inelastic, and therefore demand (D) is equal to both marginal revenue (MR) (ie the net incremental revenue from increased supply) and average revenue (AR).

Competitive pressure forces every firm to set price (P) equal to marginal cost (MC), or face zero demand. In the long run, market entry (and exit) means the level of demand for each firm is driven down to a level where marginal cost equals average cost (AC).

As a result output is set where all costs are minimised, the firm breaks even, and price is set so the benefits of consumption exceed the costs of supply on all units produced, thus maximising welfare.

At an aggregate level this results in a market where demand and marginal cost intersect and the key feature is that because firms face a horizontal demand curve, demand equals marginal revenue and price does not deviate from marginal cost as shown in figure A.2.

Figure A.2 The perfectly competitive market



The figure shows the market position is at point A with price at P_a, and quantity at Q_a. The welfare value of the market is equal to the area bounded by the demand and marginal costs curves marked by α_{pc} and shaded in green (the subscript denotes the market structure).

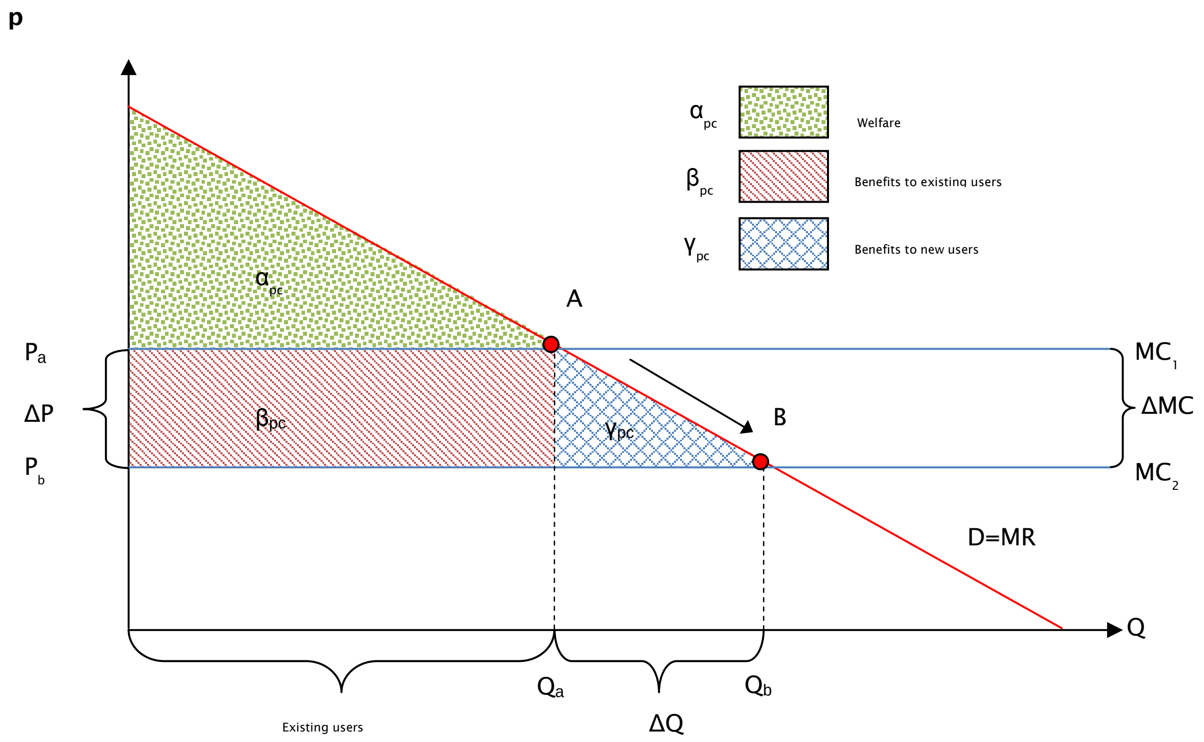
This area is the total economic surplus and represents the excess of demand over cost for the quantity of the good provided, equivalent to aggregate social willingness to pay. This is the value we seek to capture in appraisal.

A.2 The perfectly competitive model and appraisal

The standard method in cost-benefit analysis is to adopt the perfectly competitive model to analyse the impact of transport and other investments on overall levels of welfare. The benefits of an investment are measured by estimating the change in the total value of surplus.

Figure A.3 shows the effects of a fall in marginal cost on output and welfare in a perfectly competitive market. The figure can be interpreted either as the market for transport services, or as any market where transport costs form part of the cost curve.

Figure A.3 Market behaviour in perfect competition



The figure shows that as a result of investment (in transport for example) marginal cost falls from MC_1 to MC_2, and because of the perfectly competitive assumption the market moves from A to B, the quantity of output increases from Q_a to Q_b, and price falls from P_a to P_b.

The resulting increase in welfare is equal to the areas β_{pc} and γ_{pc} shaded in red and blue. Area β_{pc} represents the benefits to existing users and is equal to $Q_a(MC_1-MC_2)$.

Area γ_{pc} represents the benefits to new users induced into consumption through a lower price and is equal to ½$(Q_a-Q_b)(MC_1-MC_2)$. This equation is also known as the rule of a half because new users are assumed to enjoy, on average, half the benefit of existing users.

$$Benefits_{pc} = \beta_{pc} + \gamma_{pc} \qquad \text{(Equation A.1)}$$

$$\beta_{pc} + \gamma_{pc} = Q_a(MC_1 - MC_2) + \frac{1}{2}(Q_b - Q_a)(MC_1 - MC_2)$$

This simple equation is what lies behind most benefit calculations in transport appraisal. For example the UK DfT economic appraisal package TUBA uses this equation to estimate the benefit of road projects utilising demand matrices and generalised travel cost as proxies for marginal cost and quantity.

The key feature of the model (for our purposes) is that price is assumed to equal marginal costs which is a result of the perfectly competitive market assumptions in the model. It is this assumption that allows us to consider the above analysis as equivalent if undertaken within the transport sector or for transport-using sectors.

The assumption implies all project benefits can be captured by focusing on the transport sector – there are no wider consequences for the rest of the economy. However, it can be shown this assumption leads to a systematic bias in welfare estimation in markets where price deviates from marginal cost, and this is the essential reason for the existence of imperfect competition benefits.

A.3 The wider impacts from imperfect competition

The perfectly competitive model is an idealised approximation of market structure, but it is not realistic for all but a few special markets such as stock markets and agricultural commodities (and even here there are important caveats and exemptions).

The model is best regarded as a benchmark against which to evaluate and compare the imperfections of actual market structures which are often much more complex and violate one or more of the perfectly competitive assumptions.

Using the standard approach therefore fails to account for widespread market imperfections that exist in the economy and for the full impact of changes in marginal cost on welfare that occur following investment and this results in a systematic bias in the estimation of welfare benefits.

Almost all markets deviate from the perfectly competitive model to some extent, and this is certainly true at an aggregate level. In practical terms market imperfections can be observed from the deviation of price from marginal cost which indicates a non-optimal market position and/or structure over the long term.

The starting point for the estimation of wider economic benefits is to develop a model of the economy which relaxes the strong assumptions in the perfectly competitive model to allow for the impacts that can arise under imperfect competition.

There are several models that offer incremental improvements to the realism of the perfectly competitive model. A commonly applied model structure which has a number of characteristics in common with observed markets and behaviour is oligopoly. We go on to develop a model of oligopoly and consider the magnitude of 'missing' benefits.

A.4 Oligopoly

Oligopoly is a situation in which a firm's output is large relative to the aggregate market and individual firms therefore have some degree of market power. Since increasing output reduces prices, the firms have an incentive to restrain output in order to elevate the price.

Cournot competition is one of several models of market oligopoly in which multiple large firms compete in the same market with interdependent demand. The model is a generalisation, but in many cases it is a more appropriate representation of market structure. For example in the UK there are many industries which fit the description well; supermarkets, airlines, car manufacturers, utility providers and banks are all markets where a limited number of firms together account for the majority of market share. These compete against one another but are also highly interdependent and therefore will tend to operate in a non-optimal manner from an economic point of view in the absence of regulation.

The model used here is technically known as a symmetric Cournot oligopoly with n identical firms and a linear demand curve. The market structure has the following characteristics:

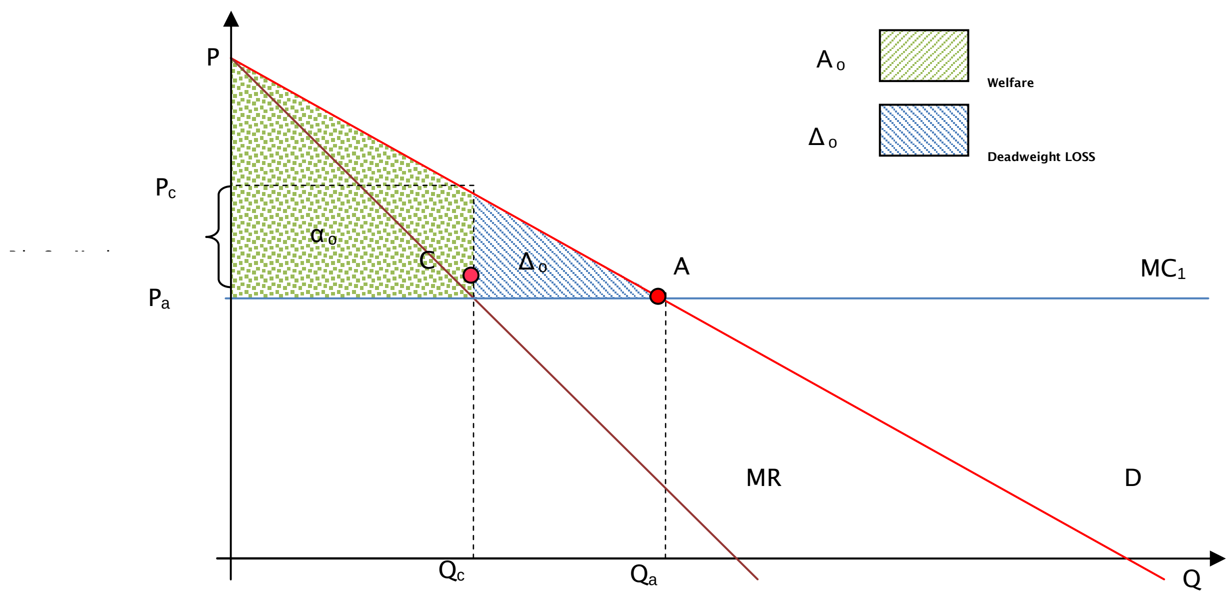
- multiple identical suppliers
- many small identical consumers
- barriers to entry
- perfect information
- homogenous products
- costless transactions

- interdependent firms that seek to maximise profit.

Because an individual firm's output is large, and there are barriers to entry that prevent the displacement of incumbents, profit maximising firms in oligopoly have some degree of market power and can set price above marginal cost.

Marginal revenue deviates from demand, because each firm realises increased supply means accepting a lower price for all its sales. The market produces less than the socially optimum quantity of output because increased production has a negative impact on overall profits. The effect is shown graphically in figure A.4.

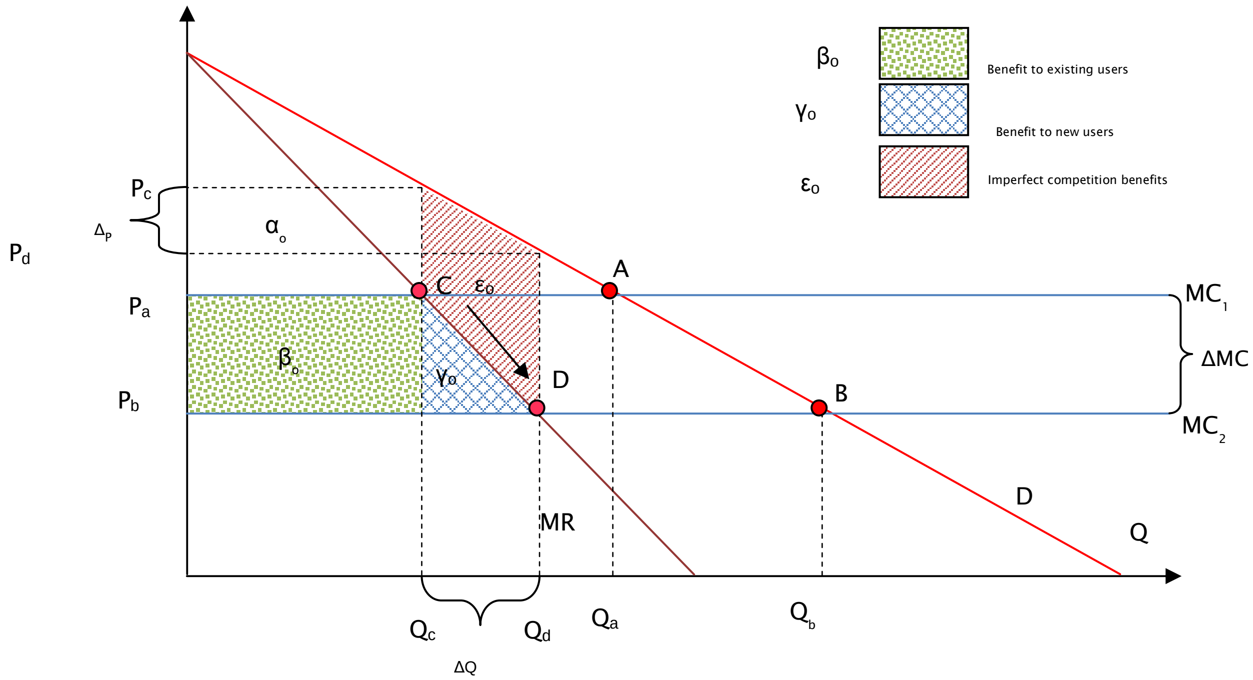
Figure A.4 The oligopolistic market



In oligopoly the market is at point C (as opposed to point A in a PC market) with price at P_c and quantity equal to Q_c. Total welfare in the market is equal to area α_o. Price is set above marginal cost, with a price cost margin equal to P_c-P_a, and as a result of this deviation there is a deadweight loss to society from lost output equal to area δ_o (shaded in blue).

The effect of a reduction in marginal cost in the oligopoly competition model is demonstrated graphically in figure A.5.

Figure A.5 Cost reductions in oligopoly



The figure shows the effect of a fall in marginal cost associated with an improvement in transport infrastructure. Marginal cost falls from MC_1 to MC_2, and the market moves from C to D, (compared with A to B in the perfectly competitive case) with firms expanding output from Q_c to Q_d.

In this model the increase in welfare is equal to areas $\beta_o + \gamma_o + \varepsilon_o$, where the latter symbol represents the gains from increasing output in an imperfectly competitive market which are omitted by the standard approach. This component of benefit represents the excess of willingness to pay (tracked by the demand curve) over marginal costs for the expansion in output. This is systematically omitted by the standard approach in appraisal and is the quantity with which we are primarily concerned when estimating the wider imperfect competition benefits.

It can be shown the simplest method of estimating the wider benefits is to estimate it as a proportion of the benefit estimate obtained under standard appraisal. The following section seeks to explain how and why this is the case algebraically.

A.5 Algebraic derivation of imperfect competition benefits

We begin by defining the market structure algebraically. We assume a symmetric Cournot oligopoly with n firms and a linear demand curve so that:

$$P = a - bQ \quad \text{(Equation A.2)}$$

$$P = a - bnQ_i \text{ and } \therefore (nQ_i = Q) \quad \text{(Equation A.3)}$$

We can rewrite these equations in terms of demand:

$$Q = \frac{a-P}{b} \quad \text{(Equation A.4)}$$

$$Q_i = \frac{a-P}{bn} \qquad \text{(Equation A.5)}$$

Where P is price, Q is quantity, *a* and *b* are constants, *n* is the number of firms, and *i* is a subscript denoting the individual firm.

We assume all firms produce the same level of output and thus individual firm demand is interdependent with that of other firms.

Profit for each firm is equal to total revenue minus total costs cost so that:

$$\pi_i = PQ_i - MCQ_i \qquad \text{(Equation A.6)}$$

Where π is profit, and MC is marginal cost. Each firm has control over the quantity of good it supplies and maximises profit by setting marginal revenue to marginal cost. Because of the market structure, every additional unit reduces the price so that:

$$MR = P - BQ_i \qquad \text{(Equation A.7)}$$

And setting marginal revenue to marginal cost:

$$P - bQ_i = MC \qquad \text{(Equation A.8)}$$

And rearranging this we can write:

$$P = MC\ - bQ_i \qquad \text{(Equation A.9)}$$

$$P = MC\ - \frac{b}{n}Q \qquad \text{(Equation A.10)}$$

$$Q_i = \frac{P-MC}{b} \qquad \text{(Equation A.11)}$$

$$Q = \frac{P-MC}{nb} \qquad \text{(Equation A.12)}$$

Substituting equation A.9 into A.3:

$$P = a - bnQ_i = MC - bQ_i \qquad \text{(Equation A.13)}$$

$$\rightarrow a - MC = bQ_i + bnQ_i$$

$$\rightarrow a - MC = Q_i b(1+n)$$

$$\rightarrow a - MC = Q_i b(1+n), \text{and finally:}$$

$$Q_i = \frac{a-MC}{b(n+1)} \qquad \text{(Equation A.14)}$$

Similarly it can be shown that:

$$Q = \frac{(a-MC)n}{b(n+1)} \qquad \text{(Equation A.15)}$$

$$P = \frac{a+nMC}{n+1} \qquad \text{(Equation A.16)}$$

Using this algebraic description of market structure we can now go on to define the relationship between standard and wider economic benefits. The full welfare benefits are:

$$Benefits_o = \beta_o + \gamma_o + \varepsilon_o \qquad \text{(Equation A.17)}$$

Based on this equation, we wish to find a parameter (τ) to determine wider benefits as a constant proportion of the benefits estimated in standard appraisal, so that:

$$\varepsilon_o = \tau(\beta_o + \gamma_o)\ and \qquad \tau = \frac{\varepsilon_o}{\beta_o+\gamma_o} \qquad \text{(Equation A.18)}$$

Since the conventional appraisal assumes this market is perfectly competitive, the observed demand curve is in reality the MR curve. The benefits captured in conventional appraisal are therefore β_o, and γ_o, which are equal to:

$$\beta_o + \gamma_o = -Q\Delta MC - \frac{\Delta Q \Delta MC}{2} \qquad \text{(Equation A.19)}$$

It is now useful to introduce the concept of market elasticity, which is defined as:

$$e(Q) = \frac{P}{Q}\frac{\delta Q}{\delta P} \approx \frac{P}{Q}\frac{\Delta Q}{\Delta P}$$ (Equation A.20)

Assuming Cournot competition implies that price is a linear function of quantity and so the derivative of quantity with respect to price is a constant (rearranging equation A.2 and differentiating):

$$\frac{\delta Q}{\delta P} = \frac{1}{b}$$ (Equation A.21)

Thus we can rewrite equation A.20:

$$e(Q) = -\frac{P}{bQ} = -\frac{P}{nbQ_i} = -\frac{P}{n(P-MC)}$$ (Equation A.22)

Rearranging equation A.20 gives the following formula for the change in quantity given a change in price, which is used to simplify later equations:

$$\Delta Q = e(Q)\frac{\Delta P}{P}Q$$ (Equation A.23)

Because price deviates from marginal cost in non-perfectly competitive markets, firms can often retain some of the fall in marginal costs in the price charged to increase profits. Because of this a change in marginal cost may not be entirely reflected in a change in price. By differentiating equation A.16 we find that:

$$\frac{\Delta P}{\Delta MC} = \frac{n}{n+1} \equiv k$$ (Equation A.24)

Incorporating this variable, we can re-write the elasticity equation A.22 as:

$$\Delta Q = e(Q)\frac{k\Delta MC}{P}Q$$ (Equation A.25)

So that the benefits captured in current appraisal can be re-written by substituting equation A.25 into A.19 so that:

$$\beta_o + \gamma_o = -Q\Delta MC(1 + e(Q)\frac{k\Delta MC}{2P})$$ (Equation A.26)

This gives us our final equation for the benefits derived in standard economic appraisal. By stating they are a function of output quantity, the change in marginal cost, market elasticity and the market pass through changes to marginal costs.

A.5.1 Wider benefits

Based on the graphical analysis wider economic benefits can be defined as:

$$\varepsilon = [(P + \Delta P) - (MC + \Delta MC)]\Delta Q - \frac{\Delta Q\Delta MC}{2} + \frac{\Delta Q\Delta P}{2}$$ (Equation A.27)

Again, this formula can be refined to improve the representation of demand by rearranging ΔQ by incorporating the substitution from equation A.24 into A.26 to reflect actual market structure, thus:

$$\varepsilon = \left[(P + \Delta P) - (MC + \Delta MC) - \frac{\Delta MC}{2} + \frac{\Delta P}{2}\right](e(Q)\frac{k}{P}Q\Delta dMC)$$ (Equation A.28)

$$\varepsilon = \left[\frac{k(P-MC)}{P}\varepsilon(Q) + e(Q)\frac{k}{P}(k-1)\Delta MC - \frac{(k-1)\Delta MC}{2}e(Q)\frac{k}{P}\right](Q\Delta dMC)$$ (Equation A.29)

$$\varepsilon = k\frac{k-1}{k} + e(Q)\frac{k(k-1)}{P}\Delta MC - e(Q)\frac{k(k-1)}{P}\frac{\Delta MC}{2}(Q\Delta dMC)$$ (Equation A.30)

And rearranging equation A.23 gives:

$$\frac{P-MC}{P} = -\frac{1}{e(Q)n}$$ (Equation A.31)

Substituting equation A.31 into A.30 gives:

$$\varepsilon = \left[1 + \varepsilon(Q)\frac{k\Delta MC}{2P}\right](Q\Delta dMC)(k-1)$$ (Equation A.32)

Which gives us an estimate of imperfect competition benefits in terms of market structure and changes in marginal cost.

Dividing the wider benefits estimate by standard benefits (equation A.32 by A.26) therefore produces an estimate of the imperfect competition uplift parameter τ, so that:

$$\tau = \frac{\varepsilon}{\beta+\gamma} = k - 1 = \frac{1}{n+1} = \frac{re(Q)}{re(Q)-1} \qquad \text{(Equation A.33)}$$

Where r is a parameter representing the price cost margin:

$$r = \frac{(P-MC)}{P} \qquad \text{(Equation A.34)}$$

This means that total benefits to society of a cost saving to a transport using market can be approximated by a fixed multiplier to the conventionally measured benefits to the firms in the market, where the multiplier can be estimated from either:

- the number of firms in the market, or
- the price cost margin in the market and the price elasticity of demand.

Appendix B: Technical proof for labour supply impacts

B.1 Labour supply impacts

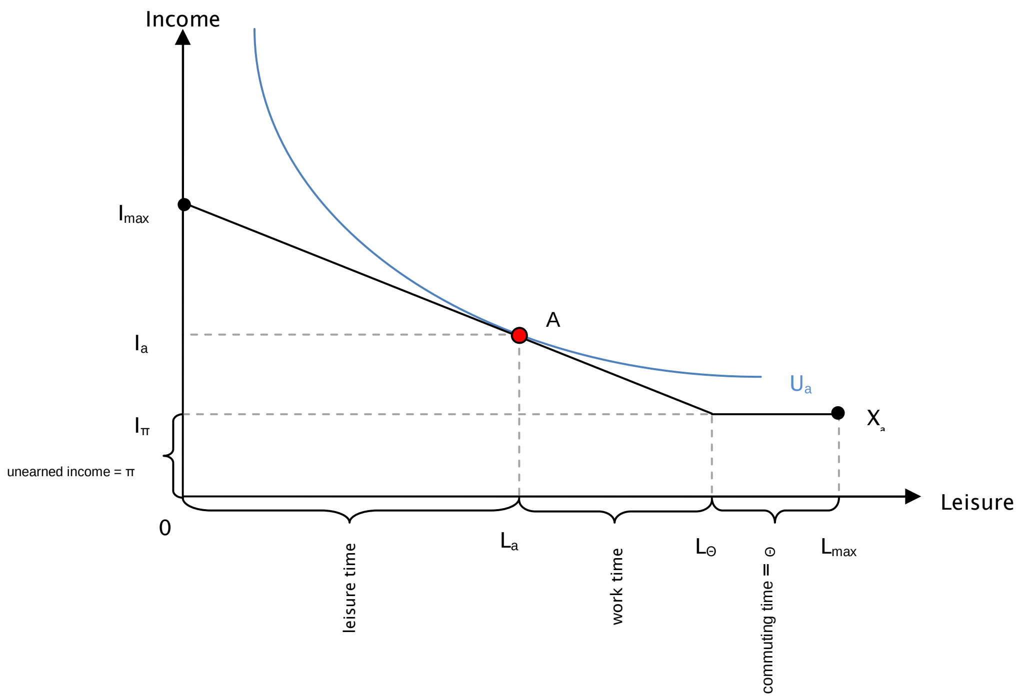
There are three main factors affecting labour supply decisions for existing workers:

- The substitution effect: an increase in wage rate will encourage increased labour supply as the marginal return to increased hours or effort will increase and, consequently, the opportunity cost of leisure time increases.
- The income effect: an increase in the returns to work (increased wage or reduced fixed cost of working) for those already employed will have a negative effect on labour supply as fewer hours or less effort is required to maintain consumption levels.
- The time budget effect: a reduction in commuting time will increase discretionary time, some of which may be allocated to work.

So for existing workers a change in wage will have both a substitution and an income effect, a change in fixed costs of working will have only an income effect, while a change in commuting time will have a time budget effect. Hence, considering a change in commuting time as equivalent to a change in the wage or in the fixed cost of working is clearly inappropriate for assessing labour supply decisions for those already in work.

The work leisure trade off incorporating fixed income and commuting costs is shown graphically in figure B.1.

Figure B.1 The work leisure trade off in employment



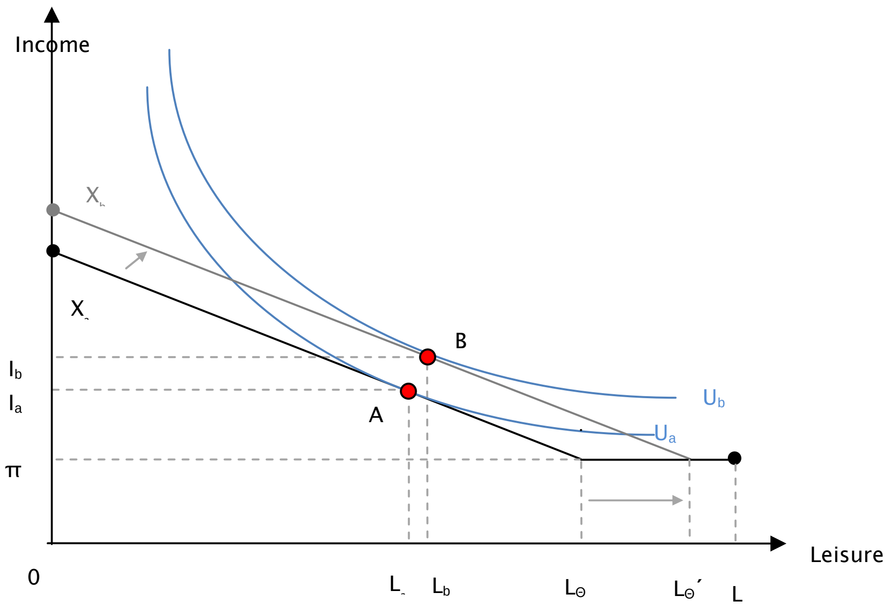
The figure demonstrates that the individual faces an income – leisure 'budget' curve X_a showing all possible leisure – income combinations. The curve is determined by three factors, the wage rate (w), fixed income (π) and commuting time (Θ), with the total time available a fixed constant (L_{max}).

The individual is endowed with I_π units of income and L_{max} units of leisure time which he or she can exchange for income at the going wage rate. Commuting time costs mean the individual's tradable 'time budget' (L_Θ) is less than the total time endowment.

The individual maximises welfare or 'happiness' by choosing the income-leisure trade off. The preferences for income (and ultimately consumption) vs leisure is represented in the 'indifference curve' U_a, which expresses all combinations of income and leisure that result in the same level of happiness. The further to the north east this indifference curve lies, the higher level of happiness is achieved. The best choice for the individual is hence where the utility curve is tangential to the budget curve. This is shown at point A where the individual supplies (L_{max}- L_a) units of labour earning $w_a(l_{max}$- $L_a)$ = I_a income and enjoying L_a units of leisure. This work leisure trade off achieves happiness level U_a.

Changes to the budget curve have an effect on the level of an individual's happiness. Figure B.2 shows the effect of a reduction in commuting time on the work-leisure trade off.

Figure B.2 The work-leisure trade off and a change in commuting time

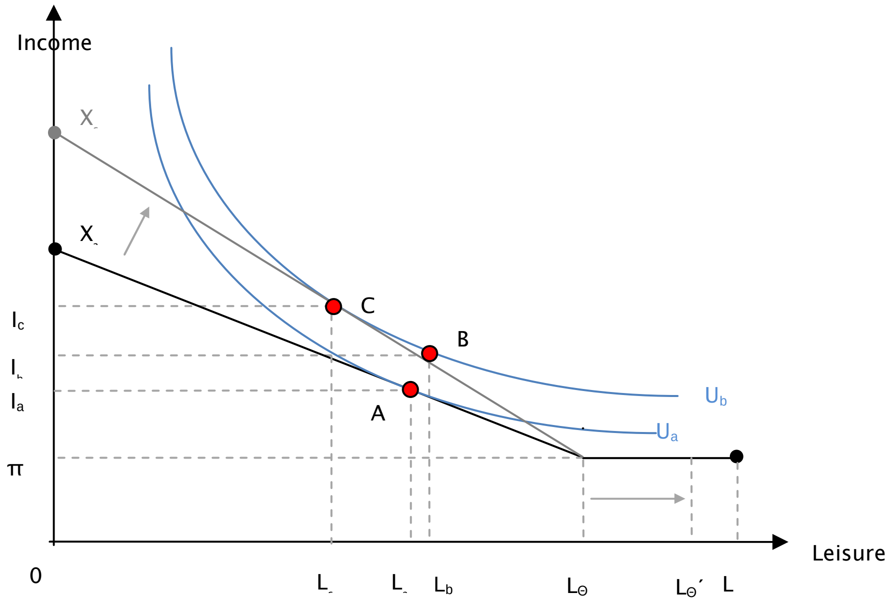


In this case the individual's commuting time falls from Θ to Θ´, and the tradable time budget increases to LΘ´. This effect shifts the budget curve outward from X_a to X_b.

In response the individual moves to point B increasing leisure from L_a to L_b and income from I_a to I_b. This enables a move to a 'higher' indifference curve, from U_a to U_b, and so the individual is better off.

Because of a lack of research into the effect of changes in commuting time on labour supply in order to estimate the empirical effects of such a change we must interpret the utility gain from commuting time savings as a wage increase or an increase in fixed income. Figure B.3 shows the implications of this.

Figure B.3 Interpreting a change in commuting time as a change in the wage rate



The figure shows a new budget curve X_c which represents a wage rate increase that provides the same level of happiness as the reduction in commuting time, shown by the curve U_b.

The wage rate is set so the individual achieves the same utility but with the original fixed income π and commuting time Θ. In effect, this is exactly what we seek to achieve when asking individuals how much they would be willing to pay for an hour time saving; what is the monetary equivalent that would make you just as well off as if your travel time was reduced by one hour.

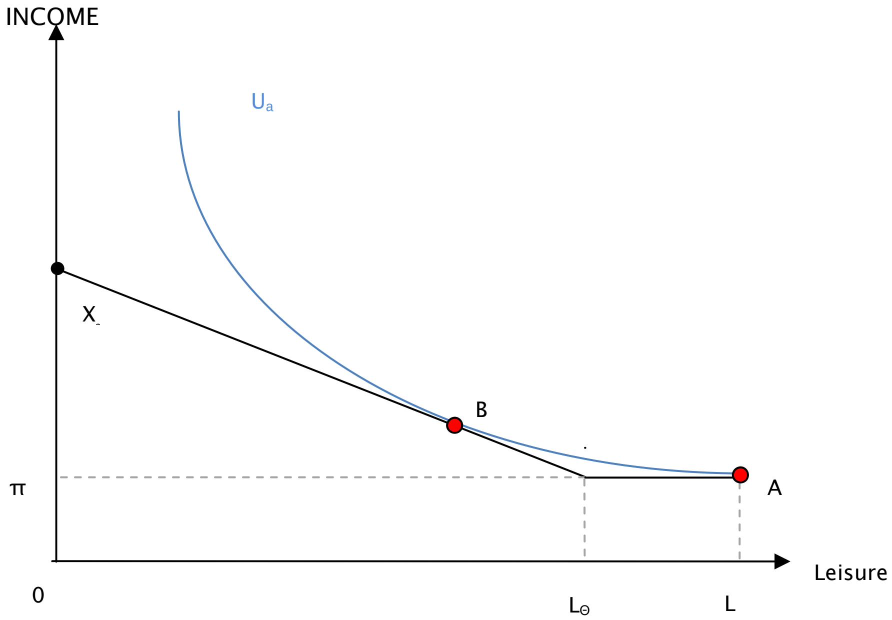
While the individual enjoys the same amount of happiness and is therefore indifferent between points B and C, we can see the amount of time dedicated to leisure is lower, and the amount of time dedicated to work higher for point C than for point B.

In practice the magnitude of the differences may be more or less than indicated, but the principle is that interpreting the change in welfare from a reduction in commuting time as a wage rate increase will misrepresent the effect on labour supply. The effect is similar when interpreting the change as a change in fixed income.

However, if we consider the labour participation decision, this problem is mitigated to some extent. In deciding whether to work or not, the relevant considerations are only the income and time allocation effects of two discrete choices. This means there is a much closer alignment between behavioural responses to an increase in wages (or fixed income) and a reduction in commuting time than with the choice of hours and effort for those in employment. The fact that workers are rarely able to choose their working hours freely contributes to this alignment.

The labour participation decision is shown graphically in figure B.4.

Figure B.4 The labour participation decision – not in employment



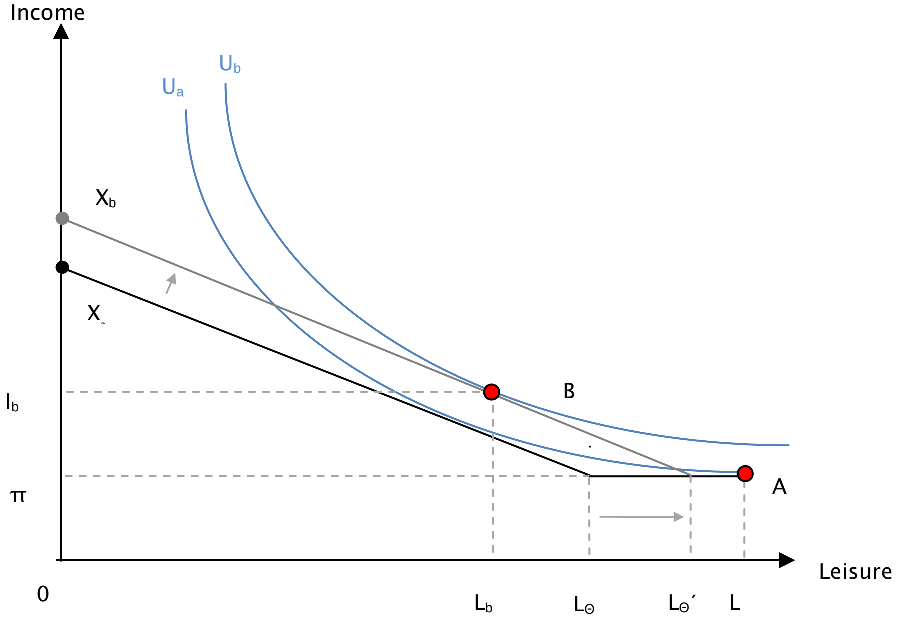
The figure shows the situation for the individual at the margins of participation. The individual is faced with the same wage leisure curve X_a but has a stronger preference for leisure and thus the utility curve is straighter.

Such a preference is common with those who are very wealthy, close to retirement, potential second earners or those who need to look after children for whom the opportunity cost of work is higher.

In this case the welfare maximising decision is to choose not to work, and the individual is at point A with L_{max} units of leisure per day and fixed income π achieving happiness level U_a. In this case the individual is almost indifferent to working at point B.

A change in commuting time reduces the time penalty from working and can induce individuals into work. This effect is shown in figure B.5.

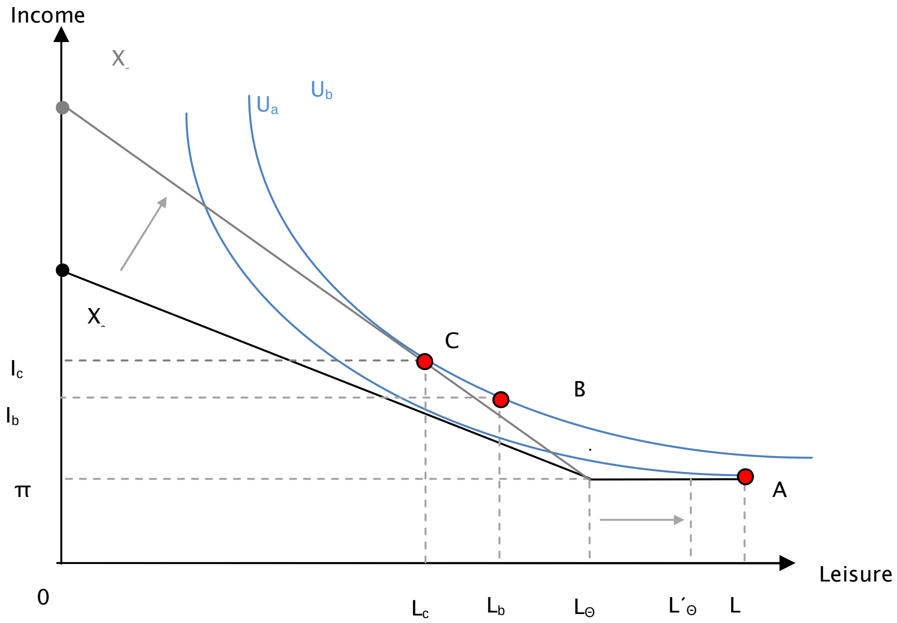
Figure B.5 The participation decisions and a change in commuting times



The figures show a fall in commuting time to Θ´ which shifts the budget curve from X_a to X_b. This effect changes the labour participation decision and the individual enters the labour market and moves to point B enjoying a higher level of happiness.

Again we can interpret this change as an increase in the wage rate or an increase in fixed income. Figure B.6 shows the change interpreted as an increase in the wage rate and is analogous to figure B.3.

Figure B.6 Interpreting a change in commuting time as a change in the wage rate for the participation decision

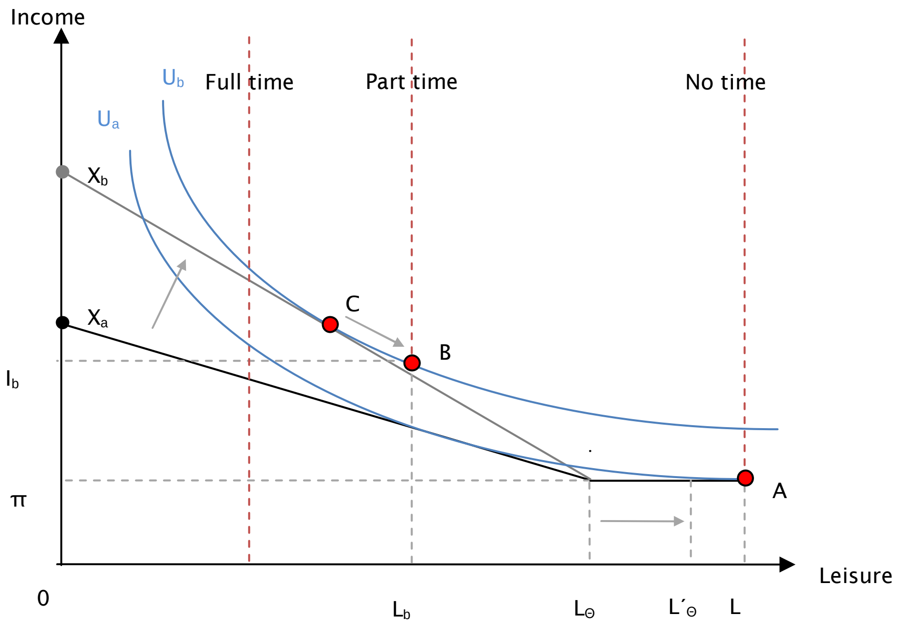


Although the actual magnitude of the behavioural change in terms of the labour-income trade off remains different for points B and C, in percentage terms the difference is significantly smaller (meaning that the relative differentials $(L_a-L_b)/L_a$ and $(L_a-L_c)/L_a$) are more similar than in the employment case).

Furthermore because we are concerned with changes in the participation rate and not the actual amount of labour supplied, this difference is less important because individuals are regarded as either in or out of employment.

The behavioural similarities are likely to be even greater if we consider the indivisibilities present in the labour market; that individuals must make a discrete choice between part-time and full-time employment rather than making a continuous choice. This effect is shown below in figure B.7.

Figure B.7 The participation decisions and indivisible labour supply



Here the individual can only choose between three employment positions: full time, part time and no time, denoted by the dashed red lines. In this example, the reduction in commuting time causes the individual to shift from no time to part-time employment.

Considering an equivalent change in the wage rate, the individual would ideally position themselves at point C, but because of indivisibilities in the labour market can only position themselves at point B; hence the behavioural impact is the same in both cases.

This effect may be mitigated to some degree by the granularity of the labour market and different levels of indivisibility for different firms and industries, but nonetheless indivisibilities are a source of market friction which means that the effects of commuting time reduction and equivalent change in wage rate (in terms of generating happiness) will tend to converge at a macroeconomic level.

In the absence of direct evidence about the impact of a change in commuting costs on labour participation, it is therefore arguably appropriate to consider the monetised value of a time saving in proportion to earnings as equivalent to an increase in wage rates. This enables us to put to use the evidence developed by Kalb (2003).

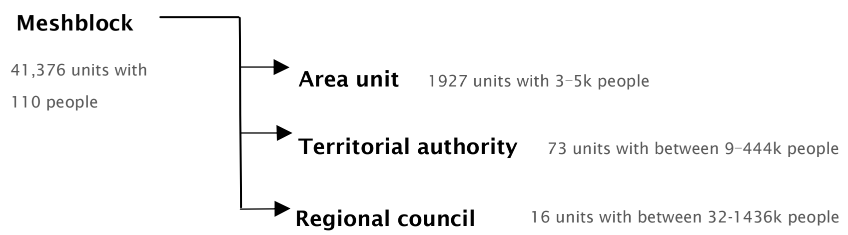
Appendix C: New Zealand geographical boundaries

Statistics NZ, the main national data body for the country, holds statistics in a hierarchy of geographical units. The most detailed unit is a 'meshblock' which is a boundary based on census data containing around 110 people and usually covering an area the size of a city block. There are around 41,376 meshblocks for the whole nation.

Meshblocks are aggregated into larger administrative boundaries for the purposes of reporting statistics. These areas include wards, constituencies, electoral districts and area units; the area unit is the next level of aggregation in terms of the statistical hierarchy and there are around 1927 of these each containing between 3000–5000 people. Area units are in turn aggregated into territorial authorities and regional councils which are the secondary and primary tiers of local government. (Regional government is responsible for some public transport, while territorial authorities are responsible for road projects, although these tiers do not always coincide).

There is therefore a wide range of statistical boundaries to choose from when considering the economic benefits from job relocations. Figure C.1 shows the relative size of each level.

Figure C.1 New Zealand statistical geography hierarchy



These geographies are further distinguished by their use for standard statistical publications. Census data from 2001 and 2006 for example is available at meshblock level, and therefore can be obtained for all higher levels, but other surveys such as income and employment surveys are not necessarily available at these more detailed geographies (at least not over the same timeframe).

So while the methodology can be applied to any level of geography, the choice needs to be carefully considered, balancing the spatial magnitude of relocation impacts that schemes are likely to generate against the availability of reliable and up-to-date information on employment and earnings.

We recommend adopting the territorial authority as the standard statistical unit for assessing the productivity benefits of job relocations (and the other wider impacts). This unit sits midway between the larger regional councils and smaller area units and critically and effectively distinguishes between different urban areas where productivity differentials are most likely to occur, while still maintaining a good level of up-to-date statistical information (the territorial authorities are broadly similar to the local authority districts used in UK appraisal).