The Benefits of Investment in Roading Infrastructure – a General Equilibrium Approach

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Abstract

Traditional cost-benefit analysis is used by New Zealand roading authorities to assess and prioritise investment in roading infrastructure. For small projects at a local level, this is generally acceptable, but for projects that have nation-wide impacts traditional cost-benefit analysis has two major short-comings – it is partial equilibrium technique and its arguments relate only to productive efficiency. In this paper we show that if a selection of roading infrastructure projects in various parts of New Zealand are evaluated using general equilibrium analysis, standard benefit-cost ratios are often considerably understated. The main reason for this is that general equilibrium analysis incorporates welfare benefits derived from allocative efficiency effects, not just those stemming from productive efficiency. The paper also estimates, with knowledge of regional input-output tables, but without knowledge of inter-regional trade, the degree to which benefits of major roading projects in a region accrue to that region.

1. Summary

This study investigates the potential net benefits that may accrue to New Zealand by undertaking further investment in road transport infrastructure.[1] To do this, the direct and indirect impacts of four proposed land transport infrastructure packages were quantified using both standard cost-benefit analysis and computable general equilibrium (CGE) modelling techniques. The four proposed land transport infrastructure packages modelled include:

- the *passing lanes package*, which consists of 402 separate projects designed to improve safety on a number of New Zealand's rural roads;
- the *Auckland western ring route package*, intended to reduce inner city traffic and increase the connectedness of Auckland's urban arterial road network;
- the *Tauranga strategic roading network package*, which will meet the future road infrastructure needs of the Tauranga and the Western Bay of Plenty regions; and
- the *Wellington regional land transport package*, intended to achieve a balanced and sustainable land transport network meeting community needs.

Each of these four packages of projects have been proposed by either Transit New Zealand or relevant local government authorities in New Zealand.

Further investment in New Zealand's land transport infrastructure would involve four broad direct impacts which need to be weighed up for each package:

- *Accident costs savings*. These impacts include:
  - a reduction of loss of life and permanent disability;
  - a reduction in legal costs; and
  - a reduction in vehicle repair costs.
- *Travel time savings*. Savings in travel time are both economic and non-economic in nature. For example, travel time savings in relation to work related travel may decrease the cost associated with distribution networks thereby increasing productivity. On other hand, travel time savings for non-work related travel may not increase measured economic productivity but nonetheless are beneficial to commuters in general.
- *Project capital costs and financing impacts*. Given a predominately fixed pool of domestic savings in New Zealand an increase in investment will necessarily result in increased foreign borrowing. The cost of this is not the capital itself, but the cost of paying for the use of the capital. For this study an annual capital charge of 6 per cent has been assumed.
- *Vehicle operating cost impacts*. Changes in travel time and safer roads are likely to change road user behaviour. For example a reduction in non-work related travel time might provide less incentive to use public transport such as the bus or the train. Changed road user behaviour has a direct impact on vehicle operating costs.

[1] The paper describes the general equilibrium research undertaken by the author as part of a broader research programme, described in Allen Consulting Group and Infometrics (2004).

For modelling the economy-wide impacts associated with investing in New Zealand's land transport infrastructure the above direct impacts are treated as increases in productive efficiency. As they work their way through the complex and interconnected industries and activities which make up the New Zealand economy they generate further benefits from enhanced allocative efficiency.

The findings of the study suggest that if all four of the proposed land transport infrastructure projects were undertaken, there would be a total benefit, net of costs, to the New Zealand economy in excess of $1.5 billion dollars annually in 2012. This total net benefit is made up of the following individual benefits:

- a net increase in GDP of $1.0 billion in 2012. This is equivalent to a net increase in per capita GDP of around $243. In other words, if the proposed set of land transport projects were to be undertaken as modelled, each person in New Zealand would, on average, be better off by $243;
- a benefit of $65.9 million attributable to the value of lives saved and permanent disability avoided; and
- a benefit of $511 million from travel time savings related to non-work activities.

In addition to increased output, the proposed land transport infrastructure projects are expected to have the following macro-economic, industry and regional impacts:

- an increase in private consumption of around $670 million in 2012. This is equivalent to an annual increase of $153 per person;
- a net increase in aggregate investment of $203 million (0.5 per cent) in 2012;
- an increase in net exports of $158 million in 2012. This arises because there is an in labour productivity allows New Zealand's industries to be more internationally competitive;
- a aggregate reduction in annual taxation of $538 million, Alternatively, it could be argued that the extra tax revenue that the government secures from a larger economy will be around $538 million per year more than what is required to pay for the annualised cost of the proposed packages;
- a net benefit to the majority of New Zealand's industries particularly those that are likely to expand as a result of increased labour productivity arising from shorter worked related travel time; and
- substantial regional benefits, particularly to the Auckland, Wellington and Western Bay of Plenty regions.

(All of the above figures are ongoing annual impacts measured at 2012.)

The findings of this study indicate that net benefits will accrue by undertaking any one, or combination, of the four proposed road infrastructure packages. That is benefits are not dependent on undertaking all four packages simultaneously. That said, however, it is possible to rank each project in terms of the aggregate net benefit accruing over the life of the infrastructure. Doing this indicates that the Tauranga strategic road network package will result in the greatest net benefit, followed by the passing lanes package and then the Auckland package.

2. The Importance of New Zealand's Road Network

It is difficult to overstate the economic and social importance of New Zealand's road network. It plays a significantly bigger role than other transport modes, and connects them all. It permeates all aspects of economic and social activity. The road network (notwithstanding the emergence and importance of e-commerce) continues to represent the arteries of modern daily life, playing a crucial role in economic activity at the local, regional and national levels. Public and private use of the road network underpins our ability to participate in employment, recreation and social activities, making access to it not just a matter of economic and social importance, but also one of equity.

The importance of the road network to economic and business activity is not difficult to understand. Roads are ubiquitous; they provide virtually total connectivity of countless origins and destinations. Unlike other modes of transport such as rail, the road system offers an almost infinite range of choices for many users. Further, roads act as a feeder and distributor for other forms of transport.

Roads are open access and multipurpose. Business and commercial travel, social activity, freight transport and passenger travel and private transport or common carrier transport services all use the same network.

In most developed nations, there has historically been a strong relationship between economic growth and transport activity. The provision of physical infrastructure (such as roads, railways, ports and airports) is generally recognised as being of vital importance to economic development. A UK study that examined the effects on the performance of the economy which might be caused by transport projects and policies made the following conclusions:[2]

- Theoretical considerations suggest that the main mechanism by which changes in transport arrangements have an effect on the economy is by change in the *costs* of movement of goods and people.
- Transport infrastructure investments can potentially produce sustained reductions in transport costs, or equivalent improvements in services.
- These costs reductions could, in principle, improve economic performance in various ways. Businesses can pass on the benefit of lower production costs to consumers in the form of lower prices, or they can implement further efficiency improvements by reorganising production and distribution. The economy can also benefit if lower transport costs can help stimulate easier transfer between jobs or greater competition between firms. All of these imply improvement in real incomes and economic growth.

In addition to the theoretical links between transport costs and economic improvements, evidence from empirical studies points to outcomes consistent with what economic theory predicts. An Australian study using a general equilibrium analysis identified the main measurable benefits from new road construction, or the improvement of existing road facilities, as including: vehicle operating cost benefits, travel time benefits, accident benefits, environmental benefits. The flow-on effects of these direct benefits throughout the economy lead to lower costs to industries and increases in real income, with further benefits in terms of population health etc. They thus expand national economic output, with the size of the gain depending on the initial productivity improvement and the market characteristics faced by the industries which benefit from the productivity improvements.[3]

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[2] Standing Advisory Committee on Trunk Road Appraisal (1998).

[3] Allen Consulting Group (1993).

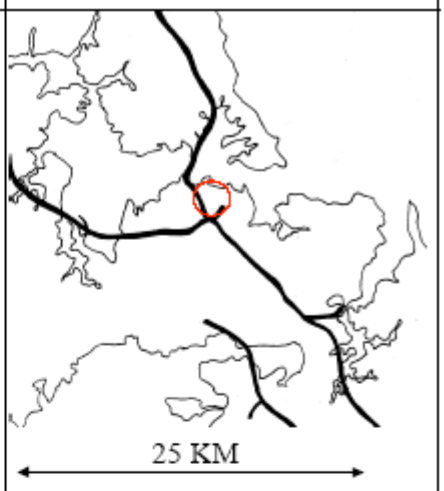
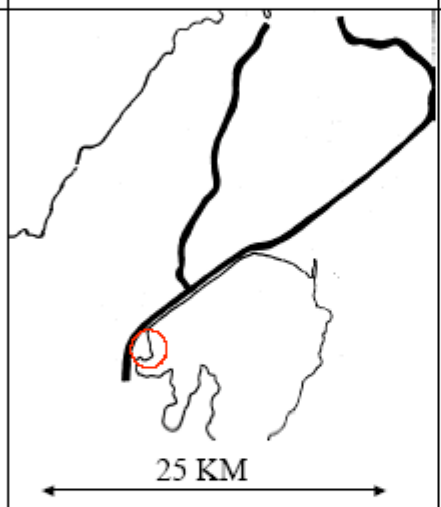
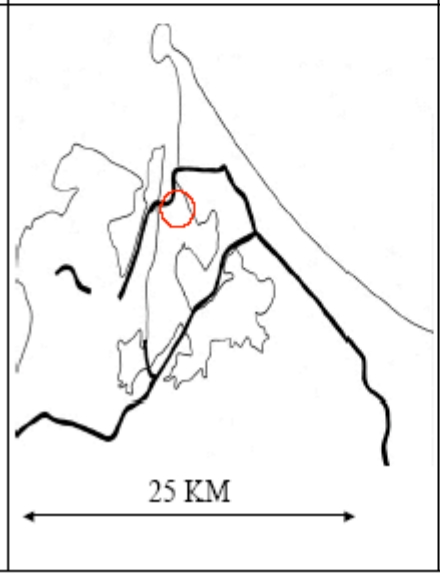
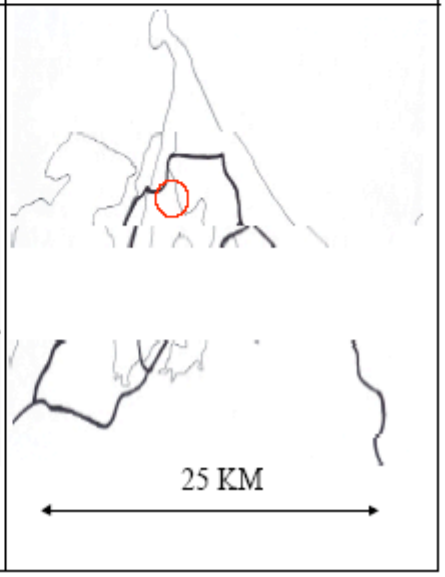
As shown in Figure 2.1 there have been very few significant road infrastructure projects over the period 1992-2002 in both Auckland and Tauranga. In Wellington there have been no significant road infrastructure projects over the period. Consequently, despite increased utilisation of New Zealand's urban road networks, the gaps in its urban arterial road systems have remained relatively unchanged for the past decade.

Currently, in New Zealand for a proposed road infrastructure project to proceed, the expected direct benefits (not including the flow on economy wide impacts) must exceed the costs by a factor of four. That is the project must have a minimum benefit cost ratio of 4 using standard cost benefit assessment techniques.

A benchmark benefit cost ratio of 4, calculated using a discount rate of ten per cent poses a very high hurdle rate for road infrastructure projects. This is despite the fact that there are ongoing costs (both direct and indirect) associated with putting-off certain projects. Such costs include, loss of economic output due to traffic congestion, road fatalities and increased legal and vehicle repair costs due to road crashes.

Figure 2.1

ROAD NETWORK CONNECTEDNESS – 1992 VS CURRENT

	1992	Current
Auckland		
Wellington		No significant change
Tauranga		

Source: New Zealand Automobile Association.

3. Evaluating Gains from Alternative Road Investments

3.1 Modelling Approach

To evaluate the economy wide implications of undertaking a number of proposed road infrastructure projects in Auckland, Wellington, Tauranga and in rural parts of New Zealand, the Energy Substitution, Social Accounting Matrix (ESSAM) model was has been used.

THE ESSAM MODEL

The Energy Substitution, Social Accounting Matrix (ESSAM) model is a computable general equilibrium model of the New Zealand economy. It takes into account all of the key inter-dependencies in the economy, such as flows of goods from one industry to another, plus the passing on of higher wage costs in one industry into prices and hence the costs of other industries.

It is useful to think of the model as simply a larger and more sophisticated form of cost-benefit analysis. However, traditional cost-benefit analysis is a partial equilibrium technique whereby variables and events which are defined as being outside the issue of interest are held constant or assumed unchanged. By contrast, in a general equilibrium model, all variables are allowed to change if they are impacted by a particular event or change in the economy. A general equilibrium approach is especially useful where one is concerned with issues that that have significant economy-wide, allocative efficiency effects

Some of the model's features are:

- 49 industry groups,
- Substitution between inputs into production - labour, capital, materials, energy; with energy split into coal, oil, gas and electricity, between which substitution is also allowed.
- Substitution between goods and services used by households.
- Social accounting matrix (SAM) for complete tracking of financial flows between households, government, business and the rest of the world.
- Taxes levied at the appropriate stage in the production process. For example GST is levied entirely on final demand, petrol taxes at the point of sale and so on.

The model's output covers the standard collection of macroeconomic and industry variables, including:

- GDP, private consumption, exports and imports, employment, etc.
- Demand for goods and services by industry, government, households and the rest of the world.
- Industry data on output, employment, exports etc.
- Import-domestic shares.
- Fiscal effects.

An additional advantage of using the ESSAM model is that its assumptions and input parameters are clearly transparent. All are open to amendment and revision where appropriate.

Further details about the ESSAM model and the assumptions that underpin it are provided in Allen Consulting and Infometrics (2004).

In addition to using a general equilibrium analysis to identify the economy wide impacts of the proposed road infrastructure this study has also undertaken a regional input-output multiplier analysis of the impacts on economic activity, jobs etc, in the three metropolitan regions of Auckland, Wellington and Tauranga. The benefits of an input-output framework include:

- it allows for a regional disaggregation of the economy wide impacts;
- it is consistent with, and complementary to, a general equilibrium analysis framework;
- it allows for a high degree of data confrontation, by analysing flows of products through the economy in a systematic way at the same time as analysing the incomes generated by economic activity; and

- it is recognised and used by Statistics New Zealand which compiles and publishes a snapshot of the size and industrial structure of the New Zealand economy by measuring the direct and indirect relationships between industries and commodities using an input output framework.

Combined, these two analytical approaches provide a comprehensive assessment of the economic impacts associated with undertaking the proposed road infrastructure projects at both the national and regional levels.

In order to compare the costs and benefits flowing from a project over time, it is necessary to bring them back to a common time dimension. For the purposes of this study a central discount rate of 8 per cent real has been used. The sensitivity of the results to changes in the discount rate has also been undertaken using real discount rates of 6 per cent and 10 per cent.

3.2 The Base Case

Like other computable general equilibrium models, the ESSAM model starts with a base case forecast of the economy at large.[4] The base case reflects expected outcomes in terms of value added, employment, sales, prices, imports and exports across the economy as a whole. It also reflects expected outcomes regarding the use of transport infrastructure by households and businesses. The taxing and spending activity of governments (including regional councils) is also included. Hence, the base case reflects expected outcomes regarding transport infrastructure spending by government. Adding these up forms a macroeconomic picture of the New Zealand economy, where the assumed scenarios do not occur.

Analysis is conducted by evaluating the changes in economic outcomes brought about by the construction of the identified road infrastructure projects in comparison to the base case. Results are reported as the net economic impact arising (i.e. an economic gain) from an assumed scenario relative to the base case (i.e. where the assumed scenario does not occur). For example, if a particular project were to result in GDP growing to $100.1 billion annually in 2012 relative to the base case forecast of only $100 billion, the results would be reported as a $100 million (or 0.1%) gain.

3.3 Roading Packages

Passing Lanes

The passing lanes package comprises 402 separate projects that are assumed to be delivering full benefits by 2012. The overarching purpose of the passing lanes project is to improve safety on a number of rural roads which are currently restricted and do not allow for safe overtaking of vehicles. This is to be achieved by constructing passing lanes every five kilometres on those roads (or sections of roads), which experience traffic volumes of between 4000 and 12000 vehicles per day.

[4] While the base case is intended to represent a plausible picture of the economy in 2012, it is not a forecast. Its role is to provide a basis for comparison so that we may ascertain the pure effects of the passing lanes package.

Auckland Western Ring Route Package

The Auckland western ring route package comprises seven linked projects, from Manukau in the south through Avondale on the western side of the CBD, to beyond Auckland's northern suburbs. Broadly speaking, the primary objective of this package of projects is to reduce inner city traffic and to increase the connectedness of Auckland's existing urban arterial road network.

Tauranga strategic roading network

The Strategic Roading Network is located in Tauranga and the surrounding Western Bay of Plenty sub region. It is a series of twelve inter-related projects, which will form a fast efficient ring road linking Tauranga, Mt Maunganui and the Port of Tauranga. The network includes high capacity feeder routes to the north, west and east. The strategic purpose of this proposed road network is to relieve congestion and accommodate future traffic growth in the Western Bay of Plenty region.

Wellington regional land transport package

The vision or ultimate goal of the Wellington regional land transport strategy is to achieve a balanced and sustainable land transport system that meets the needs of the general community. A balanced transport system is an integrated transport network with capacity balanced within and between each transport mode. A sustainable transport system is one that is environmentally and economically sustainable.

To achieve a balanced and sustainable transport solution for the region the Wellington Regional Land Transport committee has developed five key objectives:[5]

- Accessibility and economic performance
- Economic efficiency
- Affordability
- Safety
- Sustainability.

Direct impacts

Table 3.1 details the key characteristics of the four packages identified using standard benefit-cost analysis techniques. The total capital costs are estimated to be $2403m. Assuming a discount rate of 8 per cent, the annual benefits in 2012 are estimated to be $862m.

The Passing Lanes project has the highest benefit-cost ratio of 4.1, implying that, over the life of the project, for every dollar invested road users will receive $4.10 in benefits. On this basis alone the project should proceed.

That said, however, the above analysis does not take into account the allocative efficiency effects in the form of flow-on benefits from one industry to another. Accordingly, the benefit-cost ratios above understate the expected economic gains from undertaking the passing lanes project.

[5] Wellington Regional Land Transport Committee (1999).

Table 3.1

PROJECT KEY CHARCTERISTICS AND DIRECT IMPACTS

CHARACTERISTIC	Passing Lanes ($m)	Auckland Package ($m)	Tauranga Package ($m)	Wellington Package ($m)
Project costs				
Capital cost	213.5	1292.6	482.0	415.0
Annual financing charge at 6%	12.8	77.6	28.0	24.9
Expected direct impacts in 2012				
Reduction in loss of life and permanent disability	41.2	14.2	0.0	10.5
Reduction in health care costs	0.8	0.4	0.0	0.3
Reduction in travel time and congestion	80.8	379.8	245.7	62.7
Increase in vehicle operating costs	-2.4	10.2	6.0	7.1
Reduction in accident related costs	1.2	2.1	0.0	1.6
Net economic benefit in 2012	121.7	406.7	251.7	82.1
Benefit-cost ratio	4.1	2.3	3.7	1.4

Economy-wide impacts

Table 3.2 shows the results of running each roading package through the ESSAM general equilibrium model. More detail of the methodology is given in Appendix A, but briefly; reductions in business-related travel time and vehicle operating costs, together with reductions in health care costs (from fewer accidents) are incorporated into the model as increases in productive efficiency of various types. Lives saved, permanent disability avoided net of lost output, and reductions in travel time for leisure pursuits are not included in the model.

One way of expressing the total benefit to the economy is to add the change in GDP to the direct benefits that were excluded from the economy-wide model (i.e. the value of lives saved and permanent disability avoided net of the lost output and the value of travel time saved in relation to non-work travel). Doing this for the Passing Lanes project implies a net economy-wide benefit of $169.5 million annually in 2012. Using an 8 per cent discount rates reveals that the benefits of the passing lanes package exceeds its costs by a ratio of 5.7:1. Hence, for every $1 dollar invested in the passing lanes package, there will be additional benefits (both direct and indirect) worth $4.70.

For the other projects the same calculations yield:

- Auckland: $838m and benefit-cost ratio 4.6
- Tauranga: $439m and benefit-cost ratio 6.5
- Wellington: $149m and benefit-cost ratio of 2.6

Table 3.2

ECONOMY WIDE IMPACTS

MACRO ECONOMIC VARIABLE	Passing Lanes ($m)	Auckland Package ($m)	Tauranga Package ($m)	Wellington Package ($m)
Consumption				
Private Consumption	70	363	175	68
Government Consumption	-13	- 6	0	-5
Total consumption/ capita ($)	13	84	41	15
Investment	18	111	54	20
Trade				
Exports	51	282	137	50
Imports	36	196	96	35
Output				
GDP	94	567	278	100
GDP/capita ($)	22	133	65	23
Real wage rate (index)	1.512	1.507	1.510	1.513
Household income tax	-74	-281	-143	-40

MACRO ECONOMIC VARIABLE	Passing Lanes (%Δ)	Auckland Package (%Δ)	Tauranga Package (%Δ)	Wellington Package (%Δ)
Consumption				
Private Consumption	0.07	0.37	0.18	0.07
Government Consumption	-0.04	-0.02	0.00	-0.02
Total consumption/ capita ($)	0.04	0.28	0.14	0.05
Investment	0.05	0.27	0.13	0.05
Trade				
Exports	0.08	0.46	0.22	0.08
Imports	0.06	0.32	0.16	0.06
Output				
GDP	0.06	0.33	0.16	0.06
GDP/capita ($)	0.06	0.28.	0.16	0.06
Real wage rate (index)	-0.13	-0.46	-0.20	-0.07
Household income tax	-0.17	-0.79	-0.42	-0.13

The economy-wide gains expected from undertaking all four proposed road infrastructure projects are shown in Table 3.3. The modelling suggests that completing this set of proposed land transport packages will result in substantial economy wide gains to New Zealand. This is indicated by:

- an increase in GDP of $1.0 billion in 2012. This is equivalent to a net increase in per capita GDP of around $243. In other words, if the proposed set of land transport projects were to be undertaken as modelled, each person in New Zealand would be better off by $243 in 2012;

- an increase in private consumption of around $670 million in 2012. This is equivalent to per capita increase of $153 in 2012;
- a net increase in aggregate investment of $203 million (0.5 per cent) in 2012;
- a net reduction in the household tax rate. The magnitude of this reduction implies that on average of each household in New Zealand will pay $359 per year less tax; and
- an increase in net exports of $158 million in 2012 reflecting the increased international competitiveness of New Zealand's industries.

Note that the above impacts are all *ongoing* changes (relative to the base case), at annual rates.

In addition to the economy-wide impacts there are substantial direct benefits not factored into the general equilibrium modelling. These benefits include the value of lives saved and permanent disability avoided (net of the lost output included in the economy wide modelling) plus the value of travel timed saved for non-work purposes. Adding these direct benefits to the estimated economy wide benefits suggest that the set of proposed road transport infrastructure packages would result in total benefits to the New Zealand economy worth $1.6 billion in 2012 – see Table 3.4. This is equivalent to almost one per cent of GDP, or alternatively in 2012 each person in New Zealand would be better off by $375.

Using an eight per cent discount rate suggests that the aggregate benefit cost ratio for the set of proposed road transport infrastructure packages is 4.75.. The sensitivity of each of the four projects to changes in the discount rate is shown in Table 3.4

Table 3.3

ECONOMY WIDE IMPACTS OF UNDERTAKING ALL PROPOSED ROAD INFRASTRUCTURE PACKAGES

MACRO ECONOMIC VARIABLE	Net impact ($ M)	Per cent change (%)
Consumption		
Private Consumption	676	0.69
Government Consumption	-23	-0.08
Total consumption/ capita ($)	153	0.51
Investment	203	0.50
Trade		
Exports	520	0.85
Imports	362	059
Output		
GDP	1039	0.61
GDP/capita ($)	243	0.61
Real wage rate (index)	1.501	-0.86
Household income tax	-538	-1.50

Table 3.4

BENEFITS OF ROAD INFRASTRUCTURE INVESTMENT

	Passing lanes package	Auckland western ring road package	Tauranga strategic road network	Wellington regional land transport package	Total impact
Costs					
Initial capital cost	213.5	1292.6	482.0	415.0	2403.1
Annual finance cost	12.8	77.6	28.9	24.9	144.2
Benefits					
Direct	121.7	406.7	251.7	82.1	862.2
Economy wide	169.5	838.0	439.7	148.7	1599.5
BCR					
6 per cent	6.6	5.4	7.6	3.0	5.6
8 per cent	5.7	4.6	6.5	2.6	4.8
10 per cent	5.0	4.1	5.7	2.2	4.2

3.4 Regional impacts

Given that the passing lanes package is not concentrated in one region of the country it is difficult to estimate the distribution of benefits that would result from undertaking each of the 402 individual projects. While the economic benefits of each of the separate projects may accrue largely to the regions concerned, the distribution of benefits could be quite diverse and very project specific, depending on the location and class of road. A reasonable inference is that if the 402 separate projects are distributed throughout the country approximately in proportion to the distribution of economic activity, then the benefits are likely to be similarly distributed. A more precise estimation would require more knowledge on each individual project.

The Auckland region is expected to receive the greatest share of the total benefits accruing from the Auckland Western Ring Route Package. Regional economic multiplier analysis suggests that Auckland will gain a net regional benefit of $741.1 million in 2012. This consists of:

- an annual increase in regional GDP of $425.4 million in 2012:and
- an annual benefit of $315.6 million reflecting benefits associated with avoided loss of life and permanent disability and non-work related travel time savings.

Given that the Tauranga strategic roading network has a specific regional focus of Tauranga and the Western Bay of Plenty, it is no surprise that the majority of the total benefits will accrue locally. It is estimated that Tauranga and the Western Bay of Plenty will gain a net regional benefit of $372.7 million in 2012. This consists of:

- an annual increase in regional GDP of $186.1 million in 2012:and
- an annual benefit of $186.6 million reflecting benefits associated with avoided loss of life and permanent disability and non-work related travel time savings.

It is no surprise that the Wellington region will receive the lion share of the total benefits accruing from the Wellington regional land transport package. Regional economic multiplier analysis suggests that Wellington will gain a net regional benefit of $128.5 million in 2012. This consists of:

- an annual increase in regional GDP of $69.7 million in 2012:and

- an annual benefit of $58.8 million reflecting benefits associated with avoided loss of life and permanent disability and non-work related travel time savings.

The detailed calculations for estimating the regional economic impacts are set out in Appendix B.

3.5 Industry impacts

Each of the four proposed road infrastructure projects will result in a degree of structural change to the New Zealand economy. This means that some sectors of the economy will expand and displace the activity of other sectors.

The main sectors that are likely to expand as a result of undertaking the proposed road infrastructure projects are those industries that benefit from increased labour productivity arising from shorter travel times. These industries include basic metal manufacturing, other mining and quarrying and structural, sheet and fabricated metal production. Table 3.5 ranks the highest 10 industries in terms of their 2012 output results.

On the flip side some industries may experience some displacement. That is, those industries that provide services that are replaced by greater utilisation of road transport may be worse-off. It should be noted, that although these industries are likely to see less activity than otherwise, they might still grow in absolute terms. Similarly, other industries such as hospitals, nursing homes and community care may be disadvantaged due to fewer road crashes arising from safer roads.

As detailed in Table 3.6 it is expected that, if all of the proposed road infrastructure projects are undertaken, only 5 of the 49 industries analysed would experience displacement in 2012.

3.6 Summary

The main conclusion from the analysis is that there are substantial net economic gains available from investing in New Zealand's land transport infrastructure. These gains accrue not only to the economy as a whole but for three of the four packages modelled, significant benefits are likely to accrue to specific regions, namely Auckland, Wellington, Tauranga and the Bay of Plenty.

Similarly, the majority of New Zealand's industries are likely to also benefit directly due mainly to increased productivity arising from work related travel time savings. This in turn is likely to enhance the international competitiveness of New Zealand's industries and the economy as a whole. This is reflected by a significant increase in net exports.

These gains tower over the initial investment costs required to finance the proposed infrastructure. Moreover, this is the case if the set of proposed road infrastructure packages are undertaken individually or in aggregate.

Table 3.5

INDUSTRY OUTPUT: RANKING OF HIGHEST 10 (% DEVIATION FROM BASE CASE)

Industry	Passing lanes package	Auckland western ring route package	Tauranga strategic network	Wellington regional transport package	Total
	(%)	(%)	(%)	(%)	(%)
Basic metal manufacturing	0.38	2.23	1.09	0.39	4.08
Other mining & quarrying	0.26	1.56	0.76	0.28	2.86
Structural, sheet & fabricated metal products	0.20	1.16	0.57	0.20	2.13
Paper and paper product manufacturing	0.20	1.12	0.55	0.19	2.05
Gas supply	0.18	1.03	0.50	0.17	1.89
Chemical and chemical products	0.17	0.99	0.49	0.17	1.82
Road transport	0.22	0.86	0.47	0.23	1.78
Forestry & logging	0.16	0.92	0.45	0.17	1.70
Printing, publishing etc	0.15	0.88	0.43	0.15	1.62
Electricity generation	0.13	0.78	0.38	0.14	1.43

Table 3.6

INDUSTRY OUTPUT: RANKING OF LOWEST 10 (% DEVIATION FROM BASE CASE)

Industry	Passing lanes package	Auckland western ring route package	Tauranga strategic roading network	Wellington regional transport package	Total
	(%)	(%)	(%)	(%)	(%)
Dairy product manufacturing	0.05	0.24	0.12	0.04	0.44
Government administration & defence	0.05	0.22	0.11	0.04	0.41
Water supply	0.03	0.19	0.09	0.03	0.35
Construction	0.01	0.10	0.05	0.02	0.18
Medical, dental & other health services	0.01	0.04	0.02	0.01	0.08
Ownership of owner-occupied dwellings	0.00	-0.03	-0.02	0.00	-0.04
Pre-school, primary, secondary & other education	-0.01	-0.10	-0.05	-0.02	-0.17
Post-school education	-0.02	-0.13	-0.07	-0.02	-0.24
Hospitals, nursing homes, community care	-0.19	-0.12	-0.01	-0.07	-0.39
Water and rail transport	-0.17	0.04	-0.09	-0.17	-0.40

References

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Wellington Regional Land Transport Committee (1999): The Wellington Regional Land Transport Strategy 19999-2004, Wellington.

Appendix A: Direct impacts

Data and information sources

In order to model the economy-wide effects of each of the four case studies, it was necessary to identify their expected direct impacts. This was done using a number of specific data and information sources including:

- data relevant to the eleven projects in the Blenheim-Kaikoura region were used to model the expected direct impacts associated with the passing lanes package. These data were sourced from Transit New Zealand and the New Zealand Automobile Association;
- for the Auckland western ring road package the cost and benefits associated with each of the individual projects were sourced from Transit New Zealand and the New Zealand Automobile Association;
- information relevant to the Tauranga strategic roading network was obtained from Transit New Zealand, Tauranga City and the New Zealand Automobile Association; and
- information relevant to the Wellington regional land transport package was sourced from Transit New Zealand, the Wellington Regional Council and the New Zealand Automobile Association.

It is assumed that each of the packages modelled will be delivering full benefits by 2012.

Impacts

The ESSAM model deals principally with the Production Account within the System of National Accounts. It also includes the major components of the Income and Outlay Account. It does not, however, include non-economic costs. Accordingly, not all aspects of identified benefits from the proposed projects are suitable for inclusion in a general equilibrium model. Such benefits include compensation for pain and suffering, the value of travel time for non-work purposes and the value of life.

To over come this, identified benefits were disaggregated into economic and non-economic components. For example accident savings were broken into loss of life and permanent disability, health care, vehicle repairs and legal services. Moreover assumptions were made in relation to value of total travel time for non-work purposes such as recreation and education.

A breakdown of the identified direct impacts of each project in 2012 is provided in Table A.1.

Each of the identified model inputs and their underlying assumptions are discussed below.

Accident savings

For the each of the projects modelled the number of road fatalities prevented and injury time avoided are expressed as person-year equivalents.

For the passing lanes project it is estimated that in 2012, approximately 292 extra people will be alive, and 95 cases of significant injury and 175 cases of minor injury will be avoided (spread across all age groups). This is the aggregate impact of accident savings between now and 2012.

This is equivalent to 303 person years of time of which 122 person years are attributed to economic activities (paid work in the market economy).

Table A.1

AGGREGATE DIRECT IMPACTS

	Passing lanes package ($M)	Auckland western ring road package ($M)	Tauranga strategic road network ($M)	Wellington regional land transport package ($M)
Total capital cost	213.5	1,292.6	482.0	415.0
Total economic benefits	80.5	392.5	251.7	71.6
Total non-economic benefits	41.2	14.2	0.0	10.5
Total benefits	121.7	406.7	251.7	82.1

Travel time saved

For the purpose of the model, travel time is broken down into work related and non-work related purposes. Travel, which is not work related, is considered to be non-economic in nature and therefore the value of the benefits associated with non-work related travel time-savings do not serve as a model input. Savings in work-related travel time are treated as improvements in labour productivity and, in the absence of being provided with any better information, are distributed by industry according fuel use.

Direct economic impacts associated with each of the projects are detailed in Table A.2.

Table A.2

TRAVEL TIME SAVINGS

	Passing lanes package Total person hours	Auckland western ring road package Total person hours	Tauranga strategic road network Total person hours	Wellington regional land transport package Total person hours
Work	2.4	10.8	4.7	1.4
Commuting				
Work related	0.3	5.1	3.2	2.4
Non work related	0.3	5.1	3.2	2.4
Other	3.3	29.4	12.1	3.5
Total	6.2	50.4	23.2	7.6
Work-related travel as a Proportion of total time (%)	43.5	31.5	34.1	49.3

Vehicle operating costs

Net savings in vehicle operating costs include changes in the cost of fuel use and vehicle repair costs that result from changes in travel behaviour. Savings in vehicle operating costs are modelled as efficiency improvements with respect to inputs of these services into production and private consumption.

The assumed vehicle operating costs for each of the projects modelled are shown in Table A.3.

Table A.3

CHANGES IN VEHICLE OPERATING COSTS

	Passing lanes package ($M)	Auckland western ring road package ($M)	Tauranga strategic road network ($M)	Wellington regional land transport package ($M)
Net change	(2.4)	10.2	6.0	7.1

Project financing costs

For the purpose of this study it has been assumed that each of the modelled projects will be financed by government debt. Government will necessarily incur an annual financing charge as a result of taking on additional debt, which will be met, via the increases to personal income tax. That is, the construction of the additional road infrastructure will be financed through income tax.

It should be noted that the expected savings in health care costs would provide some offset to the required increase in tax rates.

Table A.4 details the expected annual finance charge associated with each of the modelled projects. These have been calculated using an interest rate of 6 per cent.

Table A.4

EXPECTED ANNUAL FINANCE CHARGES

	Passing lanes package ($M)	Auckland western ring road package ($M)	Tauranga strategic road network ($M)	Wellington regional land transport package ($M)
Annual cost	12.8	77.6	28.9	24.9

Other impacts

Other costs and benefits that are likely to arise directly from undertaking the proposed road infrastructure projects include health care and legal costs.

Savings in health care costs are modelled as a reduction in government spending together with a change in the composition of government spending away from health care services. Changes in health care costs are a direct result from changes in the number of road accidents that result in hospitalisation and ongoing health care.

It is assumed that changes in legal costs result from changes in accident rates. Specifically, a reduction in road crashes is expected to result in fewer insurance claims involving legal processes as well as less litigation.

The expected changes in health care and legal costs for each of the four road infrastructure packages is shown in Table A.5

Table A.5

CHANGES IN OTHER COSTS

	Passing lanes package ($M)	Auckland western ring road package ($M)	Tauranga strategic road network ($M)	Wellington regional land transport package ($M)
Reduction in vehicle repair costs	1.0	2.0	0.0	1.5
Health care savings	0.8	0.4	0.0	0.3
Reduction in legal costs.	0.2	0.1	0.0	0.1

Direct impacts not modelled

Using standard quantitative techniques the avoided loss of economic value (i.e. GDP) associated with reducing loss of life and permanent disability can be estimated. While these impacts are not used as inputs into the ESSAM modelling they are accounted for when calculating the both the net economy-wide total benefit and the corresponding benefit-cost ratio for each project.

For each of the projects modelled, the estimated value of avoided economic loss associated with reducing loss of life and permanent disability is shown in table Table A.6.

Table A.6

EXPECTED AVOIDED LOSS OF ECONOMIC VALUE

	Passing lanes package ($M)	Auckland western ring road package ($M)	Tauranga strategic road network ($M)	Wellington regional land transport package ($M)
Avoided loss of economic value	12.5	2.7	0.0	2.1

Other relevant assumptions

To ensure that the ESSAM model captures only the gains from improvements in allocative efficiency, total employment is held constant, apart from the increment that is assumed to arise directly from the roading package. Total capital stock utilisation is also held constant. These two assumptions mean that the benefits from the package will be understated to the extent that improvements in roading infrastructure lead to more efficient investment decisions (by the private sector) that raise the long-term rate of economic growth.

Appendix B: Regional impacts

Three of the four proposed road infrastructure packages have a specific regional focus, implying that most of the economy-wide effects from these packages are in fact likely to occur in the respective regions. For this reason, it is useful to estimate the proportion of the national benefits that will occur locally for the Auckland, Bay of Plenty and Wellington packages.

Ideally, this would be assessed with regional general equilibrium models, however such models do not exist and their development is beyond the resources of this research project. Instead, regional economic activity multipliers have been used. These multipliers are derived from regional inter-industry tables.

Regional economic multipliers

Economic multipliers estimate the indirect effects on output required to meet the requirements of a unit increase in demand. Broadly speaking there are two types of regional multipliers:

- *Type I multipliers* capture upstream effects; for example the energy required to meet an increase in demand for furniture; and
- *Type II multipliers* subsume Type I multipliers and also incorporate the effects of the induced demand that comes from increased expenditure by households. For example, employees in the furniture and energy industries will earn income that will be spent on other goods and services.

Given their wider ambit Type II multipliers are a better approximation of the general equilibrium effects than the Type I multipliers. That said however, it is important to note that Type II multipliers do not take into account the following effects:

- increased capital formation that might be required to increase industry output;
- increased exports that might be required to purchase the additional imports needed by industry to increase output – in the presence of a macroeconomic balance of payments constraint; and
- expenditure by government using revenue raised from taxation.

Exclusion of these effects suggest that Type II multipliers are likely to under or over-estimate the full range of general equilibrium effects.[6]

Calculating the regional impacts

Calculating the regional impacts arising from each of the three relevant road infrastructure packages involves the following steps:

Step 1 — Estimating the degree of over/under estimation

In order to ascertain the degree of over-estimation or under-estimation by regional Type II multipliers, we firstly compare the results from the ESSAM model with those obtained by applying Type II multipliers for New Zealand as a whole to each of the three road infrastructure packages.

[6] The extent to which Type II multipliers either under or over-estimate the full range of flow-on effects that arise from a given economic shock is an empirical question, specific to that shock and how it is simulated within a general equilibrium model.

Step 2 — Estimating the regional flow on effects

As noted above, multipliers apply to a given economic shock. For the each of packages considered the shocks have two main components: the reduction in vehicle operating costs and accident costs, and the reduction in labour demand (increase in labour efficiency) arising from lower travel times. In the first instance both are negative shocks, so multiplier analysis estimates the direct and indirect effects of a lower level of expenditure. In reality though, trade diversion occurs whereby resources saved in servicing motor vehicles or operating transport fleets, can be reallocated to other uses as dictated by consumer preferences – allocative efficiency at work. Hence the analysis can be undertaken in two ways:

Method 1 — estimate the flow-on effects of the negative shocks, as a proxy for the value of the liberated resources that can now be used elsewhere in the economy. The inputs into this calculation are the same as the inputs used for the general equilibrium modelling, excluding the additions to the labour force from lives saved. That is, output shocks are imposed on:

- the Petroleum, Rubber, Retail Trade and Health industries to capture changes in vehicle operating costs and accident costs,
- all industries in accordance with the productivity benefits arising from lower travel times.

Method 2 — estimate the flow-on effects of the new activities into which the liberated resources may flow. Of course at the regional level it is not known which new activities would materialise, but we can approximate this by the change in the mix of domestically supplied final demand that occurs in the general equilibrium model. Thus the inputs into this calculation have the same dollar value as in method 1, but rather than distributing them in the manner of method 1 they are distributed according to the change in the industry mix of final demand in the ESSAM model runs.

Step 3 — Adjusting the regional impacts for over/estimation

The estimated level of under or over-statement produced by the multiplier methodology at the national level is applied to the regional impacts calculated in step 2. For example for the Auckland package it is estimated that the Type II multiplier analysis over estimates the economic impacts by around 6.5 per cent. Applying this to the estimated regional impacts suggests an adjustment of around $36.8 million (i.e. from $603.6 million to $566.8 million).

Step 4 — Accounting for non- economic impacts

The general equilibrium analysis excludes both non-work related travel time and loss of life and permanent disability. It is reasonable to assume that virtually all of these benefit would accrue to the residents of the local region. Accordingly, these non-economic benefits are added to the regional economic impacts calculated in steps 1 to 3.

Each of the step-by-step calculations for estimating the regional impacts associated with each of the three road infrastructure packages are detailed in Table B.1.

Table B.1

ECONOMIC IMPACT ON REGIONAL GDP

	Auckland	Bay of Plenty	Wellington
Change in GDP (from ESSAM model)	566.8	277.6	102.5
Type II effect for New Zealand			
Method 1	608.2	300.7	109.4
Method 2	599.0	297.2	108.3
Average	603.6	298.9	108.86
Degree of under/over estimation	6.5%	7.7%	6.2%
Type II effect for region			
Method 1	461.9	203.9	76.0
Method 2	448.1	199.3	72.6
Average	455.0	201.6	74.30
Scaled effect on regional GDP	425.4	186.1	69.7
Loss of life, permanent disability and other travel time benefits	315.6	186.6	58.8
Total regional benefit	**741.1**	**372.7**	**128.5**