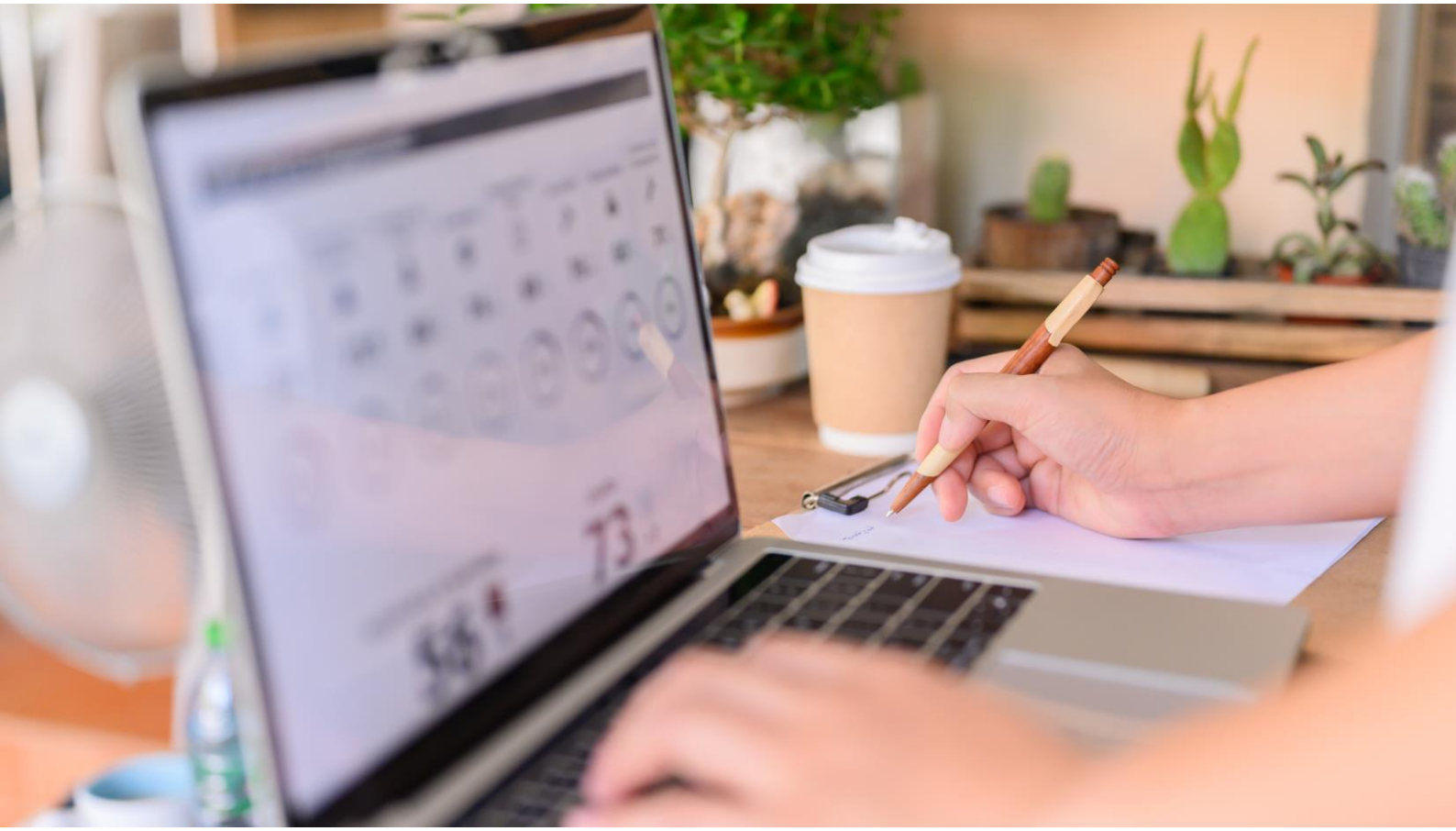

What difference can a day make?

Scoping the effects of a four-day commute

NZIER report to AA Research Foundation

September 2020

About NZIER

NZIER is a specialist consulting firm that uses applied economic research and analysis to provide a wide range of strategic advice.

We undertake and make freely available economic research aimed at promoting a better understanding of New Zealand's important economic challenges.

Our long-established Quarterly Survey of Business Opinion (QSBO) and Quarterly Predictions are available to members of NZIER.

We pride ourselves on our reputation for independence and delivering quality analysis in the right form and at the right time. We ensure quality through teamwork on individual projects, critical review at internal seminars, and by peer review.

NZIER was established in 1958.

Authorship

This paper was prepared at NZIER by Christina Leung and Michael Bealing.

It was quality approved by Gareth Chaplin.

The assistance of John Davies, Jojo Valero, Eddie Dolan, Chamika de Costa, Paula O'Kane, John Kinghorn, Patrick Ongley and Daniel Griffiths is gratefully acknowledged.

Key points

The AA Research Foundation has asked NZIER to undertake a scoping study to analyse the potential effects of a 4-day commute each week. The analysis we have scoped explores the effects on road safety, carbon emissions, economic and productivity performance, and congestion.

Key aspects that merit consideration in the project design

- Working from home means less travel, but not necessarily no travel on the day spent working from home. A study into telecommuting showed that travel on that day decreased by 94% suggesting an increase in other forms of travel on the day spent working from home (van Lier et al., 2012).
- The effects of reduced travel demand are likely to be non-linear, due to the non-linear impacts of congestion on travel speeds.[1] This highlights the importance of investing in thoughtful and sophisticated travel demand modelling for the full analysis of the effects.
- Induced travel demand is likely to erode the gains from a four-day commute over time, as reduced congestion encourages people to travel. This needs to be considered in the modelling of transport demand and economic shock design.
- Understanding the fiscal implications for infrastructure should be made a priority if the potential for the uptake of the four-day commute is shown to be material. A reduction in travel demand could have implications for infrastructure investment demand and the supply of hypothecated transport revenue. A change in infrastructure investment and spending on fuel should be considered as a potential part of the economic modelling. The implication for infrastructure investment was not included in the scope of our previous research on the benefits of decongestion in Auckland due to resourcing limitations, but it was recommended as a worthwhile next step (Leung et al., 2017).

[1] That is, a reduction in off-peak travel is unlikely to have a major impact on travel time during at period.

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1 Introduction

The AA Research Foundation commissioned NZIER to scope a research project about the potential effects of shifting from a five-day commute to a four-day commute each week.

The research began before the implications of COVID-19 on working from home were realised. COVID-19 is not the subject of this report, but the discourse and emerging research on working from home due to the pandemic is of great interest. It emphasises the value of a better understanding of the diverse and complex effect of a potential shift towards working from home more frequently.

1.1 What is a four-day commute?

At the beginning of the scoping project the four-day commute was defined as employees shifting from the traditional five-day commute to the workplace each week, to a four-day commute week with the fifth day worked from home. Under a four-day commute week the hours worked is expected to be the same relative to the traditional five-day work week, but the quantity of travel for commuting to work is 20% lower due to one day a week spent working from home.

Conceptualising the four-day commute as a 20% decrease in travel journey to work each week is helpful, because it is useful for dealing with non-traditional commuting and employment patterns, such as part-time work. Nevertheless, from the outset of this scoping project it becomes clear that straightforward linear definitions of commuting behaviour are much more complex in reality. This will be explored further in the report as we discuss the research question and scope.

1.2 What was the initial scope?

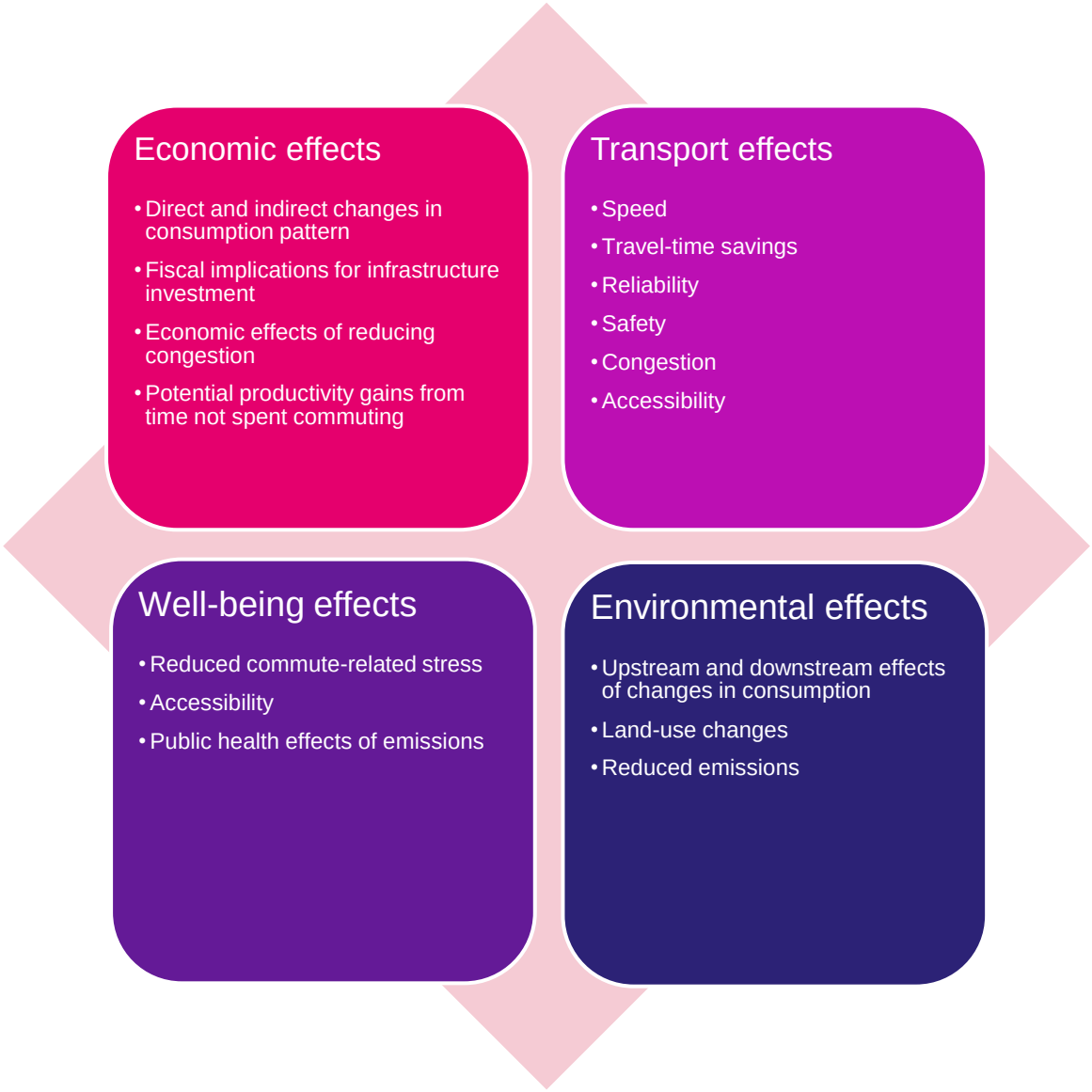
It is common for the scope of a research project to evolve in the exploratory phase. Hence it is important to document the initial scope as we explore different aspects of the research.

The initial scope for this scoping exercise was the transport impacts from employees shifting from a traditional five-day commute to the workplace each week, to a four-day commute week with the fifth day worked from home. Those effects can be summarised by the categorisation shown in Figure 1.

This approach echoes the four capitals approach (economic, natural, social and cultural) often used by the Treasury (New Zealand Treasury, 2018). Such categorisations are useful in setting up a framework to show the complexity of the different impacts, which are often inter-related. However, the impacts are not compartmentalised. For example, congestion affects the speed of travel, travel times, fuel consumption, emissions, and health outcomes.

Figure 1 Framing the impacts of a four-day commute

Stylised representation of the areas of interest at initial scoping



Source: NZIER

2 Literature review

2.1 Literature review approach

The literature review was an iterative process. The scope of the literature review was informed by the following:

- Any directions, specific requests or literature items provided by the client
- Content of the desired/relevant material – e.g. descriptive, evaluative, data-based etc.
- Nature of the publications – published/grey literature; date of publication (e.g. post 2005); language (e.g. in English only)
- Relevant websites and databases – such as the International Transport Forum, Transport Research Board, NZTA Research Report Databases, ScienceDirect, JSTOR
- No exclusion criteria were used or deemed relevant.

The search was based on the following keywords and phrases:

- Congestion
- Working from home
- Telecommuting
- Four-day work week
- Compressed work week
- Demand management
- Accessibility
- Remote working
- Future of work
- Transport disadvantage
- Urban sprawl.

Initial keywords are selected based on the topic of the search. However, once searching begins new keywords/phrases that are also appropriate are often identified and included in subsequent searching. This ensures our literature review captures the wide range of research that considers a 4-day commute week in some form .

2.2 Transport effects

The transport effects of congestion and reducing it have been the focus of much analysis

NZIER's report on the benefits of decongestion in Auckland (Leung et al., 2017) covered this literature in some detail. The impacts are summarised in Table 1. There is an overlap between the transport and economic impacts of reducing congestion, largely reflecting the productivity gains brought about by the travel time savings.

Table 1 Summary of the effects of decongestion

Based on the literature in NZIER's prior research

Sector	Benefits	Costs
Effects for business	Increased productivity in freight labour and capital More reliable delivery times Better margins Fewer delivery vehicles needed Decreased vehicle operating costs Productivity flow-on gains for industries that use transport as an input Improved access to international markets and trade hubs (through airports and ports) Fewer freight and package depots required Better land use for given fewer supply chain depots required Reduced exposure to road accidents	
Commuter and households	Labour supply increases Improved skill-job matching Can travel greater distance in same amount of time, which can improve housing options More discretionary spending given reduced spending on transport Decreased vehicle operating costs Reduced exposure to road accidents	Greater travel distances may encourage urban sprawl

Source: Leung et al., 2017

The value of reducing congestion is non-linear

Other studies show that in a highly congested network the impacts of congestion on travel demand can become non-linear. For example, Anderson (2014) investigated how public transport breakdowns affect peak commuter congestion. They found that a breakdown in public transport has a non-linear effect on congestion, hence the changes in congestion would be greater than what a linear projection would predict. This points to the importance and value of investing in well thought-out and sophisticated traffic modelling as part of the research plan, to ensure we have a sensible starting point at which to base the analysis on.

Working from home means less travel, but not necessarily no travel

Transport experts and infrastructure providers have been interested in demand management and the potential for working from home for some time as a potential solution to manage congestion and infrastructure spending.

The key questions for any analysis of the effects of working from home are:

- Does working from home affect transport and travel patterns?
- Do people still travel even when they are not commuting?

In a paper analysing telecommuting patterns in Brussels, Lier, De Witte, and Macharis (2012) surveyed people that opted to work from home (WFH) or work in a satellite office rather than commuting to the headquarters. They found that 13% of those that worked from home still completed some form of travel. Of this 13%, that distance travelled was equivalent to

42% of the commute travel. This implies working home may reduce travel distance by around 94%, but not a 100%, as people substitute commuting with other forms of travel.

Such survey results indicate that the proposed research on a four-day commute should consider ways to capture a partial reduction in travel demand. Two potential ways to approach this include:

- Specific surveys to collect timely and relevant primary data from Auckland commuters on their intended changes in travel patterns as a result of moving to a 4-day commute.
- Sensitivity analysis involving different scenarios around the level of travel reduction as a result of moving to a 4-day commute.

The first solution will yield richer evidence-based data rather than relying on different sets of assumptions, but will require investment of resources and time. The second solution is somewhat arbitrary depending on the assumptions used. These assumptions will be based on literature findings, where available, and is relatively inexpensive. But it is not necessarily representative of what Aucklanders might do. This is a classic trade-off between robust evidenced-based research and more cost-effective analysis based on a set of assumptions. Ideally, the first solution would be invested in as it would yield findings which would be more relevant for Auckland.

van Lier et al.Lier, De Witte, and Macharis (2012) also considered the effect of commuting mode choice on the reduction in externalities from working from home. They found that in general the size of the external cost depends on the proportion of the commuting trips that are undertaken by car. The more those private vehicle trips can be replaced by working from home or in a satellite office, the greater the external cost savings will be.

2.3 Economics effects

The economic effects of a four-day commute fall into three main areas:

- Direct and indirect changes in consumption patterns
- Fiscal implications for infrastructure investment
- Economic effects of reduced congestion.

2.3.1 Direct and indirect changes in consumption patterns

We found little research that looked at the effects of working from home on consumption patterns. The literature we reviewed suggests that:

- Spending on fuel reduces in proportion to the decrease in commuting
- Household spending on energy and food at home increases
- Spending on goods purchasing may not change due to the advent of online shopping.

This area probably needs further investigation in the project, but it suggests a multi-faceted modelling approach that includes:

- A decrease in fuel spending
- An increase in household energy and grocery spending
- A decrease in spending on parking and convenience food and coffee

- An increase in online shopping related output, such as courier services.

Investigating the macroeconomic and microeconomic effects of such a scenario is possible using a computable general equilibrium model.

2.3.2 Fiscal implications for infrastructure investment

Travel demand and the associated congestion is a contributing factor in decisions to invest in expanding infrastructure. It is perfectly possible that a significant uptake of the four-day commute could slow the demand for infrastructure expansion and defer investment by more than a year. This could have fiscal implications for the preparation of infrastructure budgets over multiple periods.

Understanding the fiscal implications for infrastructure demand should be made a priority if the potential for the uptake of the four-day commute is shown to be material.

The potential for infrastructure investment savings from a decrease in travel demand due to a material uptake in the four-day commute is only half the funding story. The other half of the story is the potential impact on revenue. Transport revenue is largely generated from transport demand related to the consumption of fuel. Revenue from public transport fares will also decline as a result of reduced transport demand. So, while there will be a reduction in transport demand from a four-day commute there will also be a reduction in transport demand-related revenue. The net effect of a four-day commute is likely to be revenue neutral for the Government, as the reduction in transport demand-related revenue offsets the reduction in transport-related infrastructure spending.

Nevertheless, the flow-on effects of delaying infrastructure will impact heavy and civil construction activity in the first instance and flow on to the wider economy.

2.3.3 Economic effects of reducing congestion

Congestion affects economic and employment growth trajectories

Congestion can have a dampening effect on employment in large cities, acting as a barrier to economic growth. Hymel (2009) found that while congestion can dampen economic growth trajectories, policies such as infrastructure expansion or congestion pricing can be effective in reducing congestion, restoring economic growth and employment growth in large cities. They estimate the annualised elasticity of employment growth with respect to per capita hours of travel delay is −0.02. Hence reduced congestion has positive outcomes for the labour market.

Congestion patterns influence location decisions in supply chain management

Congestion has a material effect on the performance and reliability of supply chain management. As result, congestion is a factor in management decisions about the location of supply chain facilities

A New Zealand based study (Sankaran et al., 2005) found the effect of congestion on businesses varies depending on the nature of the market of the business including the input materials, the characteristics of the products, and the location of the production and storage. Congestion is often an amplifier of delays and costs. This result is consistent with international evidence of the impacts of congestion on strategic business decisions that can have long lasting effects (Konur & Geunes, 2011). Location decisions are reasonably rigid, so

the effects of a four-day commute on congestion would need to be lasting to effect location choices and the estimating the future effects would be limited to simulations.

2.4 Well-being effects

Research on the potential effects on well-being can be classified into these main areas:

- Reduced commute-related stress
- Accessibility and transport disadvantage
- Public health effects of congested-related emissions
- Other well-being benefits.

2.4.1 Congestion-related stress

Traffic congestion is associated with increased stress levels

International studies indicate the traffic congestion is associated with stress levels and may increase work-related stress levels (Hennessy et al., 2000).

Christian (2012) showed that a congested commute, with a longer duration, was associated with sleep deprivation, stress and worse health outcomes. So, it is plausible that a reduction in travel and/or traffic congestion due to shift to a four-commute could reduce stress and improve well-being. This area would be worthwhile exploring in the project and especially the literature review. For the changes in congestion-related stress to be evaluated, two forms of information would be required:

- Evidence of the baseline level of traffic congestion-related stress in New Zealand.
- The dose-response relationship between changes in congestion level and the resulting change in stress levels.

Whether there is a sufficient evidence base for traffic congestion-related stress in New Zealand analysis to be carried out needs careful consideration.

2.4.2 Accessibility and transport disadvantage

There is also a body of research on transport disadvantage and accessibility (Dodson et al., 2004 and Bealing, 2016), including but not limited to accessibility among people with disabilities and the ageing population. While this area of research is less technical than the spatial mismatch literature, it does provide a rich qualitative insight into the causes and effects of transport disadvantage.

The transport disadvantage literature will add contextual insights to the thinking about the question of who is able to WFH.

Accessibility is a concept used in the disability discourse in relation to the social model of disability and barrier imposed by society on people with disabilities (Casas, 2007). Congestion and congestion-related stressors can compound the effects of limitations in transport accessibility for people with disabilities in the following ways:

- Intensifying the challenges in using public transport which can be crowded at peak times.
- Increasing the cost of taxi services due to increased travel time and surge pricing.

- Amplifying the limitations and constraints felt by the person with a disability (Clery et al., 2017and Hunt, 2018).

2.4.3 Other well-being effects

There is some evidence that working from home improves relationships and task sharing

The empirical literature on working from home suggest there are likely to be improvements on work-life balance. Dockery and Bawa (2018) completed a multivariate analysis of panel data from 2001 to 2013 on the impacts of working from home. They found evidence that working home can improve household relationships and support more equitable sharing of household/childcare tasks.

2.4.4 Public health effects of congested-related emissions

Congestion is associated with increased morbidity and premature mortality. Congestion-related impacts from $PM_{2.5}$ emissions from vehicle have been found to be associated with increased morbidity and premature mortality, and the effects are significant enough for congestion to be considered a key factor in public health (Levy et al., 2010). The have been two major studies that considered the impacts of air pollution, including transport emissions, on health outcomes – HAPINZ 2007 (Fisher et al., 2007) and HAPINZ 2012 (Kuschel et al., 2012). A third HAPINZ study is underway.[2]

The New Zealand-based evidence indicates there is an association between vehicle emissions and negative health outcomes in the major cities. The health benefits of shifting from driving a car to cycling is likely to exceed the health costs of increased incidences of injury associated with the mode shift (Lindsay et al., 2011).

2.5 Environmental effects

2.5.1 Land-use implications

Reduced congestion can have implications for land use. Transport, employment and housing markets overlap and interact to shape short and long term decisions on land use.

The Productivity Commission's recent inquiry into technological change and the future of work found that house prices, especially in Auckland, created barriers to job mobility and labour market matching. These barriers are particularly pronounced for workers in the agriculture, health, manufacturing, education, retail, construction and electricity, gas and water sectors (New Zealand Productivity Commission, 2020).

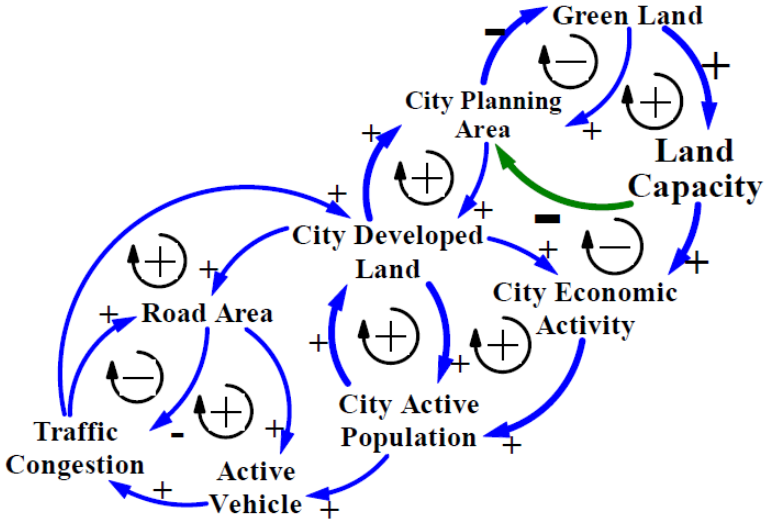
The spatial mismatch hypothesis was first proposed by (Kain, 1968). The hypothesis suggested that poor employment outcomes for minority groups in the community were the results of the spatial separation between housing and employment. There is a rich literature on spatial mismatch (e.g. Kain, 1992 and Brueckner & Zenou, 2003). Similarly, Zhou et al. (2019) found that an increase in multi-modal transport accessibility had a positive effect of employment outcomes in Hong Kong. For Sweden, Norman et al. (2017) found that an improvement in labour market accessibility due to an improvement in transport decreased

[2] https://www.transport.govt.nz/assets/Import/Uploads/Research/Documents/HAPINZ-3.0-Update_11Feb20_JMetcalfeEIL.pdf

unemployment. They also found the effect of transport accessibility was larger for low-skilled workers, indicating the importance of incorporating distributional effects in the research.

The interaction between congestion, infrastructure and land-use change is complex. The outcome is the result of a wide range of inter-related feedback loops as shown in Figure 2.

Figure 2 Congestion and land-use change



Source: Chen & Chang, 2014

3 Methodology

The literature review provides guidance on how shifting from a 5-day commute to a 4-day commute week will affect traffic flows, and key considerations when undertaking this analysis. We would look to overlay these existing research findings with a survey of Auckland households to ensure we capture changes in behaviour and travel patterns as a result of moving to a 4-day commute week which is specific to Auckland.

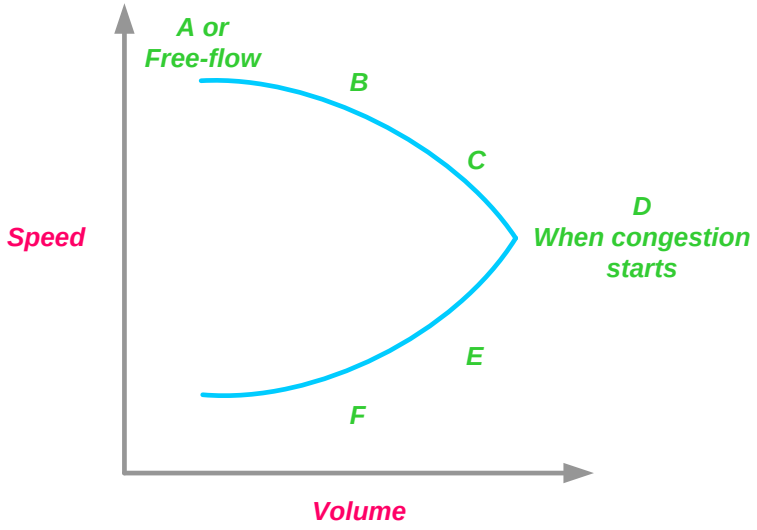
Estimating the effects of these changes in behaviour on the traffic network and the Auckland economy will involve developing scenarios for the likely volume of traffic, and how that affects the performance of the Auckland traffic network as measured by the Level of Service (LOS). The speed-flow curve and the different network levels of service are summarised in the stylised figure below.

In line with previous analysis on congestion (Wallis and Lupton, 2013 and Leung et al, 2017), congestion is defined as the state at which demand for the road exceeds its capacity. As stated in our 2017 report:

> *"we consider the Auckland network at capacity at LOS D because at LOS D the Auckland network is working at maximum sustainable flow (i.e. the relationship between speed and volume is optimised to achieve maximum throughput on the network). We define Level of Service D as the point at which congestion starts."* (Leung et al. 2017)

Figure 3 Stylised speed-flow curve and network level of service

LOS levels are in green



Source: NZIER

The cost of congestion is the difference between the observed travel time and the travel time when the road is operating at this threshold, along with schedule delay costs, reliability of travel costs and other social and environmental costs.

In the long run, the Auckland traffic network will gravitate towards LOS D, as transport demand will adjust to capacity. For example, increases in roading infrastructure will increase the capacity of the traffic network. However, that increased capacity will also induce demand, as reduced travelling times encourage more transport users onto the road. This move towards LOS D in the long run means that the timeframe for when we model the effects of a move to a 4-day commute week matters. The outstanding issue is how long the benefits for the economy persist before the Auckland traffic network moves back towards LOS D, as reduced congestion from a decline in commuting encourages other forms of travel demand.

3.1 Scenarios for analysis

In order to model the effects of a move to a 4-day commute week, we need to develop scenarios as a basis for gauging the performance of the Auckland traffic network. In the first instance, which day of the week is spent working from home matters for the impact of travel demand.

In terms of assessing the proportion of workers that can and will WFH, Stats NZ included in its June quarter Household Labour Force Survey supplementary questions to assess workers' location of work across all four Alert Levels[3]. An estimated 29% of New Zealand workers continued to WFH as restrictions were relaxed and New Zealand moved to Alert Level 1. Across the industries, the proportion that worked from home at Alert Level 1 was highest in financial and insurance services and rental, hiring and real estate services. This provides an indication of the *propensity* to WFH across the industries, although recent research shows (as detailed later in this report) it is too early to disentangle the effects of people who are choosing to WFH due to fear of COVID-19 infection, from a permanent change in commuting behaviour.

[3] https://www.stats.govt.nz/news/four-in-10-employed-new-zealanders-work-from-home-during-lockdown

Table 2 A large proportion of workers continued to WFH even as lockdown restrictions were lifted

% of employed people working at home at each COVID-19 alert level, by industry

Industry	Level 4	Level 3	Level 2	Level 1
Agriculture, Forestry and Fishing, & mining	43.0	42.3	43.1	33.6
Manufacturing & Electricity, Gas, Water and Waste Services	32.4	30.3	20.9	16.2
Construction	25.8	30.9	23.4	23.2
Wholesale Trade	44.7	42.2	32.1	27.3
Retail Trade & Accommodation and Food Services	16.6	16.4	14.7	12.2
Transport, Postal and Warehousing	25.9	21.4	16.8	16.4
Information Media and Telecommunications	78.2	82.1	59.2	47.8
Financial and Insurance Services	82.9	83.3	68.0	53.4
Rental, Hiring and Real Estate Services	62.4	62.8	51.9	55.8
Professional, Scientific and Technical Services & Administrative and Support Services	68.8	70.0	54.3	46.9
Public Administration and Safety	61.7	61.7	49.7	38.9
Education and Training	61.9	65.6	50.9	45.2
Health Care and Social Assistance	29.1	29.2	21.6	19.8
Arts and Recreation Services & Other Services	38.5	39.4	33.9	36.5
Total	**41.8**	**42.7**	**34.0**	**29.0**

Source: Stats NZ

For Auckland specifically, analysis by the Ministry of Business, Innovation & Employment (MBIE)[4] on the proportion of the workforce in each industry that can work from home provides a baseline for which to assess the *ability* of the Auckland workforce to shift to a 4-day commute week.

[4] We would like to thank Daniel Griffiths at MBIE for his assistance.

Table 3 Estimates of Auckland workforce able to WFH, by industry

Number of workers

Industry	Work from home	Industry sub-total	% that can WFH
Agriculture, Forestry and Fishing	3,000	18,000	17%
Mining	0	1,000	0%
Manufacturing	17,000	87,000	20%
Electricity, Gas, Water and Waste Services	2,000	5,000	40%
Construction	14,000	86,000	16%
Wholesale Trade	15,000	59,000	25%
Retail Trade	10,000	86,000	12%
Accommodation and Food Services	5,000	77,000	6%
Transport, Postal and Warehousing	6,000	45,000	13%
Information Media and Telecommunications	10,000	23,000	43%
Financial and Insurance Services	18,000	34,000	53%
Rental, Hiring and Real Estate Services	7,000	25,000	28%
Professional, Scientific and Technical Services	57,000	94,000	61%
Administrative and Support Services	21,000	66,000	32%
Public Administration and Safety	10,000	34,000	29%
Education and Training	38,000	69,000	55%
Health Care and Social Assistance	10,000	76,000	13%
Arts and Recreation Services	4,000	16,000	25%
Other Services	7,000	32,000	22%

Source: MBIE

These estimates provide the upper bound for the proportion of the Auckland workforce which will work from home. For a 4-day commute week, this would translate to the proportion of the Auckland workforce in each industry that reduces their commute travel to 80% of their normal commute.

Research undertaken by the University of Otago looking at the effects of working from home during the lockdown in New Zealand indicate that 89% of those surveyed would *like* to continue working from home at least part of the week.[5] This reflects the positive effects of wellbeing that those working from home reported, including more time spent with family, increased flexibility and reduced costs of commuting. The proportion of workers wanting to work from home in each industry is shown below.

5 https://www.otago.ac.nz/management/research/covid-survey/index.html

Table 4 Workers who want to continue WFH for at least part of the week, by industry

% of respondents in each industry

Industry	Every day	Several times a week	Several times a month
Agriculture, Forestry and Fishing	38%	38%	25%
Mining	-	-	-
Manufacturing	0%	75%	13%
Electricity, Gas, Water and Waste Services	0%	33%	0%
Construction	36%	43%	7%
Retail Trade and Wholesale Trade	10%	62%	19%
Accommodation and Food Services	0%	33%	67%
Transport, Postal and Warehousing	43%	14%	43%
Information Media and Telecommunications	39%	47%	11%
Financial and Insurance Services	24%	51%	20%
Rental, Hiring and Real Estate Services	0%	67%	0%
Professional, Scientific and Technical Services	19%	58%	19%
Administrative and Support Services	53%	33%	13%
Public Administration and Safety	26%	53%	16%
Education and Training	25%	41%	20%
Health Care and Social Assistance	12%	60%	21%
Arts and Recreation Services	8%	58%	33%
Other Services	29%	41%	16%

Source: University of Otago, 2020

As discussed, a survey would also enable us to get a better understanding of what other travel might take place for the worker on the fifth day that they are not commuting. This will contribute to more nuanced scenarios of travel patterns for a 4-day commute week. We propose 3 main scenarios to model: 1) All workers available to work from home do so 1 day a week, with no other travelling on the day they are working from home (considered the upper bound of the effects modelled); 2) A proportion (informed by survey results) choose to work from home 1 day a week, and do not undertake any other travel; 3) A proportion (informed by survey results) work from home 1 day a week, and a proportion undertake other travel (informed by survey on travel behaviour). These scenarios should provide us with a range as the basis to model the effects of a 4-day commute week on the Auckland economy.

3.1.1 Impact of COVID-19 on transport demand

The NZTA instigated a continuous monitor to assess how COVID-19 may have changed people's behaviour when it comes to transport .[6] This includes changes since February 2020 (based on their assessment of a 'normal week' in February) in travel patterns, mode of travel, and work patterns.

6 https://www.nzta.govt.nz/resources/covid-19-impacts-on-transport

The latest update incorporating surveying up to 30 August found that the decrease in commuters as a result of increased incidences of working from home were concentrated in private vehicle users. However, public transport has lost a larger proportion of commuters to working from home (NZ Transport Agency, 2020b). The Auckland CBD has been most impacted in the latest Alert Level 3 lockdown, with 28% of those working in the CBD having ceased commuting during that period.

When assessing commuting patterns during Alert Level 1 in July (NZ Transport Agency, 2020a) when concerns about community transmission had receded, the survey found that the proportion commuting to work had not recovered back to pre-lockdown levels. Similarly, bus patronage had remained below pre-lockdown levels.

The survey found workers want the flexibility of being able to WFH, even if they did not plan to use it. 20% of those surveyed are still working from home in some capacity, with this concentrated in the clerical, administrative and professional services industries at 49%. The lowest was in the wholesale and retail trade, with only 5% of those surveyed still working from home in July.

Figure 4 Proportion of industry still working from home during Alert Level 1

Source: NZTA, 2020a

An NZTA research note on both national and international research on emerging behavioural and attitudinal changes among transport users impacted by COVID-19 found the recent research has largely focused on the use of public transport (Frith and O'Donnell, 2020). Studies that did consider remote working found that even prior to mandated lockdown restrictions, there were increased incidences of working from home to reduce the risk of infection. This was found in the UK and the US. One UK study did find that 42% of respondents "*imagine doing most of their work from home even after the pandemic is over*" (Appinio, 2020). Another UK study found around 47% of respondents expect their "*job to be homebased in the future with limited travel to [their] workplace*" (Transport Focus, 2020). These findings suggest that even when concerns about COVID-19 infection recede there will be a permanent shift in preference towards working from home for at least part of the week.

3.1.2 NZTA scenarios to assess Auckland's future transport demand

In a study assessing the recovery in rapid transport in the wake of COVID-19, the NZTA commissioned L.E.K. Consulting, PwC and Emporium to develop likely scenarios to assess Auckland's future transport demand (L.E.K. Consulting et al., 2020):

- Low – multiple recurrences of COVID-19 in the community over the second half of 2020 reduces Auckland's transport demand, with an assumed WFH of 36%.
- Central – minimal recurrences of COVID-19 underpin a recovery in Auckland's transport demand, with an assumed WFH of 20%.
- High – elimination of COVID-19 sees a strong recovery in transport demand, based on the experience of Taiwan and Hong Kong in the wake of the 2003 SARS outbreak. WFH is assumed to be 13%.

Given the CBD largely consists of services industries, the assumed impact of working from home is greater for the CBD. These scenarios are assessed against the counterfactual of future Auckland transport demand in the absence of the COVID-19 outbreak, based on a pre-COVID historical growth trend. The report was written over 27 April to 12 June 2020, so only captures information up to that date.

Only in the High case is transport demand expected to return close to the counterfactual (of no COVID-19 outbreak) within two years, although it does not fully recover even by mid-2025 reflecting the persistent effects of the COVID-19 outbreak on the New Zealand economy. For the Low case, transport demand remains well below the counterfactual even in mid-2022, reflecting the damaging effects of multiple recurrences of COVID-19 on economic activity, particularly with an expected increase in unemployment.

When assessing historical experiences of pandemics, public transport demand in Taiwan recovered to pre-SARS levels within 6 months of the initial outbreak and there was no long-term behavioural shift away from public transport. Meanwhile, the sharp slowing in the economy because of the Global Financial Crisis had a prolonged negative impact on public transport demand.

Relative to the experience of other main cities globally, rapid transit demand in Auckland fell sharply and has been slower to recover during this current COVID-19 outbreak. This partly reflected the severity of the Alert Level 4 lockdown, which affected city centre workers who had to work from home (where possible) and the concentration of Auckland's rapid transit network in the CBD. Higher rates of car ownership in Auckland also meant a greater ability to substitute towards private vehicle travel as lockdown restrictions were lifted. It is too early to tell whether the slow recovery to normal transport and work patterns reflect concern about contracting COVID-19 (particularly on public transport), or a more permanent shift in behaviour.

3.2 Macro Strategic Modelling (MSM) modelling

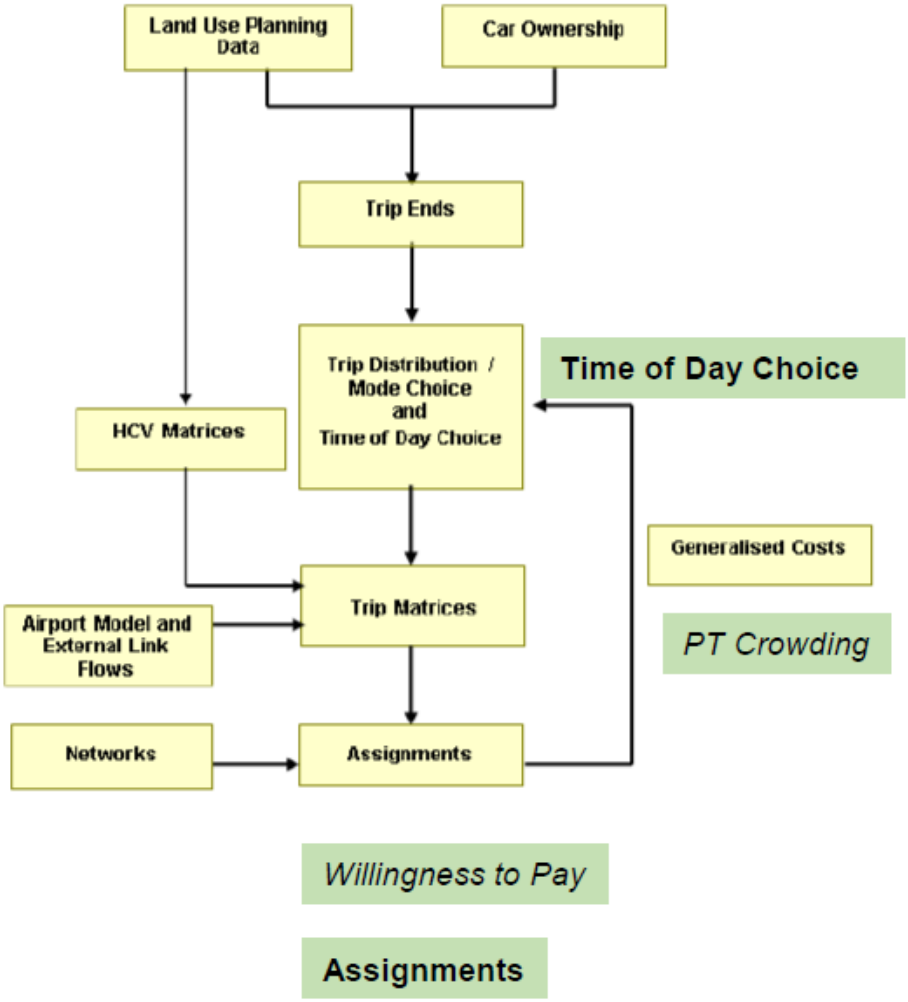
When it comes to modelling the effects of the change in travel behaviour, we propose to follow a similar approach used in NZIER's 2017 report *Benefits from Auckland road decongestion* (Leung et al., 2017), which is consistent with the NZTA's economic evaluation manual (EEM).

Once we have developed scenarios for the 4-day commute week, we would work with the Auckland Forecasting Centre to use the Auckland Transport's Macro Strategic Model (MSM)

to estimate the differences in travel times for each scenario, relative to the baseline of a 5-day commute week (known as the counterfactual). This involves translating the scenarios into what it means for the LOS of the Auckland traffic network, relative to the LOS for a 5-day commute week.

The MSM is a transport demand model which estimates many transport variables across different modes, including travel time and vehicle kilometres travelled (VKT). The diagram below shows the structure of the MSM and the factors driving transport demand across the different modes. The MSM is multimodal and includes private and public transport modes, daily trip generations and assignment of trips in the AM peak, inter-peak and PM peak periods – this is important as the time of day workers choose to commute matters for the effects of shifting to a 4-day commute week. Multiple trip purposes are modelled.

Figure 5 Structure of the MSM



Source: Auckland Forecasting Centre[7]

[7] Auckland Model Refresh 2018 https://www.transportationgroup.nz/wp-content/uploads/2-1-2-AFC_ModelRefresh_NZMUGS_Sept2018.pptx-1.pdf

As discussed, the Auckland traffic network will gravitate towards LOS D in the long run, given transport demand will adjust to capacity. This means it is more useful to assess where on the LOS curve the different scenarios will be after *one year*. Assessing the effects over a one-year horizon is appropriate given most of the benefits of any changes to the transport system, such as an infrastructure investment, are typically captured in the first year. Assessing it over the one-year horizon also means that we can reasonably assume 1) that there is no mode shift; and 2) transport behaviour, such as the location of businesses and households in response to lower travelling times, does not change. By holding these factors constant, we can isolate the impact of the shift from a 5-day to a 4-day commute week.

We can interpret the benefits estimated over the one-year horizon as capturing the benefits of increased choice of where businesses and households can locate due to reduced travelling times. Over the subsequent years, travel demand will increase as reduced travelling times induce a redistribution of industries given it allows businesses and households to locate further away for the same amount of travel time required.

We would work with the Auckland Forecasting Centre (AFC) to obtain the following outputs from the MSM, which will form inputs into our economic modelling. We assess the impact as the difference between the 5-day commute week LOS and the new LOS one year after the shift to a 4-day commute week under the scenario being modelled.

Table 5 MSM output to be populated after transport demand modelling based for each scenario LOS

Transport variables	5-day commute week LOS	Scenario 1 LOS	Scenario 2 LOS	Scenario 3 LOS
Total vehicle trips				
Total vehicle km				
Total travel time (minutes)				
Average speed (km/h)				
Average trip time (minutes)				

Source: NZIER, AFC

3.3 Computable general equilibrium (CGE) modelling[8]

The economic benefits to commuters as well as freight, trades and postal industries in the form of productivity gains (or rising labour supply for commuters) as a result of reduced travel times are then used as inputs into our CGE modelling. Applying these productivity shocks to our CGE model enables us to estimate the downstream benefits across the Auckland industries.

Our estimate from CGE modelling of the benefits will capture the effects of productivity gains for the following groups of road users:

- Freight (heavy vehicles)

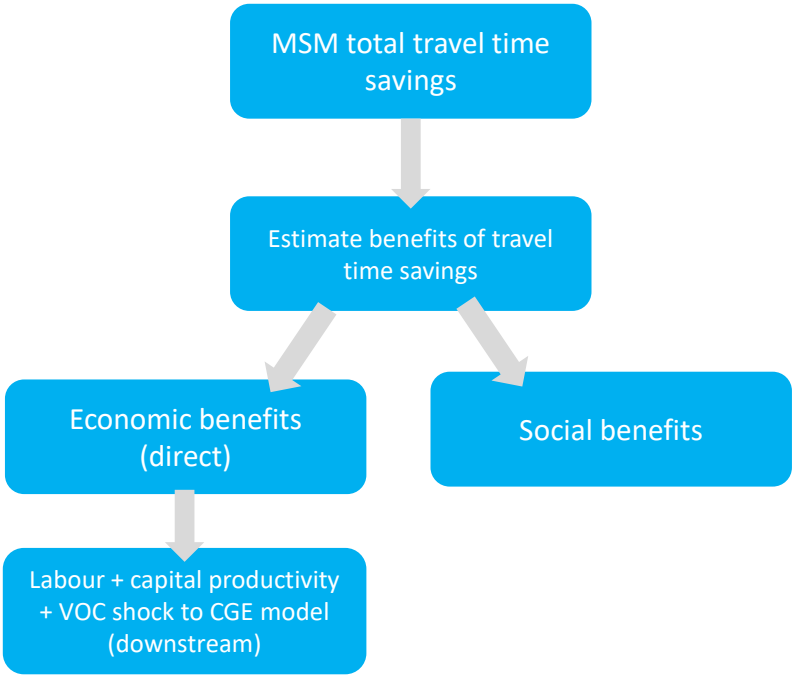
[8] A detailed description of our CGE model can be found in Appendix A.

- Trades and postal services (light commercial vehicles)
- Commuters (light private vehicles)
- Business trips (light private vehicles).

The benefits of reduced congestion go well beyond the direct time savings on freight and commuters. These benefits flow through to all businesses that use transport and employ workers who commute, as well as households who would otherwise be sitting in traffic jams. Although personal commuters make up the largest group of road users of the four, and freight the smallest in terms of numbers, the effects of congestion on freight are far-reaching along supply chains.

These benefits can be broken down into economic benefits, which would raise GDP and living standards, and social benefits, which are not measured through GDP but some of which can be valued nonetheless e.g. a reduction in carbon emissions.

Figure 6 Proposed approach to estimating the effects of a 4-day commute week



Source: NZIER

The economic benefits we estimate with our CGE modelling include:

- Direct productivity benefits
- Labour market response – increased labour supply from reduced travel times, and increase in wages from increased productivity
- Downstream benefits – such as increased household spending from higher wages.

The social benefits include:

- Travel time savings – the value commuters put on their time
- Reduced emissions – as a result of reduced travel
- Scheduling – increased certainty when planning trips.

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Appendix A CGE model description

CGE models are now our preferred method for assessing economic impacts and are used extensively in New Zealand and internationally. As a recent commentator noted regarding CGE modelling "a well-designed model that is used by skilled practitioners to shed light on issues the model was designed to illuminate can make a significant contribution to policy debates and decision making".[9]

Using actual economic data, CGE models estimate how an economy reacts to major projects or changes in policy, technology or other external factors. CGE models are useful whenever we wish to estimate the effect of changes in one part of the economy upon the rest of New Zealand.

CGE modelling is widely regarded as more robust and providing more credible impact assessments than input-output ('multiplier') methodologies.[10] Multiplier methodologies over-state economic impact estimates because they assume that economic resources such as land, labour and capital are infinitely available, are never idle or can be reallocated without adjustment costs.

NZIER's regional model

We use our CGE model, TERM-NZ[11] which is a bottom-up regional CGE model of the New Zealand economy. TERM-NZ is based on a Stats NZ's Input-Output tables that identify the structure of the industries involved. The model database is benchmarked to 2019 using Stats NZ's latest available National Accounts data (November 2019). Our CGE database contains information on 149 industries, 149 commodities and 88 districts,[12]

We usually run TERM-NZ with an aggregated version of the database to focus on geographical areas and industries of interest, speed-up the model computation and because it is not technically possible to run the model with such a large database in its full dimensions.

TERM-NZ treats New Zealand's geographical areas as separate economies. This means that we are able to account for district and region-specific inter-linkages between industries, as well as their links to households (via the labour market), local and central government, capital markets, the rest of New Zealand (via inter-district and inter-regional trade) and the global economy (via imports and exports).

9 Denniss, R. (2012) *The use and abuse of economic modelling in Australia*, Australia Institute Technical Brief No. 12.

10 See Gretton, P. (2013) *On Input-output Tables: uses and abuses*. Australian Productivity Commission Staff Research Note for a thorough discussion of what multipliers are, how they are constructed and their short-comings as tools for assessing economic impacts.

We also note that the Australian Bureau of Statistics has ceased to provide multiplier estimates from its input output tables. http://www.abs.gov.au/ausstats/abs@.nsf/Previousproducts/5209.0.55.001Main%20Features4Final%20release%202006-07%20tables?opendocument&tabname=Summary&prodno=5209.0.55.001&issue=Final%20release%202006-07%20tables&num=&view=

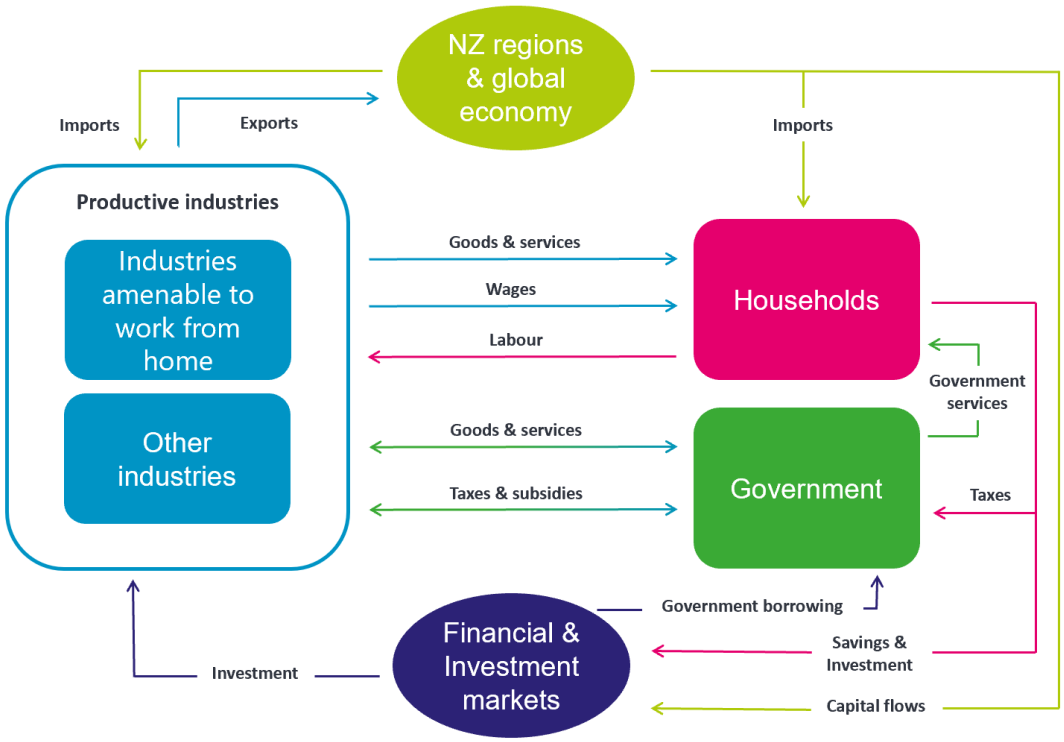
11 TERM-NZ stands for "The Enormous Regional Model" of the New Zealand economy. It was developed at NZIER by Dr Erwin Corong based on the original Australian TERM model created by Professor Glyn Wittwer of the Centre of Policy Studies, Victoria University-Melbourne, Australia. http://www.copsmodels.com/term.htm. NZIER maintains close connections with the Centre, ensuring that our modelling techniques reflect international best-practice.

12 These 88 districts comprise the 68 local territorial and unitary authorities (including the Chatham Islands) and 20 local boards within Auckland Council. These can be combined into regional or other sub-national groupings.

TERM-NZ offers a unique capability to show how developments like that proposed for road decongestion would impact on Auckland region and New Zealand.

A visual representation of TERM-NZ is shown in Figure 7. It highlights how the model can capture the complex and multidirectional relationships between the various parts of each regional economy and how they interact with the rest of New Zealand and rest of the world.

Figure 7 A CGE model shows the whole economy



Source: NZIER

Modelling approach and results interpretation

We use the static version of our CGE model, so that we compare the economy before and after the transport productivity shock is applied. There is no time dimension in the static model, so we do not look at how the economy adjusts to a new equilibrium.[13]

We assume a long run model closure in which national employment and the long-run rates of return to capital are held constant. Labour market adjustments occur through wage movements and job shifts between sectors and regions, but the total amount of employment in the New Zealand economy remains steady. The capital market adjustment occurs through capital accumulation (i.e. investment) and industry-specific rates of return are held constant.

Results are reported as percentage changes from the counterfactual, in which no transport productivity improvement has occurred. To make it easier to understand we also quantify some variables in dollar values.

[13] These fluctuations may have significant impacts and could be captured in future research by using our more sophisticated, dynamic CGE model.