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The costs and benefits of urban development

Final report

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MRCagney Pty Ltd
Level 4, 12 O'Connell Street, Auckland, 1010
PO Box 3696, Shortland Street, Auckland, 1140
New Zealand

t: +64 9 377 5590
f: +64 9 377 5591
e: auckland@mrcagney.com
www.mrcagney.com

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Executive summary

Most New Zealanders live in towns and cities, and urbanisation is expected to continue in the future. New Zealand's cities are relatively small in area: the 80% of New Zealanders who live in neighbourhoods with urban or suburban population densities occupy less than 1% of the country's total land area. However, because cities are dense concentrations of activity they generate concentrated environmental impacts and concentrated impacts from human interaction, both positive and negative.

The challenges of managing the costs of urban development and maximising the benefits of cities will be of ongoing importance. This report is intended to contribute to the evidence base for developing better urban policies by inventorying and summarising existing knowledge on the costs and benefits of urban development in New Zealand, highlighting which effects we understand well and which we do not.

The focus of the report is on urban development, or the creation and reshaping of urban places. It includes construction of new homes, shops, offices, and factories, renovation and re-purposing of existing buildings, supply of transport infrastructure, water infrastructure, and public services like schools and hospitals, and development and preservation of parks and open spaces in cities.

While urban growth is largely a matter of more or less, urban development is about how and where. Costs and benefits can vary depending upon where new urban development is located – in new 'greenfield' suburbs or 'intensification' of existing urban places – and how new buildings, neighbourhoods, and infrastructure is designed.

Defining costs and benefits

Our first research question asks: "**What are the range of costs and benefits associated with urban development?**"

Table 1 summarises the measurable, or potentially measurable, costs and benefits of urban development that we identified based on a broad review of the empirical literature. We distinguish between:

- Internalised effects that are experienced directly by the people living in or using new urban places. These costs and benefits accrue directly to people who have a financial or contractual stake in development, either as a developer or a buyer / user of new urban places.
- Three categories of external benefits and costs that accrue to other people or to the natural environment. These are 'third party' effects that either provide benefits to people who do not have a direct financial or contractual stake in development, or impose costs on them.
- The distributional impacts of any changes in house prices and rents on wealth and income inequality. These are a type of 'third party' effect that operates through impacts on prices, rather than impacts on resources.

Both internalised and external effects should be considered when assessing the overall impact of urban development on wellbeing. The net benefits that people experience from developing, occupying and using new buildings and urban places contribute to wellbeing.

In most (but not all) cases, we would expect that the overall benefits of urban development, both to individuals and to society, are likely to outweigh the costs. However, benefits and costs accrue to different people, often over different geographical scales. This makes it difficult for decision-makers and communities to perceive the

benefits of urban development as well as the costs, and to set up good incentives to promote beneficial development.

External costs and benefits are a primary consideration when asking whether there is a need for different policies to manage or attribute the costs and benefits of urban development. If urban development results in large external effects that are *not* managed or attributed by current policies, there may be a case to consider alternative policy approaches. Conversely, if no external effects can be identified, it may indicate that current policy is working well.

We focus on the measurable effects of urban development, rather than people's expectations about what might happen. However, expectations about the impact of urban development are frequently relevant for politicians and policymakers. For instance, people who believe that new development in their neighbourhood will reduce their quality of life will tend to oppose it.

Table 1: High-level summary of costs and benefits of urban development

Broad group	Categories	Explanation
Benefits and costs that are internalised by residents	• Housing and transport costs to live in different locations • Benefits of living in those locations	People's choice of location affects how much they pay for housing, transport, and utilities. People also derive varying benefits from living in different places, reflecting natural amenities like sunshine and clean air as well as agglomeration benefits and congestion and crowding costs in that location.
Agglomeration benefits	• Agglomeration in production • Agglomeration in consumption • Social and economic benefits of growth in 'declining' regions	Cities increase productivity and offer people more diversity and variety in social experiences and consumer goods and services. This reflects 'sharing', 'matching', and 'learning' processes.
Congestion and crowding costs	• Infrastructure and public service costs • Transport network effects • Impacts on neighbours • Social and cultural effects	Proximity to other people can generate various nuisances. The form of urban development can also affect infrastructure and public service costs.
Environmental impacts	• Consumption of open space • Air and water quality impacts	Concentrated human activities can damage natural ecosystems. Some of these impacts may be perceived by humans (eg unsafe water quality at beaches) while others may not be perceived (eg loss of biodiversity).
Distributional impacts on house prices and rents	• Transfers between renters / first home buyers and property owners	In 'tight' housing markets with constraints to supplying new housing to meet demand, increased population or incomes tend to increase rents and house prices. Conversely, urban development that increases housing supply can moderate the impact of growth on prices.

Several previous studies have attempted to compare the costs and benefits of urban development in different locations. They typically compare development in 'greenfield' suburbs at the edge of the city with 'intensification' of existing urban areas through infill and redevelopment. None of these studies addressed the full range of costs and benefits identified in the table above and as a result we supplemented them with a broader review of the empirical literature that attempts to measure and/or value each type of costs and benefits.

We identified some specific studies that are most relevant to measuring and/or valuing each cost or benefit. We focused on New Zealand-specific studies where available, supplemented by international studies where needed.

Measuring and valuing costs and benefits

Our second research question asks: "**What appraisal approaches, measurement methodologies and the range of metrics are available to value environmental, social and economic costs and benefits?**"

Theory and applied frameworks

We suggest drawing a distinction between *measuring* and *valuing* the costs and benefits of urban development. Measurement means being able to describe and quantify what happens as a result of urban development in different locations. Valuation entails identifying how much of an impact they have on wellbeing, often using some common 'unit of account', which is often (but not always) stated in dollars.

Credibly measuring the effects of urban development requires us to overcome various practical and conceptual challenges, including:

- The potential for feedback loops that can either mitigate or exacerbate some effects. An example would be feedback between the location of new housing, employment, and transport infrastructure that can mitigate (but not eliminate) the congestion impacts of growth in different locations.
- Nonlinearities that make it difficult to predict the future by extrapolating from the present. For instance, ecosystems are self-regulating within certain limits but if they suffer too much damage they may collapse entirely.
- Difficulties obtaining and combining data on different economic, social, and environmental outcomes.

Valuing the non-financial effects of urban development is also challenging. 'Non-market valuation' methods such as willingness to pay surveys or hedonic analysis of property sales may not fully capture the full value of some environmental, social, or cultural effects. This issue is particularly acute when dealing with impacts on the natural environment, as people may not perceive all effects, even irreversible impacts like ecosystem collapse, in the short term.

We therefore recommend a two-pronged approach to address this issue:

- For some environmental impacts, such as impacts of urban development on areas of biodiversity or coastal and freshwater quality, adopt a 'natural capital accounting' approach that seeks to preserve ecosystems at a sustainable level as a bequest for future generations.
- For other non-financial impacts, adopt a 'total economic value' approach to accounting for costs and benefits that accounts for the use and non-use values that people place on certain outcomes. Non-market valuation methods can be used to implement this approach.

Quality of the evidence base

We score each category of costs and benefits on a high/medium/low scale, where 'high' means that peer-reviewed local evidence exists and is supported by a meta-analysis or systematic analysis of the international literature and 'low' means that there is some evidence for the existence of these effects, but it is anecdotal, severely limited in scope, or otherwise insufficiently robust.

The quality of evidence is varied, and it may be difficult to accurately measure and value some impacts based on the existing evidence. Only three sub-categories (out of a total of 27) were assigned a 'High' rating, while nine were assigned a 'Medium' rating. The remaining 15 sub-categories were assigned a 'Low' rating, reflecting the fact that there is little robust, publicly-available, and New Zealand-specific evidence on them.

The three categories of effects we have scored as 'High' are:

- Agglomeration benefits in production: This is one of the principal external benefits that arises from urban development. There is a well-developed international literature that measures the drivers of agglomeration, and peer-reviewed New Zealand studies (eg Maré and Graham, 2009) that estimates the magnitude of these benefits.
- Blocked views: Once again, there is a well-developed international literature on the value that people place on views, and several New Zealand studies that provide relevant local evidence (Bourassa, Hoesli, and Sun, 2004).
- Health impacts of air pollution: Many international studies demonstrate that poor air quality leads to increased mortality and morbidity. The *Health and Air Pollution in New Zealand* (HAPINZ) study estimates air quality issues and the resulting health costs throughout New Zealand (Kuschel et al, 2012).

Costs and benefits that are internalised to residents are partly understood. We assigned a 'Medium' rating to the costs of living in different locations. This reflects the fact that there is reasonable data on differences in house prices and rents between New Zealand regions, which contribute to regional cost of living differences, and that several New Zealand and international studies have measured variations in housing and transport costs within cities, providing 'rough and ready' estimates of suburb-level variation in living costs.

On the other hand, we assigned a 'Low' rating to the benefits that individuals internalise from living in different locations. The existing evidence is not sufficient to allow us to value these benefits or compare them to costs of living. It is therefore important not to 'over-interpret' evidence on costs of living. Even if we observe that one suburb has a higher cost of living than others we cannot conclude that development there is a net negative for society without knowing whether residents obtain higher benefits from living there.

We assigned infrastructure and public service costs a 'Low' rating because the main publicly-available study of infrastructure costs to service urban development in New Zealand (CIE and Arup, 2015) analysed a small number of case studies. Internationally, there is a reasonable body of evidence that points to the existence of modest economies of scale in providing infrastructure and public services to denser urban areas, as opposed to low-density areas. However, costs for any *individual* development can vary significantly depending upon factors like capacity in existing infrastructure, topographical constraints, and design requirements. Our ability to extrapolate from this evidence base is limited.

Local governments and other infrastructure providers often hold data on infrastructure capacity and the cost of past and proposed upgrades. Councils often analyse this data to justify the proposed level of development contributions. While there are likely to be gaps in this data, it represents a potential opportunity to improve knowledge.

Transport network effects, principally including increased traffic congestion, have generally been assigned a 'Medium' or 'Low' rating. This may be a conservative rating. There is a significant body of research on the impact of urban form on transport outcomes that has been systematically reviewed by Ewing and Cervero (2010). However, most local evidence is based on transport modelling rather than analysis of observed data.

Data for measuring and valuing effects

The quality of data and evidence varies, and in some cases it is not sufficient to measure and value impacts. This is a particular issue for the following categories:

- Agglomeration benefits in consumption: These benefits are hard to measure as they can arise from the impact of larger / denser urban areas on the variety of goods, services, and social opportunities. Variety is difficult to measure and value, although some studies have attempted to do so.

- Infrastructure and public service costs: The most feasible approach would be to estimate the 'near future' costs to expand infrastructure to serve urban development where no infrastructure is currently available or where existing networks are at capacity. Infrastructure costs incurred before a certain date (eg five to ten years ago to capture recent expenditures) would be treated as sunk costs. However, implementing this is challenging as significant work is needed to compile and clean data.
- Consumption of open space: Data is available to measure consumption of open space for urban development, but not to value it.
- Water quality impacts: Some data is available to measure and value these impacts, but it is unclear how easy it would be to extend this beyond a few limited case studies.
- Social and cultural impacts: With the exception of the health impacts of transport behaviours, these are poorly understood in the New Zealand context and hence would require significant research to understand.

Second, strategic transport models (ideally coupled with land use models) and the methods in the NZ Transport Agency's *Economic Evaluation Model* are potentially relevant for measuring and valuing several categories of effects, including:

- Agglomeration benefits in production
- Transport network effects
- Health impacts of air pollution and climate change impacts of greenhouse gas emissions
- Health impacts of transport behaviour

Third, non-market valuation methods can potentially be used to value several categories of effects. Hedonic analysis of property sales, a 'revealed preference' method, can be useful to value impacts that depend upon close proximity. This principally includes impacts on neighbours. New Zealand-specific evidence is available on the impact of overshadowing and blocked views, while international evidence provides some information on the potential impact of changes to neighbourhood aesthetics and crowding. Impacts of traffic noise may also be valued using evidence from hedonic studies.

'Stated preference' evidence based on surveys that ask people how they value specific outcomes can assist in valuing costs and benefits that arise over a wider geographic scale. This includes the environmental impacts of consuming open space or damaging freshwater and coastal water quality that are perceived by humans. Non-market valuation methods are commonly used to value traffic congestion impacts (ie value of travel time parameters) and health impacts of poor air quality and road crashes (ie value of statistical life parameters).

However, non-market valuation methods do not capture some environmental impacts that are not perceived by humans in the short term, such as slow but irreversible damage to ecosystems. There is therefore a case to consider a natural capital accounting approach instead. This would entail setting 'bottom lines' for preservation of stocks of biodiversity, water quality, etc and sustainably managing them as a bequest for future generations.

Potential magnitude of costs and benefits

Where sufficient data exists, we estimate an approximate 'order of magnitude' of impacts per added household or added dwelling. The aim of this exercise was not to be precise, but to help policymakers focus on effects that are likely to be largest and hence worthiest of attention. These estimates should be interpreted as the potential outcome *if* impacts were to arise, noting that impacts like blocked views may only apply in a limited number of cases.

The following effects are likely to be highest in magnitude:

- Costs of living that are internalised by residents: This is likely to be one of the largest single effects, reflecting the fact that households typically spend 25-30% of their income on housing, transport, and utility services. By extension, it is also likely that the benefits they receive from doing so are also large.
- Agglomeration benefits in production are likely to be large. There is some evidence that they are larger for new development in central areas that are closer to existing concentrations of employment, relative to employment in less accessible peripheral locations.
- Distributional impacts on house prices and rents can be large in cities with constraints on housing supply. In these contexts, growth in housing demand can flow through into large increases in house prices and rents, thereby redistributing wealth from renters and first home buyers to landlords and home owners. Conversely, enabling urban development and increasing housing supply may reduce pressure on prices and rents, leading to a more equitable distribution of income and wealth.

Some individual categories of external costs may also be significant in some situations. This includes impacts on traffic congestion, total infrastructure costs that are not covered by user charges, specific impacts on neighbours such as overshadowing or blocked views in coastal / lakefront areas, and environmental impacts in sensitive environments.

Attributing costs and benefits

The third research question asks: **Could a common approach be developed to identify, measure and attribute the costs of urban development?**

A common conceptual framework can be used to measure and value most of the costs and benefits of urban development. Above, we articulate some key principles for doing so. A partial exception is that some environmental effects, such as loss of areas of biodiversity or damage to freshwater and coastal water quality, may be better dealt with using a natural capital accounting approach.

Because different costs and benefits arise through different mechanisms, at different geographic scales, it is challenging to incorporate all of them into a single model or measurement tool. There are likely to be computation constraints to developing a model that is both sufficiently broad and sufficiently detailed.

Our first suggestion is therefore to avoid committing to a single model or modelling approach. Instead, we suggest:

- Improving the quality of geospatial data on cities and natural environments and improving the ability of researchers and analysts to access and join together datasets held by different agencies, potentially through a clearinghouse like Statistics New Zealand's *Integrated Data Infrastructure*
- Employing existing models, such as strategic transport models, land use models like the Waikato and Wellington Integrated Scenario Explorers, and the Urban Planning that Sustains Waterbodies Decision Support System (UPSW DSS) water quality modelling.
- Where individual models do not capture all relevant effects, combining multiple models using a 'loose coupling' approach.
- Searching for ongoing opportunities to improve models to address gaps and omissions.

Our second suggestion is that further empirical research should focus on six effects that are either likely to be significant in magnitude, or that are potentially large but poorly understood at present. These are:

- Agglomeration benefits in consumption: Some studies find that these benefits may be comparable in size to agglomeration in production (Tabuchi and Yoshida, 2000; de Groot et al, 2015), but they can be

difficult to accurately measure and value as they often arise from the ability of larger cities to provide greater variety in social experiences and consumption goods and services.

- Infrastructure costs and infrastructure pricing: We suggest focusing on the medium-term costs of infrastructure to serve new development, taking into account:
    - Where there is capacity in existing infrastructure networks
    - What it will cost to upgrade at-capacity infrastructure or provide new infrastructure to greenfield areas
    - The likely profile for development in newly serviced areas and any risks to growth that may affect financing costs.
- Transport network effects: These impacts, including increased traffic congestion, potentially represent one of the largest single external costs of urban development. It is therefore important to understand them. Existing strategic transport models can in principle be used to assess them, provided that model inputs are appropriately designed and/or provided that transport models are coupled with land use models.
- Impacts on neighbours: Some people cite a broader range of (measurable and unmeasurable) costs to oppose new development, ranging from increased use of on-street parking to risk of increased property crime to reductions in neighbourhood aesthetics. It is unclear whether expected negative impacts from new development reflect what will actually happen in practice, or whether people's expectations reflect a lack of information or a 'status quo' bias that leads them to prefer things not to change. However, the hypothesised impacts may or may not materialise. We think that this issue is important and bears further investigation.
- Environmental impacts and sustainable stocks of natural capital: We suggest identifying a set of environmental outcomes that are best addressed through a natural capital accounting approach, and identifying sustainable 'bottom lines' for these outcomes. This is an exercise for scientists and communities, rather than economists. However, it may be useful to undertake a cost effectiveness analysis of alternative options for providing for sustainable outcomes. Further work is also needed to understand how this approach would integrate with a more traditional focus on measurable flows of costs and benefits.
- Distributional impacts on house prices and rents: While we have a limited understanding of these effects, some evidence suggests that they can be large. Further research is needed to understand how large these effects are, where they are most acute, and what policy factors may exacerbate or mitigate them.

Our third suggestion is that it may also be difficult to manage and attribute all impacts with a single policy mechanism. We highlight five considerations that are especially relevant when considering changes to urban policy:

- Urban development generates external benefits as well as external costs, and hence it is not clear whether it should be 'discouraged' or 'encouraged' by policy
- The impacts of urban development play out over multiple geographic scales, and the location of development often matters for determining the magnitude and direction of costs and benefits
- External costs can be mitigated, and external benefits enhanced, through good design of buildings, neighbourhoods, and infrastructure
- Constrained housing supply can affect the distribution of income and wealth
- Infrastructure costs are challenging to measure, and hence challenging to price.

1 Introduction

This report addresses three broad research questions. The first research question relates to identifying and defining costs and benefits arising from urban development, the second research question focuses on methods that have previously been used to measure and value these costs and benefits, and the third moves beyond measurement and focuses on policy options for managing and attributing costs and benefits.

The main focus of the report is to inventory and summarise existing knowledge on the costs and benefits of urban development. This is not, for the most part, a theoretical exercise, although we begin by briefly discussing some key concepts and principles to guide the inventorying exercise.

This scope excludes providing a comprehensive / comparative analysis of the costs and benefits of urban development in different locations, as that would be a major modelling and analysis effort. However, the report does present a number of examples or case studies that illustrate specific costs or benefits and highlight methodologies that could be applied more widely to estimate costs and benefits.

1.1 Research questions

RQ1: What are the range of costs and benefits associated with urban development?

- What are the material economic, social and environmental costs and benefits noting a comprehensive approach is needed that includes residents, businesses and local and central government? What impacts should we focus on to maximise the net benefits of urban development?
- What research on the costs and benefits associated with urban development is most applicable to the NZ context? We are not looking for a comprehensive literature review, but would like to our attention drawn to studies that deserve closer attention.

RQ2: What appraisal approaches, measurement methodologies and the range of metrics are available to value environmental, social and economic costs and benefits?

- What are the theory and applied frameworks for thinking about/analysing the impacts of urban development and what are the most useful?
- What data is available and how reliable and useful is it?
- What impacts can be measured and/or monetized today and with what certainty?
- What is the magnitude of the costs and benefits that can be quantified?
- What costs and benefits are internalised to beneficiaries and externalised to other people?

RQ3: Could a common approach be developed to identify, measure and attribute the costs of urban development?

1.2 Structure of this report

This report is divided into five main sections, followed by eleven appendices that provide further detail on relevant research and evidence on the costs and benefits of urban development:

- Section 2 ('Key concepts') describes what urban development is, why it happens, and how it can affect individuals, society in general, and the environment.
- Section 3 ('Measuring and valuing effects') describes conceptual and practical challenges for measure outcomes from urban development and valuing them using a common unit of account.

- Section 4 ('Identifying costs and benefits of urban development') outlines a framework for classifying the costs and benefits of urban development and defines specific effects that have been shown to arise in practice.
- Section 5 ('Summary of the evidence base') reports on the results of a broad review of empirical evidence on each category of costs and benefits, highlighting areas where we have more or less evidence.
- Section 6 ('Attributing and managing costs and benefits of growth') concludes with some reflections on potential policy implications.

2 Key concepts

2.1 What is urban development?

Development versus growth

We interpret this brief as asking 'what happens when urban development occurs in different locations?'

Urban development is related to, but not identical, to urban growth. Urban growth is an aggregate concept that refers to increases in population or economic output. Urban development, by contrast, refers to the creation and reshaping of urban places. It comprises the construction of new homes, shops, offices, and factories, the renovation and re-purposing of existing buildings, supply of new transport infrastructure, water infrastructure, and public services like schools and hospitals, and the development and preservation of parks and open spaces in cities.

Growth is largely a matter of more or less. Urban development is about how and where.

Urban growth can be an important stimulus for urban development. For instance, most of the buildings in central Dunedin were built in the late 1800s, when the Otago gold rush caused the city's population to boom. Slower growth over the last century has meant that Dunedin's city centre experienced less redevelopment than Auckland or Wellington.

However, urban growth can occur even if urban development does not keep up. This can lead to social problems such as people living in over-crowded accommodation or becoming homeless. Auckland has experienced issues due to the fact that housing development has lagged behind the city's rising population.

Conversely, urban development can occur in slow-growing or shrinking cities. Even without a rising population, increasing incomes or preferences for a better built environment can support the development of new homes in more attractive locations, renovation of existing buildings, and improvements to public places. Demographic changes also play a role: falling household sizes mean that more homes are required to house the same number of people.

Our focus is therefore on the costs and benefits that urban development, which we define as the creation or reshaping of urban places, can have when it occurs in different locations in New Zealand. In some cases, we touch upon aggregate urban growth, as effects such as congestion costs and agglomeration economies are influenced by overall city size.

Compared to what?

An implicit corollary to the above question is 'what would happen instead if urban development did not occur in a specific location?' That is, what counterfactual scenario are we comparing development against?

Demand for housing, and demand for urban places, is like a waterbed. If you push it down in one corner, the displaced water will just pop up elsewhere. By analogy, demand for development that cannot be met in one location for whatever reason does not simply disappear – rather, it displaces to other locations instead.

Assumptions about what the counterfactual locations are can affect our conclusions about whether urban development in a particular location leads to net societal costs or net societal benefits.

For instance, consider an attempt to assess the costs and benefits of developing new 'greenfield' suburbs on previously non-urban land near Auckland. This will lead to a variety of effects, such as consumption of open space / agricultural land, increased travel demands, and various benefits and costs for the people living in new homes.

If this development did not proceed, then there are a few things that could happen instead:

- People who would have otherwise lived in the new greenfield suburb would stay in Auckland and live in new 'infill' housing in existing suburbs
- They would move to other urban areas in New Zealand, such as Hamilton or Whangārei
- They would move to non-urban areas in New Zealand, for instance a lifestyle block in Western Bay of Plenty
- They would leave New Zealand and move to, say, Brisbane or Perth instead
- Lastly, in the absence of development some people may simply be unable to find housing and may end up living in overcrowded dwellings, temporary accommodation, or sleeping rough.

Each of these alternatives would lead to different types of costs and benefits. For instance, if people moved to low-density lifestyle blocks in rural areas they may consume *more* overall open space than they would in a higher-density suburb. Conversely, if people moved to Australia it would minimise local environmental impacts but potentially lead to other social and economic costs, such as increased distance to friends and family or a loss of skilled workers in New Zealand.

Rising crowding or homelessness due to a shortage of housing is potentially the costliest alternative of all. Housing deprivation is associated with a range of social and health problems, including a rise in communicable diseases and worse educational and wellbeing outcomes for children (Gray, 2001; Baker et al, 2013).

Previous attempts to calculate the costs and benefits of urban development have adopted the first approach (CIE, 2010; Nunns and Denne, 2016). That is, they compare the costs and benefits that would arise from alternative scenarios for the location of development within a single city, holding total city population constant. In reality, people are also likely to shift between cities, between urban and rural areas, and between countries as well as within cities.

In this report, we do not take a position on which counterfactual scenario is most appropriate. The evidence on costs and benefits that we compile could in principle be used to compare outcomes for urban development at a within-city, between-city, or urban-rural scale, and potentially also between New Zealand and non-New Zealand locations.

The role of policy

New Zealand already has an extensive policy regime dedicated to managing urban development and its effects. This includes the Resource Management Act, which is the framework legislation for urban planning and economic management, the Local Government Act, which sets out the roles and responsibilities of councils, and the Land Transport Management Act, which governs the provision of urban transport infrastructure and services. Urban policy is implemented by various government departments, such as the Ministry for the Environment, Ministry of Housing and Urban Development, and New Zealand Transport Agency, 62 city and district councils, 11 regional councils, and five unitary councils.

New Zealand's broader tax and social welfare system also has economic and social implications for cities. Progressive income taxes mean that part of the productivity premium that arises due to urban agglomeration

economies is captured as central government revenues. This can drive a 'wedge' between the private and social incentives for urbanisation. On the other hand, most capital gains on residential property are untaxed, increasing the private benefits that homeowners and landlords experience from property price increases (Coleman, 2017; Tax Working Group, 2018).

Central and local government policies and institutions can mitigate, manage, or in some cases unintentionally exacerbate the costs and benefits of urban development. A corollary is that the costs and benefits that we are able to observe are, in part, a function of current policy.

One example would be the negative impacts of heavy industrial activities on residential areas. In most urban areas in New Zealand, these are managed through zoning policies that separate residential and industrial activities and maintain buffers between them. An analysis may therefore find that heavy industry currently has few negative impacts on residents. This does not imply that steel mills and oil refineries have a benign impact on people who live near them, but that policy has been successful in managing negative impacts.

A contrasting example is the link between development of greenfield suburbs and the congestion impacts of increased vehicle kilometres travelled (Ewing and Cervero, 2010). The tendency for greenfield development to increase car use is exacerbated by transport policy decisions, including designing curving street networks that reduce the efficiency of public transport and walking, or building roads first and retrofitting rapid transit connections later, if at all.

Adopting a different policy approach could therefore moderate some of the transport costs that are currently associated with greenfield development.

In this report, we focus on identifying evidence on costs and benefits that arise in the context of existing policies and arrangements for managing development and pricing infrastructure. Current central and local government policy is treated as the 'base case' approach.

This reflects a pragmatic consideration: We have to start by measuring what is happening, rather than what might happen if things were different. For instance, when considering the external costs of providing infrastructure to serve a new suburb, it is useful to compare what it currently costs to build that infrastructure in that area against expected user revenues, such as development contributions, usage charges, or other fees.

In theory, an alternative approach to charging users for infrastructure may be better at attributing infrastructure costs to the people who benefit from development. This may reduce or even eliminating the external costs that are present under the current system. Evidence on the external costs that arise under current policy may provide a rationale for moving towards an alternative approach.

The role of design

The costs and benefits of urban development can vary depending both upon where new developments are located and how buildings, neighbourhoods, infrastructure, and other features are designed.

For instance, greenfield development may consume a similar quantity of undeveloped land in different locations, but the characteristics of that land and hence the environmental impacts of developing it may differ. Developing farmland, which has been extensively modified for economic use and often generates environmental costs, may be different than developing wetlands, tussock, or native bush, which may support indigenous biodiversity and local environmental benefits.

The design of new subdivisions can also affect costs and benefits. A subdivision with 'green' stormwater design and provision for preserving (or creating) corridors of native bush may result in smaller environmental impacts than a subdivision with a 'grey' infrastructure approach.

Another example would be the design of new buildings in existing urban areas. Some buildings may 'overshadow' neighbouring buildings and block access to sunlight. However, whether this occurs in practice will depend upon the height and form of new buildings (high-rise buildings are more likely to generate overshadowing than mid-rise or low-rise buildings), their placement on the site (buildings in the centre of sites may not cast shade on neighbouring sites), and the relationship of the site to the street (buildings on the north side of a sufficiently wide street will not block sunlight access to other buildings).

In this report, we mostly focus on the impact of location. This is a pragmatic consideration given the need to review a very broad set of costs and benefits in a limited timeframe. However, where costs and benefits are likely to be highly affected by design we have noted this.

2.2 Why does urban development happen?

Prior to analysing the costs and benefits of urban development it is useful to ask why cities exist in the first place.

Most people live in cities

New Zealand's population is highly concentrated in a small number of places. Table 2 divides New Zealand's population into ten deciles, ranked from lowest population density to highest density. Deciles 3 through 10, comprising 80% of New Zealand's population, occupy only 0.6% of the country's total land area. Deciles 6 through 10, comprising 50% of the population, occupy only 0.2% of total land.

While a significant portion of the remaining land is unsuitable for settlement or held in national parks, this data highlights how New Zealanders prefer to agglomerate, rather than disperse. This is a global trend: since 2011, most humans have lived in cities, and the share of people living in cities tends to be highest in wealthy countries.

Table 2: Spatial concentration of New Zealand's population

Decile of population density	Share of NZ land area	Average density (people / ha)
1 (lowest density)	97.40%	0.02
2	1.99%	0.8
3	0.21%	7.5
4	0.10%	15.4
5	0.07%	21.5
6	0.06%	26.5
7	0.05%	31.0
8	0.04%	35.7
9	0.04%	42.1
10 (highest density)	0.03%	62.8

Source: Analysis of 2013 Census population data at the meshblock level.

The costs of living in cities are generally outweighed by the benefits

Cities generate a range of inconveniences and frictions, as well as concentrated environmental impacts. These can include traffic congestion, nuisances imposed by neighbours, competition for space in desirable locations, and damage of air and water quality. Anybody who has lived in a city can think of some aspect of urban living that annoys them.

These costs can be thought of as **congestion and crowding costs**, which arise when being close to other people generates nuisances, and **environmental impacts**, which occur when human activities damage natural ecosystems.

In spite of the costs of urban living, people have chosen to concentrate in a small number of places rather than avoid them by spreading out to rural areas and small towns. This suggests that they also derive benefits from doing so (Glaeser, 2008).

There are two basic reasons why concentrating in cities may be beneficial. The first is that some places have unique **natural advantages** that make them more productive or attractive. For instance, the following factors have historically played a role in catalysing urban development:

- The presence of a deepwater harbour or navigable rivers (eg New York City)
- Proximity to productive farmland or mineral resources (eg gold-rush Melbourne)
- Sunshine and warm climates (eg Tauranga, the American 'sunbelt')
- The availability of flat, developable land for housing and business activities (Saiz, 2010).

The second reason is that proximity to other people generates various **agglomeration benefits** that increase productivity and offer people more diversity and variety in social experiences and consumer goods and services. This can generate self-reinforcing processes of urban development: for instance, Cronon (1992) shows how Chicago's small initial edge as a logistics hub for the American Midwest fostered its rapid growth into the second-largest city in the US.

Agglomeration economies are diverse in nature but tend to arise through similar mechanisms. Following Duranton and Puga (2004), these mechanisms include:

- **Sharing**: Sharing costs of indivisible goods and facilities; gains from variety; gains from individual specialisation; sharing risks
- **Matching**: Improved quality of matches in larger pools of people; improved chances of matching; mitigating hold-up problems
- **Learning**: Knowledge generation; knowledge diffusion; knowledge accumulation.

Urban development affects the environment, but not all impacts are directly perceived by humans

Some locations have natural advantages, ranging from sunshine and warm climates to proximity to natural resources, that attract urban development. Conventional urban economic theory assumes that a city's natural advantages are 'fixed' – that is, that there is limited feedback between humans and the natural environment, except insofar as land is consumed for development.

For some natural advantages, this is a reasonable assumption. For instance, Nelson is frequently named New Zealand's sunniest city. If more people move to Nelson, the city will not become any more or less sunny. Similarly, Wellington will not become more or less earthquake-prone if more people move there.

However, other natural advantages can be eroded (or in some cases enhanced) as a result of urban development. Some environmental impacts are **perceived** by humans, while others are **unperceived** and hence may not be widely recognised or valued in the short term. For example:

- Wastewater outflows into a harbour may make it unsafe to swim at local beaches – an impact that is highly noticeable to the average resident – as well as damaging the long-run health of a marine ecosystem – an impact that people may not notice.
- If wetlands that provide runoff and stormwater management services are drained and developed, residents may be exposed to flooding or bear costs to construct new stormwater systems to handle runoff and avoid flooding, but they may not be aware of impacts on local wetland biodiversity.

Some examples of environmental impacts that are widely perceived include clean air, freshwater supply, stormwater management, and natural hazard mitigation, as well as aesthetic and recreational values of environments that humans use (Meurk, Blaschke, and Simcock, 2013).

A simple model of the costs and benefits of urban development

Urban development is shaped by positive and negative feedback between humans in cities and between humans and the natural environment.

Urban economic models illustrate how city size represents a balance between agglomeration benefits and congestion / crowding costs, and hence how changes to city population can generate external benefits or external costs for others in cities (Fujita, Krugman and Venables, 1999; Glaeser, 2008).[1]

These models are highly stylised and hence should be used to obtain insights rather than for detailed policy analysis. They typically treat agglomeration and congestion / crowding in an aggregate fashion, assuming that these benefits and costs scale up with city size or density. For instance, 'congestion and crowding' is used as a catch-all term for all the nuisances associated with being around more people, ranging from traffic delays to

[1] Broadly speaking, there are two types of urban economic models: First, models that attempt to explain the distribution of residents and firms *within* cities; and second, models that attempt to explain the distribution of people *between* cities (and rural areas). Both assume and/or model these processes in different ways.

blocked views to reduced water quality at urban beaches to neighbours who have loud parties (and don't invite you).

One insight from these models is that cities can in theory be 'too big', ie more congested and crowded than would be socially optimal, or 'too small', ie not large enough to maximise agglomeration effects. Moreover, there may be a gap between the outcomes that are preferred by people living in a city and the outcomes that would be preferred at a national level. City governments may seek to maximise the benefits received by an average urban resident. Central governments, on the other hand, may prefer high-productivity or high-amenity cities to be a bit larger than that, which would increase congestion but increase the number of people who derive benefits from living there.

Another implication of urban economic models is that larger cities tend to have some combination of better natural amenities, stronger agglomeration economies, and / or smaller congestion, crowding, and perceived environmental costs. The first two factors make a city more attractive for residents, while the third factor allows more people to live there without generating excessive costs. Measures to enhance agglomeration benefits, reduce congestion / crowding costs, or enhance environmental benefits will tend to encourage city growth.

Figure 1 illustrates these dynamics, using a simple variant of the single-city model proposed by Albouy et al (2018). The first row of charts shows that a 'fixed' natural amenity (like sunshine) provides residents with a constant amount of benefits regardless of city size. The second row of charts shows agglomeration benefits that residents receive, such as higher wages or greater product variety, which rise with city size. The third row shows congestion, crowding, and perceived environmental costs, which are negative and which also rise with city size.

The final row sums all three effects together to estimate the net benefits received by city residents. Based on Albouy et al's assumptions, this results in an 'inverted U' curve in which benefits rise and then fall with city size. From the perspective of the people who live in the city, it would be best to be right at the peak of the curve – ie before diminishing returns to scale kick in.[2]

The three columns compare cities with different degrees of agglomeration economies and congestion / crowding costs.

Relative to City A, City B enjoys stronger agglomeration economies, as shown by the steeper slope of the agglomeration benefits curve. This might reflect the fact that it started out specialised in industries where agglomeration economies play a stronger role. For instance, City B might be a finance and professional services hub where face-to-face contact is important, whereas City A is a manufacturing centre (Fujita, Krugman and Venables, 1999). As a result, City B might be around 40% larger than City A.

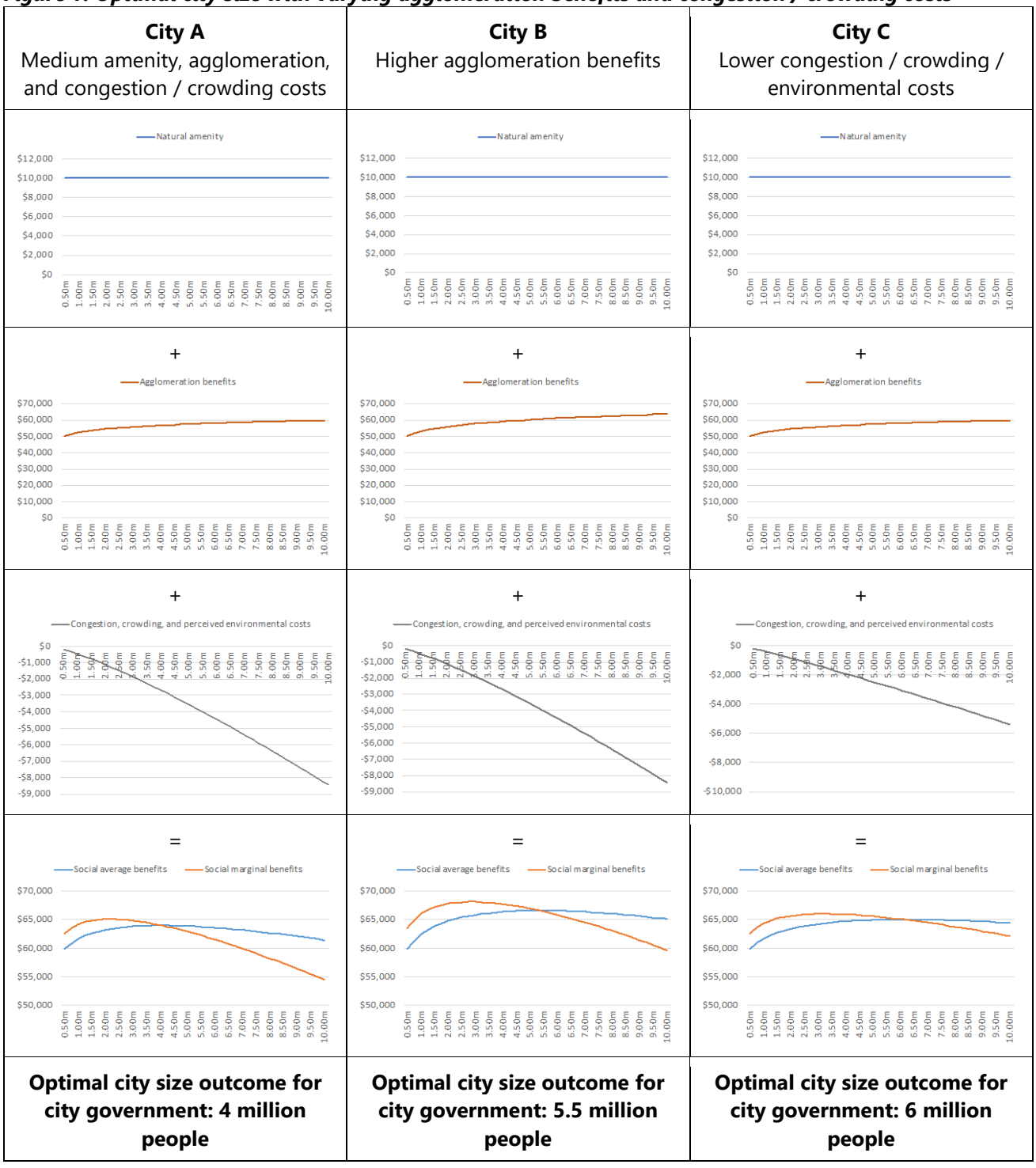
City C has similar agglomeration economies as City A, but experiences lower congestion, crowding, and environmental costs from growth, as shown by the flatter slope of the congestion curve. This could reflect a range of factors, such as:

- A better rapid transit system that allows it to handle higher transport demands without excessive congestion
- Topography and weather patterns that disperse air pollution rather than trapping it in the urban area
- A more resilient or better-protected environment that is not as vulnerable to deterioration from growth.

As a result, City C may be around 50% larger than City A.

[2] Including taxes on labour income and any public subsidies for housing or commuting costs complicates this picture somewhat as it introduces a 'wedge' between social benefits and private benefits that may lead residents to prefer a smaller city that does not maximise social benefits.

Figure 1: Optimal city size with varying agglomeration benefits and congestion / crowding costs



The role of residential mobility

The simple model shown in Figure 1 examines outcomes for a single city only. In a more realistic setting with many cities and rural locations where people can live, analysing the costs and benefits of urban development is complicated by the fact that people can move in response to changes to urban places.

Making a location more attractive, eg by improving environmental quality or expanding transport capacity, typically encourages some people to move there. This leads to direct benefits for people who move in, but it can also generate some external costs that offset the benefits that existing residents receive from the improvement. (In some cases, it may also generate some external benefits that further *enhance* quality of life for existing residents.)[3]

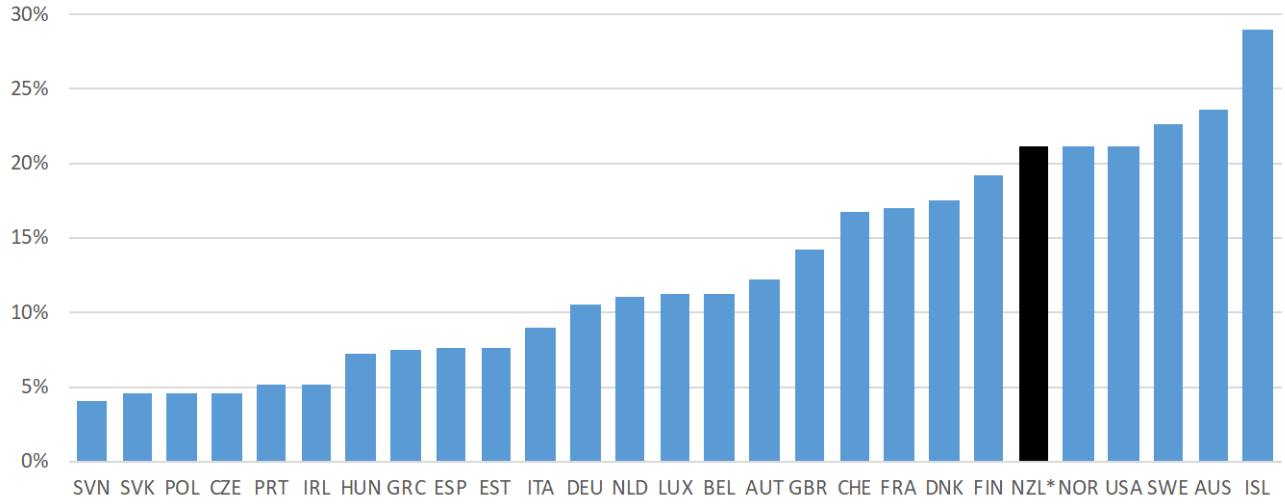
Urban economic models that account for movement between cities predict that when an intervention takes place in one city, average wellbeing levels increase by little within that city because inward migration occurs until average wellbeing is equalised around the country (Harris and Todaro, 1970; Roback, 1982). This makes utilitarian calculations of the costs and benefits of urban interventions difficult as they depend on a comparison of utility levels in locations outside the city – and in some cases outside the country. For instance, if Christchurch becomes more attractive as a place to live, it may attract people from Auckland, which may worsen traffic congestion and air quality in Christchurch while reducing congestion costs for the people remaining in Auckland.

Economists often use urban highway expansions as an analogy for the benefits of improving amenities in a single city. Road widening is typically justified on the basis that it will reduce congestion and increase travel speeds. In reality, travel times only improve for a temporary period, before 'induced demand' returns congestion to its original level (Duranton and Turner, 2011). Existing users will then experience little benefit from road widening, but new users may experience benefits, because they couldn't use the road because it was overcrowded.

The main outcome of urban highway expansions is therefore to increase the number of people who are able to use the network at a given level of congestion. This can affect the shape or overall size of a city, as shown by the impact of the US Interstate Highway System on suburbanisation and urban growth (Baum-Snow, 2007, 2010; Duranton and Turner, 2012). Similarly, the main outcome from measures to improve cities may be to increase their size.

New Zealanders are highly mobile by OECD standards, and hence there is high potential for these types of effects. Figure 2 shows that residential mobility in New Zealand is comparable to Australia, the US, and the Scandinavian countries, and considerably higher than most OECD countries.

Figure 2: Estimated share of working-age adults who moved in the last two years in OECD countries



Note: Data for other OECD countries comes from Caldera Sanchez and Andrews (2011), and is based on household survey microdata for people aged 24 to 66. New Zealand two-yearly mobility rates were estimated using 2013

[3] There will also be other positive or negative impacts on people who live in other places.

Census data on the share of people aged 25 to 64 who moved within the last five years. They are likely to be an underestimate as some households have moved multiple times in that five-year window.

New Zealanders move frequently within regions, between regions, and internationally. Table 3 shows that, between 2008 and 2013, almost one-third of New Zealanders moved houses while staying in the same region, 8% moved between regions, and 7% moved to New Zealand from overseas. According to United Nations data on international migrant stocks, over 834,000 New Zealanders lived in other countries in 2017, which is equal to 17% of New Zealand's total population.[4] Conversely, 22% of New Zealand residents migrated here from other countries.

This suggests that any changes to cost of living and the productivity and attractiveness of New Zealand's cities are likely to be followed by changes in the distribution of population (Nunns, 2018a).

Table 3: Census data on changes of residence between 2008 and 2013

Category	Number of people	Share of stated population
Total population	4,242,048	
Total population who stated a residence five years ago	3,859,428	
Residence five years ago:		
Not yet born (under 5 years)	292,041	8%
Lived overseas	284,742	7%
Lived in a different NZ region	312,378	8%
Lived in a different residence in the same region	1,207,239	31%
Lived in the same residence	1,762,155	46%
No fixed abode	873	0%

Source: Analysis of 2013 Census data published online at http://nzdotstat.stats.govt.nz/wbos/Index.aspx?DataSetCode=TABLECODE8005 and http://nzdotstat.stats.govt.nz/wbos/Index.aspx?DataSetCode=TABLECODE8004

2.3 Who does urban development affect, and over what scale?

Urban development affects, or potentially affects, many different parties. In this report we draw a conceptual distinction between effects of development that are internalised to individuals, and external effects that 'spill over' to other people, parties, or ecosystems.

Both internalised and external effects should be considered when assessing the overall impact of urban development on wellbeing. The net benefits that people experience from developing, occupying and using new buildings and urban places contribute to wellbeing.

However, external effects are a primary consideration when asking whether there is a need to adopt a different approach to manage or attribute the costs and benefits of urban development. If urban development results in large external effects that are *not* managed or attributed by current policies, there may be a case to consider alternative policy approaches. Conversely, if no external effects can be identified, it may indicate that current policy is working well.

[4] Available at http://www.un.org/en/development/desa/population/migration/data/estimates2/estimates17.shtml

In practice, the line between internalised and external effects can be blurry. For instance, there is evidence that living in more 'car-dependent' places reduces the amount of time that people spend walking, which in turn damages their health (Montgomery, 2013). Because it is unpleasant to be unhealthy, people are likely to take this into account, to some extent, when they choose where to live and how to travel. However, some health costs are externalised onto the public health system, or onto friends and family. It is also possible that people under-estimate how much of an impact physical inactivity may have on their health and life satisfaction in the long run, causing them to make decisions that, in retrospect, were sub-optimal.

Benefits that are internalised by producers and consumers

First, urban development affects people who have a direct (financial or contractual) stake in development, either as a developer or a buyer / user of new urban places. In economic parlance, this is the 'producer surplus' and 'consumer surplus' that arises from urban development.

For instance, the development of a new apartment building affects the developer, who must buy a site, design and consent the new building, finance its construction, and, they hope, sell the finished units at a price that will compensate them for the effort and risk they incurred in the process.

It also affects the people who live in the finished apartments. Residents must pay to buy or rent units, but they also benefit from the opportunity to live in a desirable location or in an attractive building. Likewise, if the developer built an office building instead, the businesses and workers that occupied it would pay rent in exchange for the benefits offered by the location and the building.

In general, it is reasonable to assume that urban development results in net benefits for people who develop, occupy and use new buildings or places. If that were not the case, then people would presumably choose a better alternative instead. These benefits are important and should not be discounted. If they are not considered it may give the erroneous impression that urban development is a net cost to society.

Moreover, people may receive higher or lower benefits from urban development in different locations. For instance, holding other factors equal, most people would prefer to live by a beach or in a warm climate. Likewise, and also holding other factors equal, most people would prefer to live somewhere that offers them a shorter commute to work.

External costs and benefits

Second, urban development can also generate external costs and benefits that accrue other people or parties who do not have a direct financial or contractual stake in the development. Following the discussion above, these can be loosely divided into three categories:

- Agglomeration benefits, or positive spillovers between people in cities
- Congestion and crowding impacts, or negative spillovers between people in cities
- Environmental impacts, or feedback between humans in cities and natural ecosystems.

Because urban development is a spatial process, these externalities are also spatial in nature. Our review of the theoretical and empirical literature suggests that different types of external costs and benefits can arise over distinct geographic scales:

- Macro: Some costs and benefits arise at the regional (or even national) scale. This could include, for instance, congestion impacts on major regional or inter-regional roads, consumption of regionally-

significant open space, or, more positively, agglomeration economies that arise at a regional level due to better links between firms and workers and the resulting central government tax revenues on higher wages in cities, which can be shared with other regions.

- Meso: Some costs and benefits arise at the sub-regional level, eg within or between suburbs. An example would be increased development that places pressure on local school rolls and required the construction of a new school.
- Micro: Some costs and benefits arise at the neighbourhood, street, or building level. New development can have a positive or negative impact on neighbours, depending upon how it is designed and how it interacts with the street and other buildings. For instance, tearing down and replacing a derelict building may improve neighbourhood aesthetics, whereas tearing down a heritage-listed building for a carpark may not.

We see all three spatial scales as important and worthy of consideration in this research. Moreover, we emphasise that individual acts of urban development can have both positive and negative effects that arise over multiple scales, and accrue to different people or parties.

For instance, consider what might happen when a new supermarket is developed in an existing suburb. The supermarket may offer a wider variety of products than existing stores, potentially at a lower price, benefitting people living in the entire suburb. However, if its carpark is poorly designed, many cars may have to entering and exiting to a busy street, delaying other traffic, causing crashes, and preventing people from walking along the street. For some residents, these local problems may offset the benefits of having a new supermarket in the area.

The external impacts of urban development may play out over different timeframes, as Duranton and Puga (2004) observe. For instance, a new supermarket opening up on a busy road may have an immediate impact on traffic congestion due to added customer trips, while damage to water quality from increased contaminant runoff from roads and paved surfaces may take place more slowly but be harder to unwind.

Moreover, patterns of urban development tend to be highly persistent. Buildings and infrastructure are durable and often out-last their original purposes. For instance, Dalgaard et al (2018) finds that places where the Romans built more roads two centuries ago are still more developed and densely settled today.[5] Similarly, land titles – the cadastral pattern – tend to be highly persistent even in the wake of major fires and other natural disasters (Hornbeck and Keniston, 2017).

As a result, it is important to consider impacts over a timeframe of multiple decades, or potentially even multiple centuries.

Distributional impacts

Some effects of urban development are best thought of as transfers between different groups, rather than net costs or benefits for society. Changes in prices resulting from urban development can have distributional impacts.

For example, consider the impacts of an influx of international tourists to a local market. The net benefit to society would be equal to the added tourist spending, minus the costs to serve tourists and the environmental and cultural impacts from added tourism.

However, if tourist use of Airbnb accommodation drove up rents in the rest of the housing market, it would affect the distribution of wealth and income between different people. Existing renters would lose out, as they

[5] In Europe, many of the road corridors laid down by the Romans have remained continuously in use, meaning that they have shaped economic activity on an ongoing basis. Conversely, in North Africa wheeled vehicles were abandoned in favour of camel caravans, Roman roads fell into disrepair, and they ceased to influence the location of economic activity.

would have to pay more for housing. Their losses would be balanced by gains for landlords, who would earn higher rental income. Society as a whole may be no better or worse off as a result, but some individuals would gain or lose.

Conversely, impacts on rents could in turn be moderated by development of new visitor accommodation. If some people chose to build sleepouts or granny flats to host Airbnb guests, it may reduce pressure on the rest of the rental market. In this case, distributional impacts on renters may be minimal, while benefits would accrue to locals who constructed new accommodation.

The distribution of these impacts between different people and parties can be important. We therefore consider whether urban development can have this effect at a broad scale, and, if so, how those effects can be assessed.

Expected versus actual effects

In general, this report focuses on effects of urban development that can be observed or measured, either directly or indirectly.

However, we highlight that people's expectations or perceptions about the effects of new urban development may be different than what actually happens in practice. Expected impacts are frequently relevant for politicians and policymakers, as people often choose to oppose or support new development based on what they think will happen.

Anecdotally, people often believe that new development in their neighbourhood will reduce their quality of life and hence the value of their homes. They may fear that new development will increase traffic congestion, cause noises late at night, encourage property crime, consume scarce on-street parking, damage the aesthetics of the neighbourhood, and so on and so forth, while discounting the potential for new development to generate benefits for the neighbourhood by, for instance, generating demand for new cafes and shops to open up.

These perceptions contribute to 'not in my backyard' sentiments towards new development. As we discuss in Appendix 7: Impacts on neighbours, there *are* in fact many measurable negative impacts that can arise from new development.

However, studies that investigate what happens to neighbouring property values when buildings are redeveloped or renovated commonly find a *positive* impact (see Section 14.5 for a review of relevant research). This suggests that development often improves neighbourhood aesthetics and quality of life, rather than reducing it as feared.

There are several potential explanations for this data. One is that new buildings tend to be more attractive or in better condition than the buildings that they replace. To maximise profits, developers may choose to buy up the 'worst house on the best street' for redevelopment, rather than tearing down a more valuable dwelling. Another is that successful redevelopment may signal to neighbours that they too have valuable development opportunities.

There are several reasons why there may be a gap between the outcomes that people expect and the outcomes that occur in practice. One is that people face information problems: They know what the neighbourhood currently looks like, but they cannot be certain what it will be like after development occurs. They might be less concerned about new development if they were better able to visualise and predict the outcome.

Cognitive biases may play a role in explaining why people expect negative outcomes from new development. Kahneman (2011) suggests that endowment effects, also called status quo bias or loss aversion, often lead

people to place a higher value on current outcomes relative to alternatives. People may prefer things to stay the same because they prefer things they already have to things that they have not previously experienced.

A possible implication is that people may tend to oppose change before it happens, but become habituated to the new status quo after a change. However, we note that this remains a poorly-understood aspect of urban development.

3 Measuring and valuing effects

When attempting to quantify the costs and benefits of urban development we suggest drawing a conceptual distinction between **measurement** and **valuation**.

Measurement means being able to describe and quantify what happens as a result of urban development in different locations. This is often done using models that attempt to capture potential future outcomes from urban development, or through statistical analysis of the outcomes that have been observed as a result of historical urban development. Both approaches have strengths and limitations.

Some examples, with made-up but plausible figures, might be:

- An additional person living in Papakura is expected to drive an average of 40 kilometres a day, emitting around 10kg of CO2 in the process, while an additional person in Sandringham is expected to drive an average of 20 kilometres a day and emit around 5kg of CO2.
- A typical 1000-home subdivision in Western Bay of Plenty is expected to consume around 70 hectares of avocado and kiwifruit orchard, whereas a typical 1000-home subdivision in Pukekohe is expected to consume around 55 hectares of market garden land.
- If another 4000 residents move into central Wellington the council will need to upgrade its wastewater / stormwater infrastructure or risk an additional five sewage outflows per annum.
- A worker with typical skills could expect to earn around $65,000 in Wellington, and contribute $130,000 to national GDP. The same worker would only expect to earn $55,000 and contribute $110,000 to national GDP in Dunedin.

Different effects are often measured in different units, and hence it is not always possible to directly compare them.

Valuation entails identifying how much of an impact they have on wellbeing, often using some common 'unit of account'. Money is often used as a unit of account, but this is not a strict requirement. It would be equally possible (and equally logical) to denominate effects in hours of people's lives, or bananas for that matter.

To value the above examples, we would have to ask questions like:

- What is the social and economic cost of the additional congestion arising from more car travel in various locations? How large are the environmental and health costs of additional vehicle emissions?
- What social and cultural value do we place on having more (or less) horticultural land?
- How much does it cost to upgrade wastewater / stormwater systems? How large are the environmental, social, and cultural costs of not doing so?

Answering these questions requires us to make assumptions about the equivalence between qualitatively different outcomes, such as financial costs / benefits and social or environmental outcomes.

There are several methods for valuing 'non-market' goods or services, each of which is subject to caveats and limitations. In some cases, it may not be possible to meaningfully value some outcomes, especially when dealing with natural environment outcomes that are not directly perceived by humans. In these cases, a 'natural capital accounting' approach can be used instead.

3.1 Challenges for measuring the effects of urban development

It is straightforward to measure some general outcomes from urban development. Remote sensing data on land cover can be used to measure the total amount of land that is urbanised, and which places are urbanised, while Census population data can be used to measure how densely settled different places are.

However, there are several practical and conceptual challenges to consider when attempting to measure the effects of urban development. These relate to:

- The need to distinguish between 'people' and 'place' effects when measuring outcomes
- The need to consider system-wide effects, such as residential mobility
- The potential for nonlinear effects from large changes to urban development
- Data limitations and the cost of cleaning and analysing data

People versus place effects

Distinguishing between the effect of places and the characteristics of individual people is a classic problem for measuring the costs and benefits of urban development. Observed differences in outcomes, such as incomes or transport behaviours, between locations often reflect both 'place' effects and 'people' effects. If analysts do not distinguish between these effects, then they may over- or under-state costs and benefits (Cheshire, Nathan, and Overman, 2014).

When analysing differences in incomes and economic productivity between locations, it is particularly important to consider that people who work in different places may have different types of skills. For instance, somebody working in retail in a suburban shopping mall may have a lower income than somebody working in the city centre head office of a bank. However, they may not have the skills required to raise their income by switching to a city centre banking job unless they first seek further training or education.

Consequently, simply comparing average incomes between these locations is likely to over-state the benefits of shifting job growth between the two locations. Comparing wages between similarly-qualified retail workers in the two locations would bring us closer to a 'like for like' comparison.

This is a key methodological challenge that must be considered for a credible analysis of the effects of urban development.

System-wide effects of urban development

Cities, and systems of cities, include a range of positive and negative feedback loops that may moderate some effects and exacerbate others. These 'general equilibrium' effects can be important for the ultimate outcome from a change.

In the previous section, we discussed how residential mobility, ie people's tendency to move to places that are more attractive, can complicate a simple attempt to calculate the costs and benefits arising from a change to a single city.

Likewise, there is often feedback between housing development, employment growth, and infrastructure provision within cities. Anas and Kim (1996) argue that firms disperse from traditional central business districts into a more 'polycentric' distribution in response to population growth in outlying areas.[6] Dispersal of jobs

[6] https://www.sciencedirect.com/science/article/pii/S0094119096900315

alongside dispersal of workers can therefore offset congestion impacts. In a similar vein, Duranton and Turner (2011, 2012) demonstrate that highway construction in the US has not reduced congestion or travel times, as highway planners envisaged. Instead, people relocated to different home and work locations, and the resulting 'induced traffic' led to a similar level of congestion.

When considering what might happen as a result of future urban development, it is necessary to take these feedback processes into account, and ideally model or estimate them.

Extrapolations may break down when nonlinear effects are present

Economic analysis often focuses on measuring and valuing changes 'at the margin'. Marginal analysis relies upon extrapolating from known trends, and predicting how a small change in one outcome may induce changes in other outcomes. It often assumes that broader economic, social, and environmental conditions do not change significantly as a result of a single, incremental change (the 'ceteris paribus' assumption).

Marginal effects are often relevant to decision-makers. For example, when councils process resource consents for new development they typically focus on how each individual development will affect the urban and natural environment, rather than attempting to forecast broader changes.

However, marginal analysis can go awry when it is used to assess the impact of large changes in systems that exhibit nonlinear behaviours.

For instance, a small change in an existing suburb's density may generate different transport outcomes than a large increase. Low-density suburbs typically have less public transport services, and fewer destinations are within walking and cycling distance. In this context, a small increase in development is likely to increase traffic congestion, as most new residents will be required to drive to most destinations. This will create costs for existing residents.

However, a large amount of development may catalyse other changes that moderate the relationship between local population growth and congestion, and potentially mitigate growth in congestion costs for existing residents. Transport agencies may respond to a large change by supplying new rapid transit infrastructure, allowing more people to avoid traffic congestion. New businesses may open up in the suburb, allowing more people to walk to the shops or to local employment opportunities.

Marginal analysis based on existing trends would not necessarily capture these feedback loops.

Nonlinearities are a particular risk in natural ecosystems. Ecosystems are self-regulating within certain limits, but if they suffer too much damage they may collapse entirely. Moreover, they tend to be irreplaceable, or at least extremely difficult to restore after a collapse.

For instance, a small amount of runoff into a harbour may lead to small damages to water quality that are difficult for people to notice. However, a large amount of runoff may significantly damage water quality and the harbour environment, leading to the loss of fish stocks and safe swimming opportunities. These impacts are likely to be highly noticeable, but it may not be possible to predict them based on observations about what happened as a result of small amounts of runoff.

It is important to take the potential for nonlinear effects into account when analysing what might happen from future urban development. However, nonlinearities may be difficult to model or predict.

Data limitations

Urban development is a spatial process that affects people and environments at various geographic scales. To analyse its effects, it is necessary to be able to access, integrate, and analyse various types of geospatial data.

This is straightforward in principle but can be challenging in practice.

Geographical information systems (GIS) analysis is facilitated by a number of sophisticated tools, including proprietary analysis and mapping software like ArcGIS and open-source tools like QGIS and R. However, the quality of analysis is only as good as the quality of input data, and hence it is often necessary to invest a significant amount of time in data cleaning and integration.

The following broad categories of data are relevant for an analysis of the costs and benefits of urban development:

- Land cover and geography: This may include remote sensing data on land cover (ie whether a given piece of land is urbanised, used for agriculture, or left in a natural state), data on topography, soil quality (ie land use capability data), and natural hazards (eg flood plains, landslide risk, earthquake risk).
- Location of population and economic activities: This includes Census data on population and employment, which can be summarised at a detailed geographic level, district plan zoning maps (held by councils), and potentially proprietary data on specific land uses (eg restaurant listings).
- Property data: This includes property parcel outlines (published by Land Information New Zealand), property valuation data (held by councils and licensed to other parties by CoreLogic), property sales data (same), and data on rental bonds.
- Infrastructure networks: This includes road network maps (open source and proprietary sources available), water / wastewater asset data (held by councils or other infrastructure providers), data on schools and hospitals (from central government), etc.
- Environmental monitoring: This includes air quality and water quality monitoring at selected sites (undertaken by regional councils), plus data from ad-hoc collections.
- Data on people: This principally includes administrative data, tax data, and survey data collected by central government and linked together for research use in Statistics New Zealand's *Integrated Data Infrastructure*.

These data sources are held by different parties and hence it may be difficult to obtain them and join them together for analysis.

In our experience, it is common to encounter unexpected and even counterintuitive problems when attempting to join and analyse multiple data sets. For example:

- LINZ property parcels do not align with council valuation records. Rather than a 'one-to-one' relationship in which each parcel matches to a single valuation record, there is a 'many-to-many' relationship. Some parcels have multiple property titles registered against them, each of which has its own valuation record (eg a block of flats on a single residential sites). And some rating valuations match to multiple parcels (eg a house with a shared interest in a piece of common land).
- Rating valuation data and LIDAR survey data both provide estimates of the size of existing buildings on each site. However, in both Auckland and Wellington we have found that there is a very weak relationship between these two measures – in some cases, LIDAR data indicates that there is a skyscraper on a given site, while rating valuation data indicates a small bungalow.

Before committing to a given analytical approach, it is therefore essential to consider whether these types of practical challenges are likely to arise, and if so, how they can be addressed in a cost-effective fashion.

3.2 Modelling future urban development

If the aim is to assess the costs and benefits of *future* urban development, then it will be necessary to be able to model (or otherwise predict) what might happen as a result. Once again, there are several practical and conceptual challenges:

- Models can be used to educate participants or decision-makers or to predict outcomes at a detailed level
- Models used to analyse impacts must be able to address alternative scenarios
- Different types of models are needed to capture outcomes at different spatial scales
- Multiple models may be needed to measure different types of impacts
- Empirical analysis can substitute for or compliment modelling

Educational models versus detailed predictive models

We highlight a distinction between models that are intended to educate people about key dynamics, and models that are intended to predict and analyse specific outcomes.

Educational models tend to be simpler, and they often omit specific details in order to focus attention on important dynamics of the relevant system. They make high-level predictions about what might happen as a result of a specific change.

In urban economics, there are a number of simple models that illustrate important features of cities. Fujita, Krugman and Venables (1999) and Glaeser (2008) review many urban economics models and discuss what they imply. Simple urban economics models cover issues such as:

- How transport costs and constraints on housing availability shape how people choose where to locate *within* cities (the Alonso-Mills-Muth model)
- How amenity and productivity shape the distribution of people *between* cities, and relative house prices and wages between cities (the Rosen-Roback model)
- How inter-city transport costs and economies of scale in production shape the distribution of economic activity between cities (the Krugman regional agglomeration model).

These models are mathematical in nature and typically provide a few key insights, often with policy relevance.

Van den Belt (2004) outlines an alternative approach to participatory development of educational modelling. She describes a 'mediated modelling' approach in which participants define the structure and inputs to a system dynamics model that can then be used to simulate potential alternatives. This approach relies upon facilitation and computer modelling.

In the following discussion, we focus principally on models that attempt to predict specific outcomes, often at a high level of detail. These models often have 'black box' elements due to their complexity and computational requirements, and hence may be less accessible for people who are seeking an intuitive understanding of urban development systems.

The need to analyse alternative scenarios

As described in the previous section, analysing the costs and benefits of urban development is an inherently comparative exercise. That is, it is necessary to be able to compare what will occur if development occurs in a certain location, or with a certain form and design, relative to another location or another form and design.

Consequently, a key requirement for any modelling approach is that it should be able to simulate and compare alternative scenarios for urban development.

In the appendices, we outline several case studies where models were used to analyse the effect of different urban development on traffic congestion (see Section 13.3), air quality (see Section 16.3), and urban water quality (see Section 16.6). In these cases, alternative scenarios for the location of urban development were defined as fixed model inputs, rather than allowed to adjust in response to modelled outcomes.

These case studies are therefore best seen as 'ceteris paribus' exercises that compare alternative development locations while holding many other factors constant. They do not capture the potential for feedback to other systems.

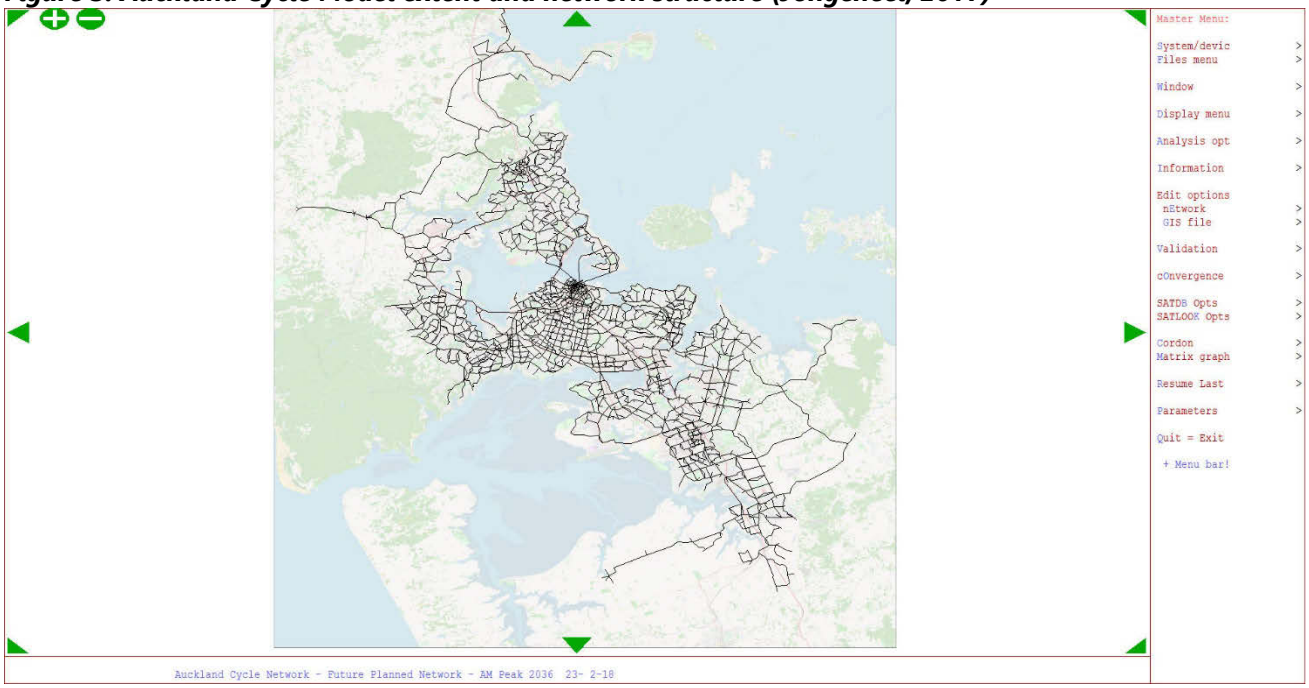
Different models, different scales

There is often a trade-off between the spatial resolution of a model (ie its ability to capture variations in outcomes between places), the types of relationships that are captured in the model (ie its ability to model feedback between outcomes) and the computational complexity of the model.

To illustrate this point, we discuss two models that have recently been applied to assess the impact of cycling investments in Auckland.

Jongeneel (2017) describes the Auckland Cycle Model, which is frequently used to assess the impact of individual cycling investments in Auckland. As shown in Figure 3, the model is spatially disaggregated. It models cycle trips between roughly 1000 zones and assigns them to a network consisting of a large number of cycling links, each of which is assigned a 'relative attractiveness' score that takes into account its length, gradient and the comfort / safety of cycle facilities.

Figure 3: Auckland Cycle Model extent and network structure (Jongeneel, 2017)



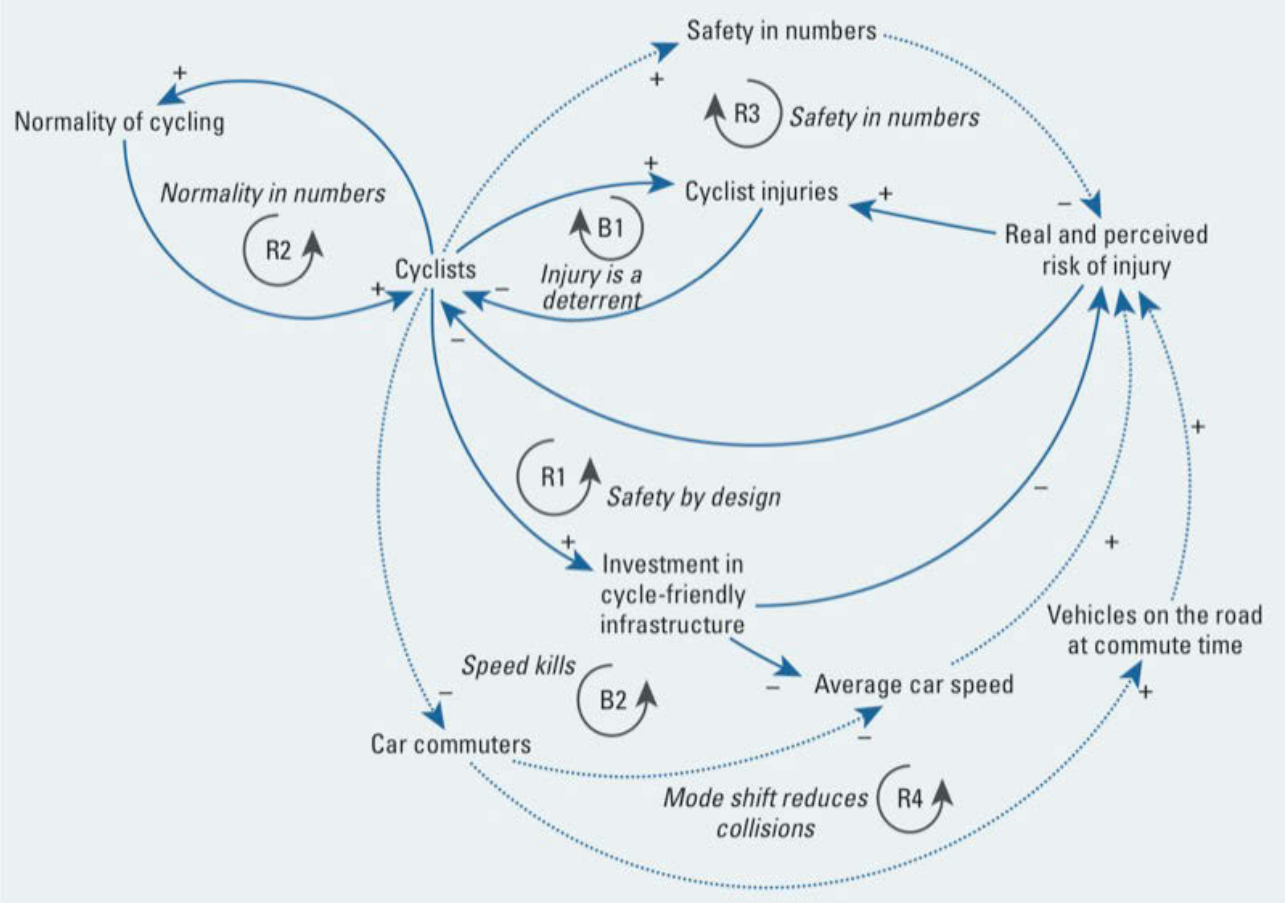
This model is designed to predict how cycling behaviour will change as a result of new cycle facilities on specific streets. To do so, it accounts for variations in cycling use between locations, eg due to proximity to destinations, and predicts the impact of improvements to facility quality by extrapolating from outcomes observed after past changes.

However, the model treats a number of other important factors as fixed inputs. Auckland's total population and the expected future distribution of population between zones are incorporated as a fixed input to the model, although there is some evidence that improvements to cycling facilities can affect people's location choices (Donovan, 2017). Preferences for cycling relative to other transport modes and driver behaviour towards cyclists are also assumed to be fixed.

By contrast, MacMillan et al (2014) use a system dynamics model to predict how cycling behaviour will change in response to broad improvements to cycling facilities. This model, which is explained in Figure 4, captures a feedback between transport investment, transport behaviours and social / cultural preferences. For instance, it allows for increasing visibility of everyday cyclists to 'normalise' cycling and thus increase people's willingness to cycle.

Model processes and inputs were defined based on consultation with experts, and calibrated against observed data for Auckland. MacMillan et al's model therefore captures a broader set of relationships than Jongeneel's model. However, the trade-off is that MacMillan et al's model is highly spatially aggregated as it models outcomes for the city as a whole. It is therefore useful for understanding how the system as a whole may respond to new investments, but does not provide specific predictions for changes to cycle volumes on any particular street.

Figure 4: System dynamics model of cycling demand (MacMillan et al, 2014)



Notes: Causal loop diagram for bicycle commuting developed from stakeholder interviews and workshops, literature review, and data incorporation. Dotted lines denote loops identified by stakeholders and the literature, but where local data suggests they are currently inactive. Arrows with a positive sign (+) indicate that a change in the originating variable leads to a corresponding change in the variable at the arrowhead. Arrows with negative signs (–) indicate that a change in the originating variable leads to a change in the opposite direction for the arrowhead variable (R, reinforcing or positive feedback loop; B, balancing or negative feedback loop).

When using models, it is therefore important to consider whether spatial detail is more important than capturing all relevant system dynamics. If a more detailed model is used, it is essential to ask what the consequences of ignoring some dynamics are.

Loose coupling of multiple models

There are a number of existing models that analyse and predict outcomes in cities. These include:

- Demographic models that predict future changes to population, age structure, and household structure – for instance, Statistics New Zealand uses these models to predict future population growth at a subnational level
- Economic models that predict future growth in economic output (GDP) and employment – for instance, the Ministry for Business, Innovation, and Employment provides short-term projections for industry employment at a regional level and medium-term projections for industry employment at a national level

- Transport models that simulate changes to traffic volumes, public transport demands, and (sometimes) walking or cycling activity based on future population and employment location and transport infrastructure provision
- Integrated land use models such as the Waikato Integrated Scenario Explorer[7] or the Wellington Integrated Scenario Explorer that attempt to predict changes in land use between different rural and urban uses.

Existing models typically only capture some outcomes from urban development, and exclude others. For instance, most transport models predict future changes in how easy it will to travel to and from different locations, but they do not allow this to affect where future population and employment growth will be located. In transport models, locations that become more accessible do not attract more growth, although we know that this happens in practice.

In addition, most existing models address outcomes for a single region only, and do not capture the potential for people to move between regions (or internationally) in response to local changes.

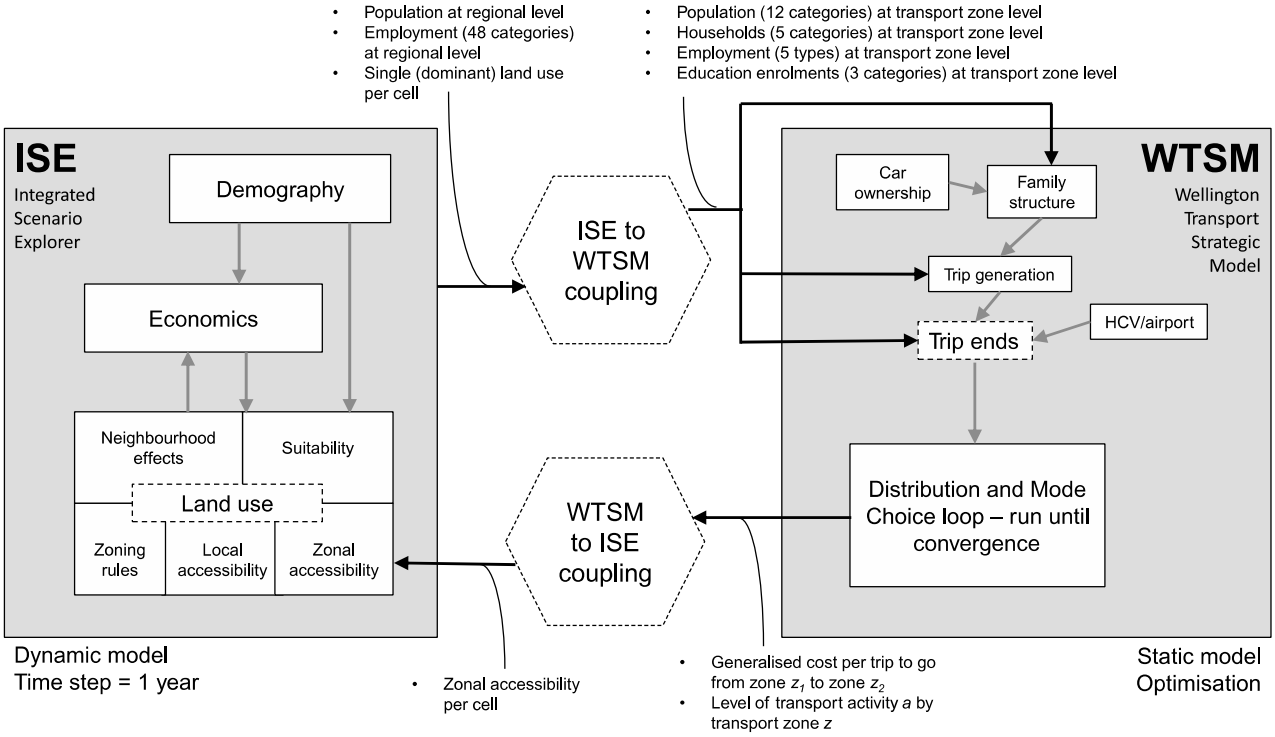
To address this issue, Harvey et al (2018) used a 'loose coupling' approach to integrate land use and transport models in the Wellington region. This approach:

> *allows the existing models to be kept in their original forms and as separate software applications. More specifically, we used manual loose coupling, where the coupling is undertaken manually using coded scripts and analyst input, rather than being fully automated. There are many advantages of loose coupling when there are existing models of subsystems, including the ability to make updates to the component models without needing to change the whole system, shorter development time, and lower initial cost… Disadvantages include decreased version control for data as the responsibility is left to the user, increased user training time due to the manual transfer process, increased risk of human error in the data transfer process, and the need to reconcile different model scales, assumptions, and base datasets without being able to alter the underlying models.*

The following diagram shows how they designed the coupling between the ISE model, which predicts land use change, and the WTSM model, which simulates transport outcomes. However, the high cost of running the WTSM model meant that a limited number of iterations were allowed.

[7] http://www.creatingfutures.org.nz/wise/what-is-wise/#works

Figure 5: Loose coupling of land use and transport models (Harvey et al, 2018)



A loose coupling approach is likely to be useful for modelling the impacts of urban development. The process that Harvey et al outline for integrating land use and transport models is a useful start. However, we believe that there may be a case to extend it to capture:

- Linkages between land use changes and house price and rents, which would provide better information on costs of living and also the economic drivers of urban development
- Migration between regions and internationally in response to local conditions, including changes to productivity and wages, changes to environmental and urban amenities, and the availability and price of housing. Hsieh and Moretti (2015) and Ganong and Shoag (2017) highlight the importance of local conditions, in particular house prices, for inter-regional migration in the United States, while Nunns (2018a) provides some evidence for New Zealand.

Empirical analysis as a substitute for or complement to modelling

Finally, modelling is not the only way, or even the best way, to analyse the costs and benefits of urban development. Empirical analysis of outcomes from previous patterns of urban development can be more valuable than modelling.

Most of the evidence that we review in the appendices is empirical in nature. For instance, when considering agglomeration benefits that can arise from urban development, we draw upon research by Maré and Graham (2009) that uses firm and worker microdata to estimate the degree to which urban scale and density lead to higher productivity in different industries in practice, rather than in theory.

Extrapolating from observed outcomes can be used as a substitute for modelling in some situations. Extrapolations are most likely to be valid when:

- There a low likelihood of nonlinear effects that lead to major divergences from observed trends

- Statistical analysis provides a good basis for identifying causal effects, as opposed to simple correlations between outcomes that may arise due to omitted variables.

Empirical analysis should also be used to complement or sense-check modelling.

A practical example relates to the use of transport models to predict the impact of urban development on congestion levels. As noted above, most transport models treat population and employment location and transport infrastructure provision as fixed inputs that do not adjust in response to modelled transport conditions. As a result, they may over-estimate the impacts of urban development on congestion (if they fail to account for the fact that some jobs will shift to be closer to new residents) or under-estimate impacts (if they fail to account for the fact that new roads will attract induced traffic).

Outcomes from transport modelling of alternative urban development scenarios can be validated against data on the link between urban form and transport outcomes. The relationship between distance to the city centre and vehicle kilometres travelled (VKT) per person is a key summary statistic. Based on a review of international studies, Ewing and Cervero (2010) suggest that the elasticity of VKT with respect to distance is around -0.2. This implies that doubling distance to the city centre should, on average, increase VKT by 20%.

If a scenario is expected to result in a significantly different VKT gradient, then it suggests that it is not a realistic scenario.

3.3 Concepts for valuation

Some of the external effects of urban development are financial or economic in nature, and hence straightforward to value and compare. This includes effects such as infrastructure costs and impacts on economic productivity via increased agglomeration economies.

However, urban development also has a variety of non-economic effects, including environmental, social, and cultural impacts. To compare different types of effects using a common unit of account, is necessary to make assumptions about the economic or financial value of non-economic costs and benefits.

There is no ideal way to to do this. In some cases, the challenges associated with valuing non-monetary outcomes may be too large to make valuation a realistic exercise. However, it is often possible to at least partly value many non-monetary effects.

To value effects, it is necessary to start by asking what people value, and how. Values are inherently subjective, and two different people may place very different values on the same outcome. Nonetheless, it is important to start with this question, rather than imposing the analyst's perspective about what they should value.

People can only value things that they perceive. Where there are significant unperceived effects, which is common when dealing with environmental impacts, valuation may not necessarily be meaningful. In these cases, an 'accounting' approach designed to preserve a given level of natural capital stocks as a bequest for future generations may be more appropriate.

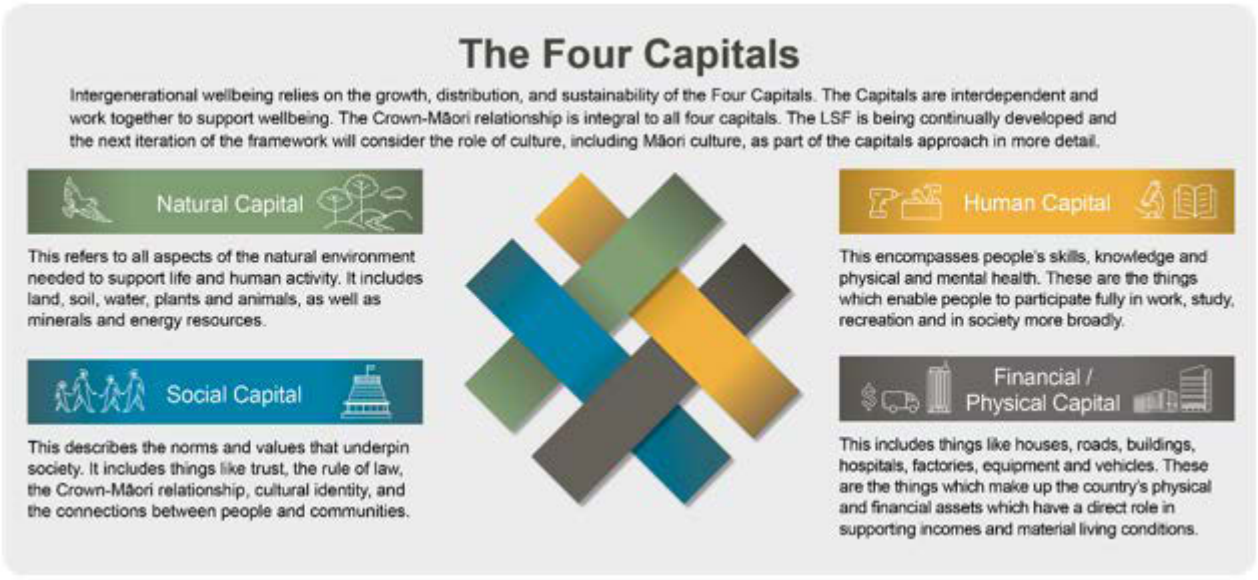
A focus on wellbeing

The brief for this work is not restricted to financial impacts of urban development, such as impacts on infrastructure costs or impacts on economic output (gross domestic product). Rather, the brief encompasses broader impacts on living standards and wellbeing.

In recent years there has been a move away from narrow 'financial' measures of wellbeing and towards more holistic measures that include environmental, social, cultural, and economic costs and benefits. In New Zealand, this is exemplified by the Treasury's *Living Standards Framework* (LSF), as well as the notions of sustainability in the Resource Management Act (RMA) which is the framework legislation for urban planning in New Zealand.[8]

As shown in Figure 6, the LSF expands from a focus on 'flows' of wellbeing, such as annual income or annual economic output, towards consideration of 'stocks' of natural, social, human, and financial/physical capital that can sustain present and future wellbeing.

Figure 6: The 'four capitals' addressed in the Treasury's Living Standards Framework



Some of the costs and benefits of urban development are straightforward to consider in 'flow' terms. This includes, for instance, wage premia that people may earn from living in productive cities and the costs of congestion that they face while travelling in cities.

However, other costs and benefits relate to the creation or destruction of stocks of natural, social, human, and physical capital. Urban development can create durable buildings and infrastructure that can have a persistent (positive or negative) impact on wellbeing.[9] Urban development can also affect natural ecosystems, potentially in an irreversible way.

Total economic value

A common framework is required to assess flows of wellbeing and how they are affected by the availability and use of natural, social, human, and financial/physical capital. Total economic value (TEV) is a useful framework for identifying and valuing different streams of costs and benefits, including financial and non-financial outcomes.

Figure 7 summarises the TEV framework and provides examples of how this approach would apply to valuing the benefits of a river environment.[10] It distinguishes between use values, which relate to the benefits that people

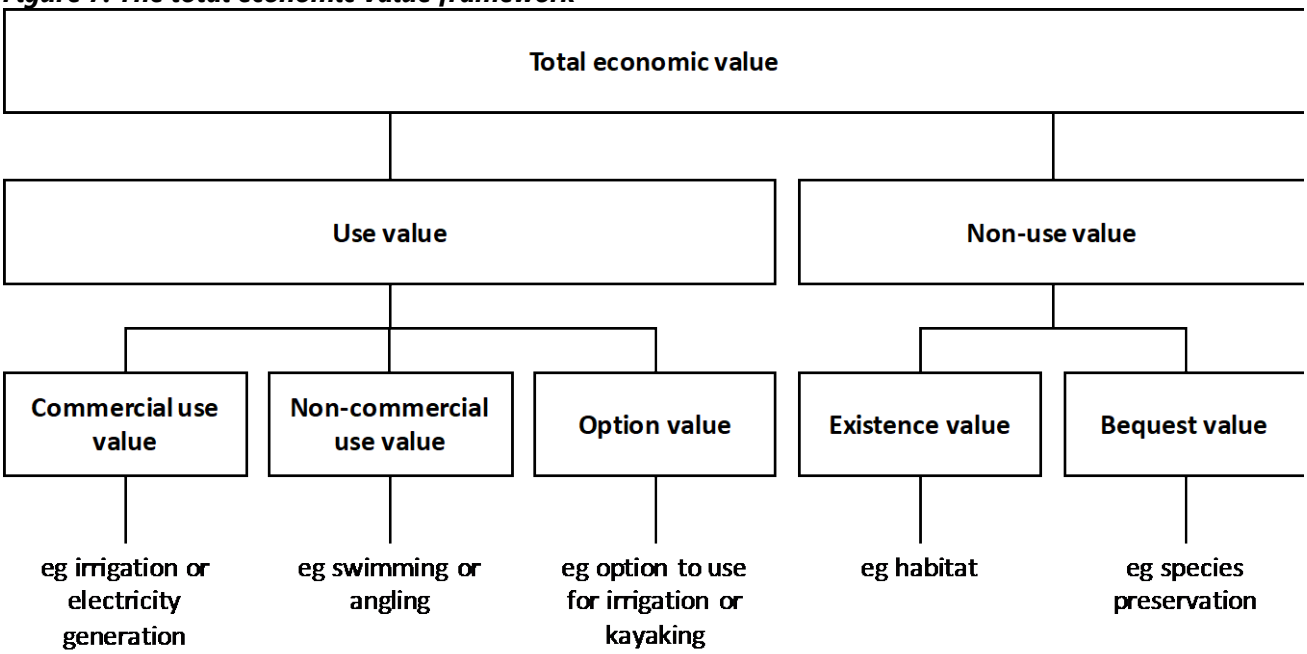
[8] https://treasury.govt.nz/information-and-services/nz-economy/living-standards
[9] For instance, transport investments like the London Underground, the US interstate highway system, and – locally – the Auckland Harbour Bridge have shaped urban growth (Heblich, Redding and Sturm, 2018; Duranton and Turner, 2012; Grimes, 2011). The effects can last decades or even millennia, as shown by the impact of Roman roads on present-day regional development in Europe (Dalgaard et al, 2018).
[10] This example is drawn from http://www.mfe.govt.nz/publications/fresh-water-rma/option-and-existence-values-waitaki-catchment/3-total-economic-value

receive from current use, or expect to receive from future use, and non-use values, which reflect the value that people derive from the existence of natural or man-made capital and the opportunity to bequest it to future generations.

The framework also distinguishes between commercial use values, which arise from uses that people pay for, and non-commercial use values, which arise from uses that people enjoy but do not pay directly for. Option values relate to preserving flexibility for future commercial or non-commercial use.

Measures of economic output, such as gross domestic product, typically only reflect commercial use values, and exclude other use and non-use values. Capturing the value of non-commercial uses, option value, and non-use values requires some information on the equivalence between monetary and non-monetary outcomes. We cover this below when discussing non-market valuation techniques.

Figure 7: The total economic value framework



Natural capital accounting and bequest value

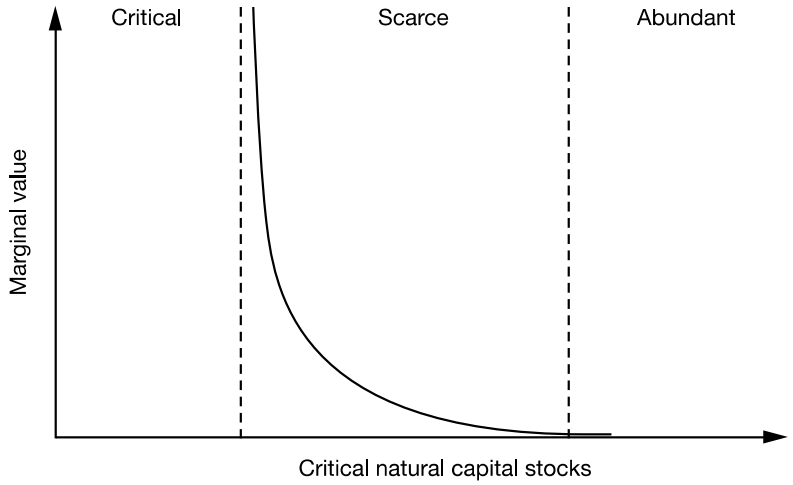
Some outcomes may be difficult to value using 'flow' measures of value. This issue is particularly acute when dealing with natural capital, due to the fact that many outcomes may not be perceived by humans in the short term. In these cases, a natural capital accounting approach may be more appropriate.

Van den Belt and Cole (2014) observe that the perceived value of natural capital may rise as it becomes scarce or degraded. Current perceived values may therefore be a poor guide to future values:

> *Most ES [ecosystem services] are essential, non-rival (i.e. the enjoyment one person derives does not subtract from the enjoyment of another person) and non-substitutable, and frequently have thresholds beyond which the ecosystems that provide them cannot regenerate. Therefore, Costanza et al. (1997) suggested that the demand curve is like that represented in [the following diagram], where each point on the curve represents the sum of marginal benefits for all beneficiaries. For ES, the demand curve is almost vertical where supply ('critical natural capital stocks') is the minimum necessary to meet human needs.*

This can be for survival or alternatively can be the minimum required for the ES to regenerate or avoid destructive positive feedback loops, such as in run-away climate change.

Figure 8: Estimation of consumer surplus for an essential, non-rival and non-substitutable ecosystem service (van den Belt and Cole, 2014)



In response to this issue, Barbier (2019) and Helm (2019) recommend focusing on the sustainability of asset levels rather than evaluating flows of costs and benefits. In a different but relevant context, Chichilnisky (1996) develops a coherent framework for considering an evaluation of costs and benefits that includes both flows and long run stock levels and demonstrates that it better reflects long-term sustainability of wellbeing than a purely flow-based approach.

An example would be the current global policy approach of holding climate change to 'well below two degrees of warming'. Rather than attempt to measure and value the impacts of different amounts of climate change, the focus is on setting a threshold for what is likely to be a relatively safe outcome.

We see this approach as most appropriate for ecosystems and environments that may be affected by urban development, as issues around irreversible impacts and inability to perceive effects are most acute in this area. It is less appropriate for addressing issues that principally arise in the built environment or between humans, as people are more likely to be able to perceive and value these impacts.

Putting this into practice would entail:

- Identifying key ecosystems and environments that may be affected by urban development. The review in the appendices suggests that areas of biodiversity and native bush, freshwater streams and lakes, and coastal and marine areas are likely to be the main cases.
- Identifying a long-term sustainable level for these ecosystems and environments.
- Defining an approach to ensure that these ecosystems and environments are sustainable, eg by minimising urban development that might affect them or by requiring development to be designed in a way that mitigates or avoids impacts.

3.4 Non-market valuation methods

For non-monetary outcomes where a natural capital accounting approach is not appropriate, non-market valuation methods can be used to identify the broader benefits outlined in the total economic value framework.[11]

Non-market valuation techniques attempt to measure the trade-offs that people make between money and other environmental, social, or cultural outcomes. There are three basic approaches:

- 'Market-based' techniques rely upon evidence on what people actually pay for access to a given amenity, or what costs they would incur if it were not available. For instance, this could entail looking at how much money people spend to book campsites in national parks, or the cost to replace a wetland's flood protection role with flood control infrastructure like seawalls and pump stations. These techniques typically only provide a lower bound estimate on the value of non-market goods or services as they do not account for the consumer surplus that people obtain from their expenditures.
- 'Stated preference' evidence relies on asking people how they would trade off competing 'goods'. An example would be a survey that asked people whether they would prefer to pay a small toll to reduce their commute time by ten minutes, or whether they would be willing to pay more in rates to fund biodiversity protection. This is also called the 'contingent valuation' method. Another method is choice modelling, which asks people to choose between alternative goods.
- 'Revealed preference' evidence relies on observing what people actually do when faced with a choice. An example would be a study of whether residential properties downwind of an industrial emitter were less valuable than similar properties upwind, or whether homes next to major parks sell for higher prices than homes several kilometres away. Revealed preference methods include hedonic analysis of property sales and the travel cost method.

These methods are widely used and their strengths and weaknesses are covered in a variety of papers, including Brander and Koetse (2011) and van Zyl and Au (2018).[12] Consequently, our discussion focuses on a few key points about SP and RP techniques.

Stated preference methods

Stated preference methods include:

- Contingent valuation: this entails presenting people with a hypothetical situation in which they must state how much they would be willing to pay for or how much compensation they would be willing to accept in exchange for a given outcome
- Choice modelling: this involves presenting people with a range of discrete alternatives and asking them to choose their most preferred alternative. The results can then be analysed to estimate willingness to pay for certain outcomes.

Stated preference studies often provide a 'bundled' estimate of the non-commercial use values, option value, and non-use values that people derive from a given outcome. For instance, if people state that they are willing to pay (say) $100 per annum to clean up a local beach, they may be thinking of the value they get from visiting the beach, and the value they place on its continued existence for future generations.

[11] Non-market valuation methods can capture non-use values, as people frequently express a willingness to pay to preserve places they do not (intend to) visit. Chan, Satterfield, and Goldstein 2012) also argue that it is difficult to ask people to place a monetary value on cultural values through which the ontological importance of all things is understood. There may be intrinsic challenges to measuring values that do not fit will in an economic framework using an economic framework, especially where the resulting economic decision-making framework is touted as complete. They advocate for multi-method approaches to assessing value including individual, expert and group-deliberative processes as an alternative.
[12] Brander and Koetse also point out that SP and RP methods estimate different measures of consumer surplus. SP methods estimate compensating and equivalent surplus, while RP methods estimate Marshallian consumer surplus. For large changes in the price or availability of goods, these two methods will produce different outcomes.

However, stated preference studies can be subject to 'hypothetical bias', because people do not actually bear the cost of their choices. Moreover, they can obtain different results depending upon how questions are stated. Consider two alternative ways of asking survey participants how they value views:

- Approach 1: "How much would you be willing to pay (WTP) to obtain a view of a notable landscape?"
- Approach 2: "How much compensation would you be willing to accept (WTA) in exchange for giving up a view of a notable landscape?"

In theory, we would expect people to give the same answer to both questions. If somebody was willing to pay $10 to obtain a view, it seems logical that they would also be willing to accept $10 to give up that view. In practice, people give very different responses to these questions. As Kahneman, Knetsch and Thaler (1990) document, measured WTA values are usually several times higher than WTP values – reflecting that the expected pain of losing something is typically larger than the expected pleasure of obtaining it.

Revealed preference methods

Revealed preference methods include:

- Travel cost analysis: this entails analysing the distance that people have travelled to access a specific location, and the costs that they have incurred in order to do so. This provides information on the shape of the demand curve for the amenities located in that place.
- Hedonic pricing: this involves analysing how property prices vary depending upon access to or exposure to a specific amenity or disamenity, after controlling for other factors that also affect prices. This provides information on whether people are willing to pay for close proximity to a given location.

Revealed preference methods tend to provide more information on non-commercial use values on non-use values. For instance, people may be willing to pay more to live close to a beach because they value the opportunity to swim or sunbathe there. But the price they are willing to pay is unlikely to reflect the value they place on the continued existence of the beach for future generations.

The hedonic pricing method is relevant for measuring a variety of costs and benefits in urban environments. The literature reviewed in the appendices suggests that it can be used to value effects ranging from the impact of blocked views to the effect of new development on neighbouring properties to the value that people place on access to theatres and cafes.

Hedonic pricing is most relevant for measuring costs or benefits that depend upon close physical proximity or accessibility to a specific location, such as a park or a beach. In these cases, the degree to which house prices rise (or fall) with proximity can be used as a measure of the value that people derive from them.

Transport infrastructure that improves access to an amenity can reduce the value associated with immediate physical proximity. This does not mean that people are now deriving lower benefits from this amenity, but that those benefits are distributed over a larger area and hence are more difficult to measure.[13]

Costs and benefits that arise at a regional or national level, such as city-wide traffic congestion or air quality, are harder to measure using the hedonic pricing method. In theory, comparing average house prices between cities might provide information about overall benefits of different locations.

[13] Some studies have responded to this issue by measuring access to amenities via transport networks (de Groot et al, 2015).

In practice, this may not be a valid comparison as regional house prices can also be driven up by scarcity of housing relative to demand. A growing city that is not succeeding at building enough new homes may have higher prices than another city that is building more homes. Higher prices in the first city indicate that something has gone wrong with housing development – not that the city is offering rising benefits to residents.

Although hedonic analysis is useful for measuring external costs and benefits that have a spatial dimension, care is needed when applying it and interpreting the results. It may not be able to value many amenities accurately.

4 Identifying costs and benefits of urban development

In this section, we address the first research question, which asks: "What are the range of costs and benefits associated with urban development?" We classify costs and benefits according to whether they are internalised to residents or other users of new urban places, or externalised on other people or on the environment.

4.1 Previous studies of costs and benefits

To define and classify costs and benefits that can arise from urban development, we reviewed several recent attempts to measure some of the costs and benefits of urban development in Australia, New Zealand, and the United States (summarised in Appendix 1). We then undertook a broad review of the literature on specific types of costs and benefits that arise from urban development, urban form, and cities in general to fill gaps that were not addressed by those studies (summarised in Appendices 2 through 11).

The four most relevant studies we identified were:

- A study by the Centre for International Economics (2010) that looked at the costs and benefits of alternative urban growth scenarios (ie more greenfield expansion or more intensification) in Sydney, and a follow-up study by the Centre for International Economics and Arup (2012) that compared alternative scenarios for intensification
- A study by the Victoria Transport Policy Institute that looked at the costs and benefits of higher- or lower-density urban development in United States cities (Litman, 2015).
- A research paper by Nunns and Denne (2016) that estimated and compared the marginal external costs and benefits of greenfield development and urban intensification in Auckland.

These studies focused on analysing the differences between alternative locations for urban development within cities, rather than measuring the impact of a larger or smaller amount of development. A common finding was that redevelopment or infill development in existing urban areas tends to result in smaller external costs than greenfield development on the urban fringe.

Although these studies all compiled outcomes into a single reporting framework, they did not employ a single model or method to measure and value different categories of effects. Instead, they used a mix of methods to estimate costs and benefits, including compilation of infrastructure cost estimates, analysis of transport model outputs or observed transport data, and application of various non-market valuation methods to quantify non-financial impacts.

A limitation of these studies is that they generally focused on external costs and benefits, and paid less attention to a comprehensive analysis of internalised costs and benefits. Moreover, a review of the broader literature suggests that none of these studies succeeded in capturing the full range of costs and benefits of urban development, although they frequently assessed the most material impacts.

4.2 A taxonomy of costs and benefits

Table 4 defines ten broad categories of costs and benefits that can arise from urban development, many of which include sub-categories of effects. The aim of this table is to provide a general framework for classifying

the effects of urban development and identifying specific effects for which there is some evidence. To that end, it includes:

- One category that addresses the costs and benefits that are internalised by individuals, including costs of living and benefits of certain locations.
- Two categories that reflect the external benefits of urban development. These reflect the fact that proximity and scale can lead to social benefits, which are often described as agglomeration economies.
- Six categories that cover distinct types of external costs (and sometimes benefits) of urban development. We have identified a wider range of social costs to reflect the distinct mechanisms that can generate costs, and emphasise that the proliferation of categories does not imply that costs outweigh benefits.
- One category that addresses distributional impacts that arise from increases or decreases in house prices and rents. This is important for thinking about how urban development can affect income and wealth inequality.

One thing that we have not included is a category for the external costs of communicable diseases in cities. Historically, disease burden was *the* major disadvantage of living in a city, as being close to other people helped spread cholera, plague, etc. However, improvements to water supply and sanitation and improvements to the quality of housing have largely eliminated these ills (see Schrader, 2016, chapter 7 for a discussion of urban health in New Zealand). Today, discussions of cities and health are more likely to focus on the impact of transport behaviours on 'diseases of inactivity' like diabetes and obesity.

A key point emerging from this review is that urban development generates a range of internalised benefits for residents and and external benefits for society. For the most part, these benefits are likely to be larger than the costs, meaning that urban development is usually a net positive for society. However, because benefits and costs may accrue over different geographical scales, to different people, it may be difficult for people to perceive them and factor them into decisions.

To guide thinking on these issues, Table 4 identifies the geographic scale over which effects vary, the scale over which they must be measured, and factors that can mitigate or exacerbate effects.

For example, the costs of increased traffic congestion are likely to vary at a 'meso' level. This reflects the fact that people living in different suburbs may drive longer or shorter average distances to work and shopping, or have different access to public transport, walking, and cycling options. However, these effects must be measured at the 'macro' level, because congestion is a region-wide issue and people typically commute outside of their home suburbs.

The empirical literature indicates that impacts on traffic congestion may be exacerbated or mitigated by factors such as:

- Location within the city: Places that are further from major employment centres and other key destinations tend to generate longer car trips
- Street design: Congestion may be exacerbated by inefficient street networks that concentrate traffic on a small number of roads, or, conversely, reduced by street grids or major ring roads
- Availability of non-car transport options: Where good-quality public transport, walking, and cycling options are available, it can reduce the need to drive and hence mitigate congestion impacts of new development.

To give another example, the costs of overshadowing neighbouring buildings or blocking their views are likely to vary at a 'micro' scale. They are affected by local topography, the design of new and existing buildings, and the relationship of buildings to the street. As a result, these effects must also be measured at a micro scale.

The empirical literature indicates that the cost of overshadowing and blocked views will be affected by factors like:

- Density: Exposure to these effects will generally be higher in higher-density areas
- Location in relation to coastal or lakefront views: Most New Zealand evidence indicates that people place a high value on water views and a lower value on views of land
- Topography: Presence of hills, valleys, and slopes may affect the likelihood of overshadowing and blocked views
- Design: Buildings can often be designed to minimise impact on neighbours, albeit at a cost in terms of foregone development potential.

The following section summarises further findings about the quality of existing evidence on these effects, the availability of data and methods to measure and value them, and the potential magnitude of each effect.

Table 4: Categories of costs and benefits arising from urban development

Category	Sub-categories	Scale over which effects vary	Scale over which they should be measured	Factors that can exacerbate or mitigate effects
Costs and benefits that are internalised by residents	Costs of living in different locations	Meso / micro	Meso	Cost to build new housing; transport and energy costs; scarcity of housing and development capacity
	Benefits of living in those locations	Meso / micro	Meso	Natural amenities (eg climate, beaches); agglomeration benefits, eg better access to economic and social opportunities People's access to alternative housing options
Agglomeration benefits	Agglomeration in production	Meso	Macro	City size; density; location / accessibility; industrial composition; workforce characteristics (eg skill levels)
	Agglomeration in consumption	Meso	Macro	City size; density; location / accessibility; design of urban places
Social and economic benefits of growth in 'declining' regions		Macro	Macro	City growth; unemployment levels; industrial composition; workforce characteristics (eg skill levels)
Infrastructure and public service costs	Transport infrastructure	Meso / macro	Meso / macro	Infrastructure construction and maintenance costs; transport volumes; willingness to accept congestion; charging policy
	Water, wastewater, and stormwater	Meso / macro	Meso / macro	Infrastructure construction costs; green water design; charging policy
	Power and communications infrastructure	Meso	Meso	Infrastructure construction and maintenance costs; energy efficiency; charging policy

	Parks and community facilities	Meso	Meso	Infrastructure construction costs; availability of existing parks; willingness to accept crowded / low quality parks; charging policy
	Public services, eg health and education	Meso / macro	Meso / macro	Infrastructure and public service costs; economies of scale in provision; willingness to accept crowded / low quality services
Transport network effects	Increased traffic congestion	Meso	Macro	Location; street design; availability of non-car transport options; cost of car ownership and parking
	Traffic noise	Meso	Micro	Location; design of roads and nearby homes; vehicle fleet characteristics; availability of non-car transport options
Impacts on neighbours	Overshadowing of existing buildings	Micro	Micro	Density; topography; building design
	Blocked views	Micro	Micro	Location (coastal / lakefront areas); density; topography; building design
	Changes to neighbourhood aesthetics and crowding	Micro	Micro	Building design; density
	Nuisances from incompatible activities	Micro	Micro	Types of activities; proximity
Consumption of open space	Foregone environmental services	Meso	Macro	Location; type of open space being developed; characteristics of existing ecosystems; density; green design features
	Foregone aesthetic and recreational benefits	Meso	Macro	Location; type of open space being developed; density; green design features
	Foregone option value, bequest value, and existence value	Meso	Macro	Location; type of open space being developed; characteristics of existing

				ecosystems; density; green design features
Air and water quality	Health impacts of air pollution	Meso	Meso	Location; transport volumes; building design (ie heating sources)
	Climate change impacts of GHG emissions	Meso	Macro	Location; transport volumes; building design (ie heating sources)
	Reduced freshwater and coastal water quality	Meso	Macro / meso	Location, especially proximity to water bodies; characteristics of existing ecosystems; density; infrastructure design
Social and cultural effects	Health impacts of changes to transport behaviour	Meso	Meso	Location; density; mix of residential and business activities; street design; availability of walking and cycling facilities
	Mental health impacts of built environment	Micro / meso	Micro / meso	Location; density
	Impacts on social capital, trust, and community cohesion	Micro / meso	Meso	Density; neighbourhood design; home ownership
	Cultural impacts from modifying places	Micro	Micro / macro	Design; characteristics of site being developed
Distributional impacts on house prices and rents	Transfers between renters / first home buyers and property owners	Macro	Macro	City-wide constraints on housing supply; scarcity of housing; growth rates

5 Summary of the evidence base

In this section, we summarise our key findings from a review of the empirical literature on the categories of costs and benefits of urban development that are identified in the previous section. The aim of this summary is to review the state of existing knowledge, identify methods and data sources that can be used to measure and value effects, and highlight key gaps in our understanding.

This section addresses the second research question, which asks: "**What appraisal approaches, measurement methodologies and the range of metrics are available to value environmental, social and economic costs and benefits?**"

We have reviewed a large volume of evidence and research and hence this is intended to be a high-level summary, rather than a detailed discussion of any specific effect. Appendices 2 through 11 provide further detail on each category, including case studies that demonstrate how some costs and benefits have previously been measured or valued.

5.1 Quality of the evidence base

This sub-section addresses RQ2, bullet 3: **"What impacts can be measured and/or monetized today and with what certainty?"**

To do so, we review and summarise the quality of the available evidence on each category of costs and benefits:

- Focusing on New Zealand-specific evidence where it is available
- Reviewing relevant international evidence to support findings from New Zealand-specific studies or to help develop an understanding of effects for which little New Zealand-specific evidence is available
- Concentrating on research or other studies that are publicly available, ideally in peer-reviewed academic journals but also in working papers, technical reports, and policy briefs where appropriate

The quality of evidence for different costs and benefits varies significantly, and hence we may be less confident in our ability to measure and value some impacts based on the existing evidence. Table 5 summarises the quality of evidence, scoring each category on a high/medium/low scale:

- 'High' means that peer-reviewed local evidence exists and is supported by a meta-analysis or systematic analysis of the international literature. We can be confident that these effects exist and usually be reasonably confident about how large they are and what factors exacerbate or mitigate them.
- 'Medium' means that peer-reviewed international evidence exists, but no local evidence is available and/or that some local evidence exists but may be circumstantial or has not been peer reviewed. These effects are likely to exist but there may be uncertainty about how large they are or how they may manifest in the New Zealand context.
- 'Low' means that there is some evidence for the existence of these effects, but it is anecdotal, severely limited in scope, or otherwise insufficiently robust. These effects may exist, but without further research and analysis it is difficult to be confident about how large they are and what factors may exacerbate or mitigate them.

In each category, we identify one or more key studies that provide relevant, although not necessarily exhaustive, evidence on the cost or benefit in question. The appendices summarise a broader range of studies.

A key finding is that there is a dearth of high-quality evidence on most costs and benefits of urban development. Only three sub-categories (out of a total of 27) were assigned a 'High' rating, while nine were assigned a 'Medium' rating. The remaining 15 sub-categories were assigned a 'Low' rating, reflecting the fact that there is little robust, publicly-available, and New Zealand-specific evidence on them.

The three categories of effects we have scored as 'High' are:

- Agglomeration benefits in production: This is one of the primary external benefits that arises from urban development. There is a well-developed international literature that measures the drivers of agglomeration, and peer-reviewed New Zealand studies (eg Maré and Graham, 2009) that estimates the magnitude of these benefits.
- Blocked views: Once again, there is a well-developed international literature on the value that people place on views, and several New Zealand studies that provide relevant local evidence.
- Health impacts of air pollution: A wide range of international studies establish that poor air quality principally from fine particulate matter (PM), leads to increased mortality and morbidity. The *Health and Air Pollution in New Zealand* (HAPINZ) study estimates air quality issues and the resulting health costs throughout New Zealand (Kuschel et al, 2012).

Some other notable findings are as follows.

Infrastructure and public service costs are assigned a 'Low' rating because the main publicly-available study of infrastructure costs to service urban development in New Zealand (CIE and Arup, 2015) analysed a small number of case studies. Internationally, there is a reasonable body of evidence that points to the existence of modest economies of scale in providing infrastructure and public services to denser urban areas, as opposed to low-density areas. However, costs for any *individual* development can vary significantly depending upon factors like capacity in existing infrastructure, topographical constraints, and design requirements. Our ability to extrapolate from this evidence base is limited.

That being said, local governments and other infrastructure providers often hold data on infrastructure capacity and the cost of proposed upgrades. Councils often analyse this data to justify the proposed level of development contributions. While there are likely to be gaps in this data, it represents a potential opportunity to improve knowledge.

Costs and benefits that are internalised to residents are partly understood. We assigned a 'Medium' rating to the costs of living in different locations. This reflects the fact that:

- There is reasonable data on differences in house prices and rents between New Zealand regions, which allows us to measure a key component of regional differences in costs of living
- Several New Zealand and international studies have measured variations in housing and transport costs within cities, providing estimates of suburb-level variation in living costs. However, these studies are subject to data limitations and hence should be treated with some caution.

Conversely, we assigned a 'Low' rating to the benefits of living in different locations (or in different quality of housing). Some studies address this to some extent, eg by developing quality of life indices for different New Zealand towns and cities (Preston et al, 2018) or measuring how people trade off different location and housing attributes (Yeoman and Akehurst, 2015). However, this evidence is not sufficient to allow us to value these benefits, or compare them to costs of living.

Because we have limited evidence on the benefits that people derive from different locations, it is important to interpret evidence on costs of living with caution. Even if we observe that one suburb has a higher cost of living

than others we cannot conclude that development there is a net negative for society without knowing whether residents obtain higher benefits from living there.

Transport network effects, principally including increased traffic congestion, have generally been assigned a 'Medium' or 'Low' rating. This is likely to be a conservative rating. There is a significant body of research on the impact of urban form on transport outcomes that has been systematically reviewed by Ewing and Cervero (2010). However, most of the local evidence is based on transport modelling, rather than analysis of observed data, and hence may suffer from the modelling limitations discussed in Section 3.2.

Table 5: Quality of the evidence base on costs and benefits of urban development

Category	Sub-categories	Quality of evidence	Key evidence / research
Costs and benefits that are internalised by residents	Costs of living in different locations	Medium	Mattingly and Morrisey (2014), "Housing and transport expenditure: socio-spatial indicators of affordability in Auckland"; Nunns et al (2014), "Location Affordability in New Zealand Cities"
	Benefits of living in those locations	Low	Yeoman and Akehurst (2015), "Housing We'd Choose: A Study of Housing Preferences, Choices and Trade-offs in Auckland"; Preston et al (2018), "Amenities and the attractiveness of New Zealand cities"; Glaeser, Kolko and Saiz (2001), "Consumer city"
Agglomeration benefits	Agglomeration in production	High	Maré and Graham (2009), "Agglomeration elasticities in New Zealand"; Maré (2008), "Labour productivity in Auckland firms"; Maré (2016), "Urban productivity estimation with heterogeneous prices and labour"
	Agglomeration in consumption	Low	Preston et al (2018), "Amenities and the attractiveness of New Zealand cities"; Tabuchi and Yoshida (2000), "Separating urban agglomeration economies in consumption and production"; de Groot et al (2015), *Cities and the Urban Land Premium*
Social and economic benefits of growth in 'declining' regions		Low	Austin, Glaeser and Summers (2018), "Saving the heartland: Place-based policies in 21st century America"; Stillman, Velamur, and Aitken (2010), "The long-run impact of New Zealand's structural reform on local communities"; Maré, Grimes and Morten (2009), "Adjustment in local labour and housing markets"
Infrastructure and public service costs	Transport infrastructure	Low	CIE and Arup (2015), "Auckland Cost of Residential Servicing Report"
	Water, wastewater, and stormwater	Low	CIE and Arup (2015), "Auckland Cost of Residential Servicing Report"
	Power and communications infrastructure	Low	N/A – little published information
	Parks and community facilities	Low	CIE and Arup (2015), "Auckland Cost of Residential Servicing Report"
	Public services, eg health and education	Low	CIE and Arup (2012), "Costs and benefits of alternative growth scenarios for Sydney: Focusing on existing urban areas"
Transport network effects	Increased traffic congestion	Medium	Ewing and Cervero (2010), "Travel and the built environment: a meta-analysis"; Auckland Council (2011), "Auckland Plan Scenario Evaluation Workstream Technical Report"
	Traffic noise	Low	Hannaby et al (2014), "State Highways noise mapping – Auckland motorways"
Impacts on neighbours	Overshadowing of existing buildings	Medium	Fleming et al (2018), "Valuing sunshine"

	Blocked views	High	Bourassa, Hoesli and Sun (2004), "What's in a view?"
	Changes to neighbourhood aesthetics and crowding	Medium	Various international studies
	Nuisances from incompatible activities	Low	Nunns, Allpress and Balderston (2016), "How Do Aucklanders Value Their Parks?☒The impact of proximity to open space on residential property values"
Consumption of open space	Foregone environmental services	Low	Meurk, Blaschke and Simcock (2013), "Ecosystem services in New Zealand cities"
	Foregone aesthetic and recreational benefits	Medium	Brander and Koetse (2011), "The value of urban open space: Meta-analyses of contingent valuation and hedonic pricing results"; Curran-Cournane et al (2014), "Trade-offs between high class land and development: Recent and future pressures on Auckland's valuable soil resources"
	Foregone option value, bequest value, and existence value	Low	N/A – no local research
Air and water quality	Health impacts of air pollution	High	Kuschel et al (2012), "Updated Health and Air Pollution in New Zealand Study"
	Climate change impacts of GHG emissions	Medium	Ewing and Cervero (2010), "Travel and the built environment: a meta-analysis"; IPCC reports
	Reduced freshwater and coastal water quality	Medium	Moores et al (2016), "Urban Development and the NPS-FM: Lucas Creek Catchment Case Study"
Social and cultural effects	Health impacts of changes to transport behaviour	Medium	Shaw et al (2018), "Health consequences of transport patterns in New Zealand's largest cities"; Ewing and Cervero (2010), "Travel and the built environment: a meta-analysis"
	Mental health impacts of built environment	Low	N/A – limited studies and no local evidence
	Impacts on social capital, trust, and community cohesion	Low	Roskruge, Grimes, McCann and Poot (2013), "Homeownership, social capital and satisfaction with local government"; Mazumdar et al (2017), "The built environment and social capital: A systematic review"
	Cultural impacts from modifying places	Low	Nijkamp (2012), "Economic valuation of cultural heritage"; Nunns, Hitchins and Balderston (2014), "The value of land, floorspace and amenities: a hedonic price analysis of property sales in Auckland"

Distributional impacts on house prices and rents	Transfers between renters / first home buyers and property owners	Medium	Saiz (2007), "Immigration and housing rents in American cities"; Coleman and Landon-Lane (2007), "Housing markets and migration in New Zealand, 1962-2006"; Stillman and Maré (2008), "Housing markets and migration: evidence from New Zealand"

5.2 Data for measuring and valuing effects

This sub-section addresses RQ2, bullet 2: "**What data is available and how reliable and useful is it?**"

Based on our review of the evidence, we consider how each cost or benefit could be measured and valued. In doing so, we consider:

- What data or models might be available to measure various effects
- Whether there are any existing or widely used evaluation methodologies that can be applied, for instance from methods outlined in the NZ Transport Agency's *Economic Evaluation Manual* (EEM)
- Whether further research is required to measure effects or obtain parameters for valuing impacts
- Whether a natural capital accounting approach may be appropriate as a substitute (or supplement) for valuation.

Table 6 summarises some key suggestions about how different effects could be measured and valued. Appendices 2 through 11 contain a more detailed discussion of options for measuring and valuing effects.

In this table, we address individual effects on a case-by-case basis rather than attempting to outline a comprehensive modelling approach. Following the discussion in Section 3.2, multiple models (or methods) may be needed, and it is likely to be preferable to 'loosely couple' different models rather than attempt to develop a single mega-model.

We highlight the following broad findings from this analysis:

First, the quality of data and evidence varies, and in some cases it is not sufficient to measure and value impacts. This is a particular issue for the following categories of external costs:

- Agglomeration in consumption: These benefits are hard to measure as they can arise from the impact of larger / denser urban areas on the variety of goods, services, and social opportunities. Variety is difficult to measure and value, although some studies have attempted to do so.
- Infrastructure and public service costs: We discuss this in more depth below
- Consumption of open space: Data is available to measure this, but not to value it
- Water quality impacts: Some data is available to measure and value these impacts, but it is unclear how broadly applicable it is
- Social and cultural impacts: With the exception of the health impacts of transport behaviours, these are poorly understood in the New Zealand context, and hence difficult to value with confidence.

Second, strategic transport models and NZTA's EEM are potentially relevant for measuring and valuing several categories of effects, including:

- Agglomeration benefits in production
- Transport network effects
- Health impacts of air pollution and climate change impacts of greenhouse gas emissions
- Health impacts of transport behaviour

However, the caveats and cautions outlined in Section 3.2 should be taken into account when using these models. They do not capture feedback between housing development, employment growth, and infrastructure provision, meaning that any expected feedback must be designed into model inputs or addressed by combining transport models with land use models.

Third, non-market valuation methods can potentially be used to value several categories of effects. Following the discussion in Section 3.4, hedonic analysis, a 'revealed preference' method, can be useful to value impacts that depend upon close proximity. This principally includes impacts on neighbours. New Zealand evidence is available on the impact of overshadowing and blocked views, and international evidence is available on the impact of changes to neighbourhood aesthetics and crowding. Impacts of traffic noise may also be valued using evidence from hedonic studies.

'Stated preference' evidence can assist in valuing costs and benefits that arise over a wider geographic scale. This includes the impacts of consuming open space and the impacts of reduced freshwater and coastal water quality. We also note that non-market valuation methods are commonly used to value traffic congestion impacts (ie value of travel time parameters) and health impacts of poor air quality and road crashes (ie value of statistical life parameters).

However, because some environmental impacts are not perceived, non-market valuation methods may not be able to fully capture them. There is therefore a case to consider a natural capital accounting approach instead. This would entail setting 'bottom lines' for preservation of stocks of biodiversity, water quality, etc and sustainably managing them as a bequest for future generations.

Measuring and valuing infrastructure and public service costs

There are a number of practical and conceptual challenges that make it difficult to accurately measure the cost of infrastructure and public services to serve new development. In particular:

- Infrastructure is lumpy and long-lived: New infrastructure may be intended to serve expected growth over a long period of time
- Infrastructure providers often borrow to finance capital costs: This means that financing costs are higher when there is a longer time lag between infrastructure provision and user uptake
- Infrastructure can be adapted or expanded: Transport networks in particular can be adapted to deal with growing demands, for instance by converting parking lanes to bus lanes
- Some infrastructure demands are localised, but others are spread over networks: For instance, demand for schools tends to be localised to school zones, while demand for transport infrastructure arises at the network level
- Operating, maintenance, and renewal costs must also be considered

Moreover, cities already have existing infrastructure networks, some of which was built with the intention that it would serve development that has not yet occurred.

The theoretically ideal approach would be to calculate the long-run average cost to service urban development in different locations, taking into account past infrastructure spending, planned future investment, and the past and expected future timing of development. However, this would require a large amount of historical infrastructure data, which is not available.

As a result, a 'second best' approach should be considered. This would focus on estimating the 'near future' costs to expand infrastructure to serve urban development where no infrastructure is currently available or where existing networks are at capacity. Infrastructure costs incurred before a certain date (eg five to ten years ago to capture recent expenditures) would be treated as sunk costs. This approach was used in several recent studies of infrastructure costs to service growth (CIE, 2010; CIE and Arup, 2015).

This approach would entail three key steps:

- First, use asset management data to estimate remaining capacity in existing infrastructure networks, stated in terms of the number of additional users or households that infrastructure can accommodate. If information on remaining capacity is not available, a yes/no indicator of whether there is remaining capacity could be used.
- Second, identify proposed, planned, or recently developed infrastructure from data in long term plans or business cases. Then, calculate the estimated capacity that these are expected to serve, and identify the location expected to be served.
- Third, use Statistics New Zealand population projections (or other relevant projections) to estimate the timing of development in these catchments and hence the cost of financing new infrastructure.

Although this approach is simple to describe, data limitations are likely to make it challenging to implement. In addition, implementing this approach for transport networks will require expert judgment about how to address the relationship between development in one location and transport investments in another 'downstream' location.

Table 6: Measurement and valuation of urban development

Category	Sub-categories	Data or method required to measure effect	Data or assumptions required to value effect
Costs and benefits that are internalised by residents	Costs of living in different locations	Household Economic Survey data or housing cost and transport cost estimates from aggregate data Property valuation and sales data may also be useful	These impacts are financial and hence can be valued using Household Economic Survey data or similar data
	Benefits of living in those locations	NZ General Social Survey data could be analysed to estimate the impact of different urban form variables on life satisfaction	Research is needed to define an equivalence between quality of life and monetary outcomes
Agglomeration benefits	Agglomeration in production	Data on existing patterns of economic productivity is available from SNZ's *Integrated Data Infrastructure*; alternatively, regional or sub-regional estimates can be derived from SNZ's Regional GDP and employment data Changes to effective job density can be estimated based on either changes to the physical distribution of jobs or transport-access weighted distribution, based on strategic transport model outputs	NZTA EEM approach can be used to value the impact of changes to job accessibility / proximity
	Agglomeration in consumption	Further research is required to identify key consumption amenities and measure how urban development affects their availability A key challenge will be identifying how to measure consumption amenities, as the literature suggests that variety in goods and services plays a key role	Research is needed to identify how to value these benefits
Social and economic benefits of growth in 'declining' regions		Following Austin, Glaeser and Summers (2018), some socioeconomic problems arising from persistent regional economic shocks can be measured by correlating data on unemployment, crime, and 'deaths of despair'	Some effects are monetary (eg reduced unemployment benefit payments / increased labour income), while others could be valued based on impacts on quality of life
Infrastructure and public service costs	Transport infrastructure	To estimate capacity in existing networks, data on existing transport capacity and congestion or crowding levels is needed Costs and capacities for proposed or potential upgrades could be sourced from business cases or Long Term Plans A key challenge is attributing transport upgrades to development occurring in specific locations Councils often must address this question when setting development contributions; the methods they use for doing so should be investigated for relevance	Costs of new transport infrastructure to serve growth can be compared with user charges, which include: development contributions and (estimated) petrol tax payments based on vehicle kilometres travelled (see transport effects section)

	Water, wastewater, and stormwater	Provider data on capacity in existing networks is needed to identify areas in need of upgrades Costs and capacities for proposed or potential upgrades could be sourced from business cases or Long Term Plans Data on population / household projections in catchments could be sourced from SNZ or other sources to calculate financing costs	Costs of new water infrastructure to serve growth can be compared with user charges, which include development contributions / connection fees and water charges
	Power and communications infrastructure	Data from infrastructure providers or regulators would be needed to measure capacity and costs to expand networks in different locations	Local lines company connection fees / charging policies
	Parks and community facilities	Costs for proposed or potential upgrades could be sourced from business cases or Long Term Plans	Costs of new facilities to serve growth can be compared with user charges, principally development contributions
	Public services, eg health and education	Ministry of Education and District Health Board data on the cost of proposed school and hospital upgrades, relative to population projections in intended service catchments	Costs of new facilities are not directly recovered from users, so it would be necessary to consider general tax revenue as a funding source
Transport network effects	Increased traffic congestion	Strategic transport models could be used to estimate the congestion impact of urban development in different locations Inputs would have to be designed to reflect long-run relationships between population and employment location and feedback to infrastructure provision (see discussion in Section 3.2)	NZTA EEM parameters can be used to value changes in traffic delay
	Traffic noise	Strategic transport models could be used to estimate the impact of urban development in different locations on traffic volumes and hence traffic noise levels	NZTA EEM parameters can be used to value traffic noise impacts
Impacts on neighbours	Overshadowing of existing buildings	Shading from existing development patterns can be measured using digital elevation maps and remote sensing (LIDAR) data on building footprints and heights (not available in all regions) Scenarios for increases in building height could then be developed and compared This would involve complex GIS analysis	Impacts of different development scenarios could be valued using existing property valuation data and the results from a recent Wellington study of the impact of sunlight access on property prices (Fleming et al, 2018)
	Blocked views	Property sales databases can be used to identify the share of dwellings in different areas that have views of water (which are more highly valued than views of land)	Impacts of different development scenarios could be valued using existing property valuation data and the results from studies of the impact of views on property values (eg

		This can be used to define scenarios for blockage of views from new development, eg coupled with GIS analysis of new building locations	Bourassa, Hoesli and Sun, 2004; Nunns, Hitchins and Balderston, 2015)
	Changes to neighbourhood aesthetics and crowding	The density of existing buildings and population / employment can be estimated using rating valuation datasets and Census data These can quantify exposure to any changes, but it is not clear whether new urban development has positive or negative impacts	New research would be needed to value any effects in the New Zealand context
	Nuisances from incompatible activities	Council district plan maps identify industrial zones and sometimes other nuisances that are 'buffered' from surrounding residential areas This could be used to identify areas where new development may lead to incompatible activities	The negative impacts of 'intruding' incompatible activities could be valued using using existing property valuation data and the results from hedonic studies of the impact of industrial activities on nearby residential property values (eg Nunns, Allpress, and Balderston, 2016)
Consumption of open space	Foregone environmental services	The characteristics of existing open space around cities can be identified using GIS data on land use capability (to measure versatile agricultural soils), regional and national parks (to identify recreation areas), conservation land (to identify ecosystems etc) This data is incorporated into some models like the Waikato and Wellington Integrated Scenario Explorers	New New Zealand-specific research on willingness to pay for ecosystem services provided by different types of open space is required Value transfer from other jurisdictions may be a viable alternative, although potentially subject to significant uncertainty A natural capital accounting approach is likely to be appropriate for some types of open space, eg areas of biodiversity
	Foregone aesthetic and recreational benefits	As above	New New Zealand-specific research on willingness to pay for preservation of different types of open space would be required
	Foregone option value, bequest value, and existence value	As above	As above
Air and water quality	Health impacts of air pollution	The Health and Air Pollution in New Zealand (HAPINZ) model can be used to measure existing air quality Strategic transport modelling plus assumptions about vehicle emissions can be used to estimate impact of urban development on transport emissions Scenarios should be constructed to estimate impacts of changes to domestic fires	HAPINZ model assumptions can be used to value health impacts of changes to air quality relative to the baseline scenario Alternative assumptions about the value of health impacts should also be considered

	Climate change impacts of GHG emissions	Most impacts will arise from changes to transport behaviours, which can be modelled in strategic transport models, plus emissions from home heating and industrial activities These impacts can be modelled using a similar approach as above	Assumptions about social cost of GHG emissions should be applied NZTA EEM recommends $70/tonne (in 2018 NZD), but other sources cite higher figures
	Reduced freshwater and coastal water quality	The Urban Planning that Sustains Waterbodies Decision Support System (UPSW-DSS) used to model the impact of development in the Lucas Creek catchment (Moore et al, 2016) could be extended assess impacts in other catchments It is unclear whether input data is available nationally	Existing studies provide estimates of willingness to pay for freshwater and coastal water quality improvements in Auckland; these could be applied to value impacts A natural capital accounting approach is likely to be appropriate for water quality outcomes given the unperceivable nature of some outcomes
Social and cultural effects	Health impacts of changes to transport behaviour	Most impacts will arise from changes to transport behaviours, which can be assessed using transport models if they cover walking and cycling An alternative would be to extrapolate from empirical data (eg Census data on walking and cycling commuting) or studies on urban form and walking and cycling	NZTA EEM parameters can be used to estimate the value of health benefits of added active transport These parameters appear to include some external benefits and some internalised benefits
	Mental health impacts of built environment	We have not identified a preferred data source SNZ's *Integrated Data Infrastructure* could be investigated as a potential source	Research would be needed to value mental health impacts Treasury's CBAx tool may provide some proxy values
	Impacts on social capital, trust, and community cohesion	We have not identified a preferred data source SNZ's *Integrated Data Infrastructure* or the New Zealand General Social Survey could be investigated as a potential source	Research would be needed to value these impacts Treasury's CBAx tool may provide some proxy values
	Cultural impacts from modifying places	Data to identify sites and places with cultural significance is not comprehensive Data on heritage listed properties is available, but data on (eg) sites and places of significance or value to mana whenua is often incomplete Information on other places with cultural significance is incomplete	New evidence would be needed to value external impacts, such as surveys of willingness to pay to preserve places of cultural significance Some evidence is available from hedonic analysis of the value that people place on heritage properties (eg Nunns, Hitchins, and Balderston, 2014)
Distributional impacts on house prices and rents	Transfers between renters / first home buyers and property owners	Further econometric research is needed to measure the impact of growth on regional property prices and identify factors that increase or decrease these impacts	Distributional impacts between renters and landlords could be valued using Census data on the share of households in each city that rent or live in owner-occupied housing and

		This could be used to predict how growth in different places will flow through to changes in house prices and rents	scenarios for changes in city population and hence housing prices

5.3 Potential magnitude of costs and benefits

This sub-section addresses RQ2, bullet 4: "**What is the magnitude of the costs and benefits that can be quantified?**"

As noted in Table 4, the size of costs and benefits can vary according to the location, form, and design of urban development. It is therefore difficult to pin down exactly how large some effects are. However, the literature we have reviewed provides some initial insight into the potential magnitude and direction of different effects.

For each cost/benefit for which sufficient evidence exists, we estimate an approximate 'order of magnitude' impact per added household or added dwelling.[14] The aim of this exercise was not to be precise, but to help policymakers focus in on effects that are likely to be largest and hence most in need of management.

These estimates should be interpreted as the potential outcome *if* impacts were to arise. They are not additive. For instance, the estimate for blocked views reflects the potential cost that might arise in the small share of cases where development of a new dwelling blocks an existing coastal or lakefront view. This is most likely to happen in existing urban areas, rather than greenfield areas, and as a result development that blocks views is unlikely to *also* result in costs from the consumption of open space.

We use the following categories to summarise the potential magnitude of impacts:

- High: This indicates annual impacts of $10,000 or above per household/dwelling
- Medium: This indicates annual impacts of $1,000 to $10,000 per household/dwelling
- Low: This indicates an annual impact of under $1,000 per household/dwelling
- Unknown: This indicates that insufficient evidence is available to draw a conclusion about magnitudes.

For context, we note that 2013 Census data, which remains the most recently-released Census data, shows a median household income of $63,800 per annum.[15] Thus an external cost or benefit equal to $1000 would be equal to around 1.6% of median household income.

Table 7 summarises these estimates, which indicate that the following effects are likely to be highest in magnitude:

- Costs and benefits of living that are internalised by residents: This is likely to be one of the largest single effects, reflecting the fact that households typically spend 25-30% of their income on housing, transport, and utility services. As a result, it is also likely that the benefits they receive from doing so are also large.
- Agglomeration benefits in production are likely to be large. There is some evidence that they are larger for new development in central areas that are closer to existing concentrations of employment, relative to employment in less accessible peripheral locations.
- Distributional impacts on house prices and rents can be large in cities with constraints on housing supply. In these contexts, growth in housing demand can flow through into large increases in house prices and rents, thereby redistributing wealth from renters and first home buyers to landlords and home owners. Conversely, enabling urban development and increasing housing supply may reduce pressure on prices and rents, leading to the opposite effect.

[14] A typical household is assumed to include 3 people, 1.5 of whom are employed, and consumes approximately 1000m^2 of land. A discount rate of 6% is used to convert present value impacts to annual impacts, if needed.
[15] http://nzdotstat.stats.govt.nz/wbos/Index.aspx?DataSetCode=TABLECODE8135

No individual category of external costs is likely to fall into the 'High' category, except in extreme cases such as development in a highly sensitive ecosystem. It is therefore possible that the external benefits of urban development outweigh the external costs, at least for well-designed developments in low-cost locations.

Table 7: Potential magnitude of effects

Magnitude codes: H = >$10,000 annual impacts, M = $1000-$10,000 annual impacts, L = <$1000 annual impacts, 0 = no external effects / all impacts are internalised to users

Category	Sub-categories	Magnitude and direction	Notes / commentary
Costs and benefits that are internalised by residents	Costs of living in different locations	High, negative	Household economic survey suggests that around 25-30% of average household budget is spent on housing, transport, and utilities.
	Benefits of living in those locations	High, positive	We would expect internalised benefits to be similar in magnitude to internalised costs
Agglomeration benefits	Agglomeration in production	High, positive	Case studies in Section 10.3 suggest average impacts on the order of $7000 per added employee in most NZ cities. If we assume 1.5 employees per household, this is equivalent to around $10,000 in benefits per added household. Benefits are likely to be higher in more central areas and lower in more peripheral areas.
	Agglomeration in consumption	Medium / high, positive	Some international literature suggests that these benefits are similar in scale to agglomeration in production. Local evidence is not sufficient to validate this, so we have provisionally scored this as medium / high
Social and economic benefits of growth in 'declining' regions		Unknown, positive	No clear evidence is available to estimate the magnitude of these effects and hence we have marked this as uncertain
Infrastructure and public service costs	Transport infrastructure	Medium, negative	Auckland case studies indicate that infrastructure costs may total $100k+ per dwelling, while user charges recoup perhaps half of this. This implies external infrastructure costs on the order of $50,000 per dwelling, or $3000-5000 per annum at a 6% discount rate. Transport and water infrastructure accounts for the majority of these costs.
	Water, wastewater, and stormwater	Medium, negative	See above
	Power and communications infrastructure	N/A	Privately provided and expected to be fully charged to users
	Parks and community facilities	Low, negative	See above. Parks in greenfield suburbs are often provided by developers and vested to councils.
	Public services, eg health and education	Low / Medium, direction unclear	Public service costs vary mostly by population size; some evidence that cities offer economies of scale in provision

Transport network effects	Increased traffic congestion	Medium, negative	Annual average deadweight cost of congestion in Auckland is around $1000 per capita, which implies average costs of around $3000 per household. Marginal costs appear to be similar to average costs across the entire network.
	Traffic noise	Uncertain, negative	Doubling traffic volumes increases noise levels by 3dB; houses next to roads experience costs equal to 1-3% of house value per dB increase. Assessing the magnitude of impacts would require analysis of exposure.
Impacts on neighbours	Overshadowing of existing buildings	Medium, negative	Fleming et al find that a one-hour change in daily sunlight exposure is associated with a 2.6% impact on house price. Nunns and Denne (2016) used similar data to estimate a present value per-dwelling externality of $10,000 or more for a midrise apartment blocks. This translates to an annual impact in the range of $1000.
	Blocked views	Medium, negative	In cases where this occurs, the present value of per-dwelling external costs may be on the order of $10-20,000 for new apartment buildings that block views to existing homes (Nunns and Denne, 2016). This translates to an annual impact in the range of $1000-2000.
	Changes to neighbourhood aesthetics and crowding	Unknown, may be positive	International research shows that effects are potentially positive but highly spatially concentrated.
	Nuisances from incompatible activities	Unknown, negative	These effects are likely to be highly spatially concentrated in areas around incompatible activities. In practice, existing district plans attempt to manage incompatibilities.
Consumption of open space	Foregone environmental services	Medium, negative	Value transfer from Brander and Koetse (2011), summarised in Section 15.4, suggests that the willingness to pay to preserve open space may be in the range of $2000-15,000 per hectare per annum. Assuming the high end of this range and around 13 dwellings per hectare implies a cost of around $1-2000 per dwelling.
	Foregone aesthetic and recreational benefits	Medium, negative	See above. We note that not all environmental services may be perceived.
	Foregone option value, bequest value, and existence value	Low, negative	Some evidence indicates that option value is generally an order of magnitude lower than direct/indirect use values.
Air and water quality	Health impacts of air pollution	Low, negative	HAPINZ suggests that average health costs per resident from PM_{10} emissions are around $1000 per annum in Auckland, and most other cities are less polluted. Estimates reported in Rohani and Kuschel (2017) indicate that marginal impacts are potentially smaller.
	Climate change impacts of GHG emissions	Low, negative	CO_2 emission impacts are often of a similar order of magnitude to air quality impacts.

	Reduced freshwater and coastal water quality	Medium, negative	Lucas Creek study indicates mitigation costs of between $4000-$20,000 per dwelling. At the upper end of this range, this equates to annual costs of $1000-2000 per dwelling. If damage costs are similar to mitigation costs, this suggests medium impacts.
Social and cultural effects	Health impacts of changes to transport behaviour	Low, negative or positive	Shaw et al (2018) estimate that the difference between Auckland and Wellington transport / urban form outcomes equates to 57 annual excess loss of disability-adjusted life years (DALYs), or around 0.4 DALYs per 1000 residents. If we assume three people per household and assume that the value of each DALY is equivalent to the average wage, this implies an annual cost per household on the order of $100 per annum.
	Mental health impacts of built environment	Unknown	No clear evidence is available to estimate the magnitude of these effects and hence we have marked this as uncertain
	Impacts on social capital, trust, and community cohesion	Unknown	No clear evidence is available to estimate the magnitude of these effects and hence we have marked this as uncertain
	Cultural impacts from modifying places	Unknown	No clear evidence is available to estimate the magnitude of these effects and hence we have marked this as uncertain
Distributional impacts on house prices and rents	Transfers between renters / first home buyers and property owners	Medium / high positive and negative effects; zero net effects	Point estimates from Nunns (2018a) suggest that impacts on rents may be on the order of $10,000 per added household in supply-constrained cities but not in cities with abundant housing supply. Other evidence suggests impacts could be an order of magnitude lower.

5.4 Recommendations for further research

This review highlights our limited understanding of some potentially important costs and benefits arising from urban development, how they vary between locations, and how they are influenced by building, neighbourhood, and infrastructure design.

We have a good understanding of some important effects, including agglomeration benefits in production, the costs of blocked views in coastal / lakefront areas, and the costs of air pollution. International evidence and some New Zealand-specific studies provide a starting basis for understanding effects such as traffic congestion impacts, health impacts of transport behaviours, and some environmental impacts such as consumption of open space at the edge of cities. However, many other effects are less well understood, including effects such as distributional impacts on house prices and rents that may be large in some cities.

Because different costs and benefits arise through different mechanisms, at different geographic scales, it is challenging to incorporate all of them into a single model. Our first suggestion is therefore to avoid investing in a single model or modelling approach. Instead, we suggest:

- Employing existing models, such as strategic transport models, land use models like the Waikato and Wellington Integrated Scenario Explorers, and the Urban Planning that Sustains Waterbodies Decision Support System (UPSW DSS) water quality modelling
- Combining these models using a 'loose coupling' approach where individual models do not capture all relevant effects, and searching for ongoing opportunities to improve models to address gaps and omissions
- Focusing on improving the quality of geospatial data on cities and natural environments and improving the ability of researchers and analysts to access and join together datasets held by different agencies.

Our second suggestion is that further research or analysis should focus on six effects that are either likely to be significant in magnitude, or that are potentially large but poorly understood at present.

Agglomeration benefits in consumption

Several studies have found that these benefits may be comparable in size to agglomeration in production (Tabuchi and Yoshida, 2000; de Groot et al, 2015), but they are difficult to accurately measure and value.

As outlined in Section 10.4, agglomeration in consumption can arise from several mechanisms, such as the ability to share costs for cultural facilities like stadia and museums and the ability of larger cities to provide greater variety in social experiences and consumption goods and services. Our recommendation is therefore to study how urban development influences the production of consumer amenities. Some studies have done this by using data on supermarket and restaurant product variety (Handbury and Weinstein, 2014; Schiff, 2014). An associated piece of research would be to estimate the value that different types of people obtain from variety.

Infrastructure costs and infrastructure pricing

The cost of infrastructure to serve new urban development is an important issue for councils, central government, and other infrastructure providers. Many urban areas are facing financial pressure and seeking opportunities to make development more financially sustainable.

It is therefore important to understand the medium-term costs of infrastructure, taking into account:

- Where there is capacity in existing infrastructure networks

- What it will cost to upgrade at-capacity infrastructure or provide new infrastructure to greenfield areas
- The likely profile for development in newly serviced areas and any risks to growth that may affect financing costs.

However, we emphasise that this is likely to be a technically challenging exercise due to data limitations and the highly location-specific nature of some costs.

Transport network effects

We have a reasonable understanding of transport network effects associated with alternative patterns of urban development, plus other flow-on effects such as the health impacts of transport behaviours. Empirical evidence from international cities and some limited local modelling efforts provide information on these effects.

Transport network effects, including increased traffic congestion, potentially represent one of the largest single external costs of urban development, and certainly one that is visible to existing residents. It is therefore important to understand these effects. Existing strategic transport models can in principle be used to assess them, provided that model inputs are appropriately designed and/or provided that transport models are coupled with land use models.

Impacts on neighbours

We have a reasonable understanding of some specific external costs that new development may impose on neighbours, such as blocked views or overshadowing. However, some existing residents cite a broader range of (measurable and unmeasurable) costs to oppose new development, ranging from increased use of on-street parking to risk of increased property prime to reductions in neighbourhood aesthetics. It is unclear whether expected negative impacts from new development reflect what will actually happen in practice, or whether people's expectations reflect a lack of information or a 'status quo' bias that leads them to prefer things not to change.

Empirical studies summarised in Section 14.5 show that redevelopment or renovation of buildings often has a positive, rather than a negative, impact on the value of other houses in the neighbourhood. This indicates that redevelopment can improve neighbourhood aesthetics or quality of life, in contrast with some people's expectations.

We think that this issue is important and bears further investigation. Research that measures and values the neighbourhood impacts of redevelopment and infill development would be valuable for helping us understand the impacts of growth in existing urbanised areas, especially if it is compared with what people expected to happen.

Environmental impacts and sustainable stocks of natural capital

As observed in Section 3.3, some environmental outcomes are difficult to accurate measure and value. There is a case to address them through a natural capital accounting approach that seeks to preserve ecosystems at a sustainable level as a bequest for future generations.

However, non-market valuation methods can plausibly be used to value some environmental outcomes, such as consumption of farmland for development (ie conversion of an extensively modified environment to another extensively modified environment). The discussion in Section 15.4 suggests that stated preference methods are more likely to capture the effects of interest than hedonic analysis of property sales.

We therefore suggest identifying specific environmental outcomes that are best addressed through a natural capital accounting approach and defining sustainable 'bottom lines' for them. This is an exercise for scientists and communities, rather than economists. However, it may be useful to undertake a cost effectiveness analysis of alternative options for providing for sustainable outcomes, as Moore et al (2016) did in the Lucas Creek water modelling case study that we discuss in Section 16.6.

Further work would be needed to align this approach with the approach used for other outcomes, which focuses more on quantifiable costs and benefits.

Distributional impacts on house prices and rents

Lastly, poorly planned and managed urban development can make renters and first home buyers worse off. In 'tight' housing markets where there are constraints to supplying new housing to meet increased demand, increasing urban population or incomes tend to increase rents and house prices. Conversely, urban development that increases housing supply can moderate the impact of growth on prices.

These distributional impacts may be large, but we do not have a precise understanding of their magnitude or what policy factors may exacerbate or mitigate them. Further research that explores these relationships may be valuable for planning urban development to improve, rather than worsen, price pressures in urban housing markets.

6 Attributing and managing costs and benefits of growth

To conclude, this section addresses the third research question: "**Could a common approach be developed to identify, measure and attribute the costs of urban development?**"

Previous sections have described a common conceptual framework for assessing the costs and benefits of urban development, outlined a framework for categorising costs and benefits, and described how individual categories of costs and benefits could be measured and valued.

However, although a common framework can be used, differences in the mechanisms through which different effects occur, the different geographical scales over which they occur, and the different factors that exacerbate or mitigate them make it challenging to capture all impacts in a single model or measurement tool.

In this section, we also highlight five findings that also have potential policy implications.

Urban development generates external benefits as well as external costs

We should not assume that urban development generates net costs for society. Although urban development results in congestion and crowding costs and environmental impacts, it also generates significant agglomeration benefits that support higher productivity and incomes and a greater variety of consumption opportunities.

Focusing only on the costs of urban development may lead to the position that it should be limited or discouraged. A more holistic perspective that also considers benefits is likely to lead to the opposite view.

This is not to say that all urban development is equally beneficial. In Table 4, we identified a variety of factors that can exacerbate or mitigate external costs, or enhance benefits. These factors should be taken into account when trying to develop policy.

The impacts of urban development play out over multiple geographic scales

Urban development generates costs and benefits at the macro level (regional or national), meso level (suburb), and micro level (building or neighbourhood). This makes it challenging to design a single policy mechanism that addresses all external costs and benefits.

Some external costs are highly localised, such as impacts of overshadowing and blocked views, while others arise at a regional scale, such as the impacts of urban development on traffic congestion and air quality.

The external benefits of urban development tend to arise at a regional or even national scale. Agglomeration economies can shape productivity at a city level. Furthermore, because increased labour income and productivity flows through to increased central government tax revenues, agglomeration can have direct financial benefits for central government.

Focusing only on localised effects may lead to a socially inefficient outcome. An example would be if restrictions on tall buildings, designed to prevent overshadowing and preserve views, led to more greenfield development in locations where most people have to drive significant distances for daily needs, thereby exacerbating regional traffic congestion.

Conversely, focusing only on regional or national effects may also lead to a socially inefficient outcome. It may lead to a city that is productive and has an efficient transport system, but one that is unattractive or inconvenient for residents at the neighbourhood or building level.

Policy must find a balance between localised effects, which are often but not always negative, and regional or national effects, which can be positive. A 'horses for courses' approach to designing policy and institutions may be needed.

For example, congestion pricing is likely to be an efficient way to internalise the costs of increased traffic congestion and better manage the impact of new development on demand for transport infrastructure. If tolls are set appropriately, people will pay for the impact they have on the transport network *at the point of impact*. This will reduce the need for infrastructure providers to guess how people living in different places will use the transport network in order to charge them location-specific development contributions.

A similar pricing approach may be relevant for managing the health impacts of air quality, as these impacts also arise at a city or airshed level.

A pricing approach is likely to be harder to implement for other effects. The costs of overshadowing and blocked views could in theory be internalised by charging a fee and using it to compensate neighbours, but as these outcomes are highly site-specific it would not be possible to set fees at a regional level. However, a 'Coasean' approach that allows neighbours to bargain on these issues may still be relevant.

In a different vein, pricing in environmental impacts, such as loss of areas of biodiversity or reduced water quality, is challenging because people may not perceive all of the values associated with ecosystems, or the risks of degrading them beyond a sustainable point.

External costs can be mitigated through good design of buildings, neighbourhoods, and infrastructure

The location of urban development is important for determining the resulting costs and benefits, but it is not the only or even the most important factor.

Design of buildings, neighbourhoods, and infrastructure can mitigate many external costs. Some examples include:

- A subdivision with 'green' stormwater design and provision for preserving (or creating) corridors of native bush may result in smaller environmental impacts than a subdivision with a 'grey' infrastructure approach.
- New buildings that are set back from neighbouring buildings or placed on the north side of a wide street are less likely to block sunlight access to other properties.
- Designing new suburbs with efficient, direct public transport routes and street grids that support walking and cycling activity can reduce the need to drive, relative to a street design based on cul-de-sacs and collector roads.

There are often financial costs to designing new urban places to mitigate external costs, and hence design requirements need to be implemented carefully. However, we see design as an important tool for maximising benefits and minimising costs, regardless of the location of new development.

Constrained housing supply can affect the distribution of income and wealth

Cities with an insufficient or constrained supply of housing appear to experience larger increases in house prices and rents in response to any increases in demand for housing.

This has consequences for the distribution of income and wealth: Renters and first home buyers are worse off, as they must pay more for housing, while landlords and homeowners benefit from increasing asset values. Because renters and first home buyers tend to have lower incomes, the overall effect is to redistribute income *away* from people who have less money to start with.

We don't know enough to be certain about the magnitude of these effects, but they are potentially quite large. We do know that both house prices and rents have increased significantly faster than incomes over the last generation, and that this has coincided with a low rate of new housing construction (Office of the Mayor of Auckland, 2017).

Although a range of demand- and supply-side factors play a role, a key driver of price increases is whether urban housing is abundant or scarce. Urban development can help to ease scarcity of housing, if it is done consistently, at sufficient scale, and in the right locations.

We therefore emphasise that enabling urban development is important to avoid further distributional consequences.

Infrastructure costs are challenging to measure, and hence challenging to price

There are significant practical and conceptual challenges to accurately measuring the costs of infrastructure required to service urban development in different locations. This makes it difficult to accurately reflect these these costs in infrastructure charging policies.

To an extent, we can overcome this problem by investing in improved infrastructure planning and asset management data and better practices for storing and analysing this data. Partnerships between the Crown and local government may be an important spur for this.

However, some of the problems we face in this area reflect intrinsic uncertainty. One issue is that infrastructure financing costs, which are important for council-funded infrastructure, are highly dependent on the timing of new development, which cannot be projected with certainty. When there is a longer lag between infrastructure provision and user uptake, eg due to a drop-off in housing construction in a recession, borrowing costs are higher.

Another issue is that new development can have network-wide effects on transport infrastructure. For instance, development of a new greenfield suburb may increase congestion on a road ten kilometres away, creating pressure to widen that road. These effects are important because transport infrastructure accounts for a large share of public infrastructure spending, but they are also hard to accurately predict. A different approach may be needed to internalise transport infrastructure costs, relative to water / wastewater / stormwater costs or costs to provide local schools, which are much more localised to specific catchments.

7 References

Adams, M. and Chapman, R., 2016. Do denser urban areas save on infrastructure? Evidence from New Zealand territorial authorities. *Policy Quarterly*, *12*(4).

Ahvenniemi, H., Pennanen, K., Knuuti, A., Arvola, A. and Viitanen, K., 2018. Impact of infill development on prices of existing apartments in Finnish urban neighbourhoods. *International Journal of Strategic Property Management*, *22*(3), pp.157-167.

Albouy, D., Behrens, K., Robert-Nicoud, F. and Seegert, N., 2018. The optimal distribution of population across cities. *Journal of Urban Economics*.

Allison, N., Lupton, D. and Wallis, I., 2013. *Development of a public transport investment model*. NZ Transport Agency Research Report 524.

Amore, K., 2016. Severe housing deprivation in Aotearoa/New Zealand 2001–2013. Wellington: He Kainga Oranga/Housing and Health Research Programme. University of Otago.

Anas, A. and Kim, I., 1996. General equilibrium models of polycentric urban land use with endogenous congestion and job agglomeration. *Journal of Urban Economics*, *40*(2), pp.232-256.

Anas, A., Arnott, R. and Small, K.A., 1998. Urban Spatial Structure, *Journal of Economic Literature*, Vol. 36, No. 3, pp. 1426-1464.

Andrews, D., Caldera Sánchez, A. and Johansson, Å., 2011. Housing markets and structural policies in OECD countries. OECD Economics Department Working Papers, No. 836, OECD Publishing, Paris.

Apatov, E. and Grimes, A., 2016. Higher education institutions and regional growth: The case of New Zealand. Motu Working Paper 16-11.

Aries, M.B., Aarts, M.P. and van Hoof, J., 2015. Daylight and health: A review of the evidence and consequences for the built environment. *Lighting Research & Technology*, *47*(1), pp.6-27.

Arzaghi, M. and Henderson, J.V., 2008. Networking off Madison Avenue. *The Review of Economic Studies*, *75*(4), pp.1011-1038.

Atkinson, R.W., Kang, S., Anderson, H.R., Mills, I.C. and Walton, H.A., 2014. Epidemiological time series studies of PM2. 5 and daily mortality and hospital admissions: a systematic review and meta-analysis. *Thorax*.

Auckland Council, 2017. *National Policy Statement on Urban Development Capacity 2016: Housing and business development capacity assessment for Auckland*.

Auckland Council. 2011. *Auckland Plan Scenario Evaluation Workstream Technical Report*. Auckland: Auckland Council.

Auckland Council., 2015. *Future Urban Land Supply Strategy*. Available online at http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/plansstrategies/Councilstrategies/Pages/futureurbanlandsupplystrategy.aspx.

Auckland Transport, 2015. *Parking Strategy*. Auckland, New Zealand.

Austin, B., Glaeser, E. and Summers, L.H., 2018, March. Saving the heartland: Place-based policies in 21st century America. In *Brookings Papers on Economic Activity Conference Drafts*.

Baker, M.G., McDonald, A., Zhang, J. and Howden-Chapman, P., 2013. *Infectious diseases attributable to household crowding in New Zealand: A systematic review and burden of disease estimate* (Vol. 1, No. 1.26, p. 33). Wellington: He Kainga Oranga/Housing and Health Research.

Barbier, E.B., 2019. The concept of natural capital. *Oxford Review of Economic Policy*, *35*(1), pp.14-36.

Barnett, A.G., Williams, G.M., Schwartz, J., Best, T.L., Neller, A.H., Petroeschevsky, A.L. and Simpson, R.W., 2006. The effects of air pollution on hospitalizations for cardiovascular disease in elderly people in Australian and New Zealand cities. *Environmental health perspectives*, *114*(7), p.1018.

Barnett, A.G., Williams, G.M., Schwartz, J., Neller, A.H., Best, T.L., Petroeschevsky, A.L. and Simpson, R.W., 2005. Air pollution and child respiratory health: a case-crossover study in Australia and New Zealand. *American journal of respiratory and critical care medicine*, *171*(11), pp.1272-1278.

Baskaran, R., Cullen, R. and Takatsuka, Y., 2009. Estimating the value of agricultural ecosystem services: a case study of New Zealand pastoral farming. *Australasian Journal of Environmental Management*, *16*(2), pp.103-112.

Batstone, C. and Sinner, J. 2010. *Techniques for evaluating community preferences for managing coastal ecosystems. Auckland region stormwater case study, discrete choice model estimation*. Prepared by Cawthron Institute for Auckland Regional Council. ARC Technical Report 010/012.

Batstone, C., Roberts, B. and Sharp, B. 2008. *Evaluating Coastal Receiving Environments and the Effects of Stormwater Phase 1 Interim Report*. Prepared by Cawthron Institute for Auckland Regional Council. Auckland Regional Council Working Report 137.

Baum-Snow, N., 2007. Did highways cause suburbanization? *The Quarterly Journal of Economics*, *122*(2), pp.775-805.

Baum-Snow, N., 2010. Changes in transportation infrastructure and commuting patterns in US metropolitan areas, 1960-2000. *American Economic Review*, *100*(2), pp.378-82.

Beinhocker, E.D., 2006. *The origin of wealth: Evolution, complexity, and the radical remaking of economics*. Harvard Business Press.

Bennett, J., 2000. *Natural heritage valuation methods: applications to cultural heritage*. Paper presented to the ISEE 2000 Pre-Conference Workshop "Heritage Economics: Challenges for Heritage Conservation and Sustainable Development in the 21st Century".

Berglund, B., Lindvall, T., Schwela, D. and World Health Organization Occupational and Environmental Health Team, 1999. *Guidelines for community noise*. Geneva: World Health Organization. http://www.who.int/iris/handle/10665/66217

Best, R. and Burke, P., 2018. *Fuel prices and road accident outcomes in New Zealand*. CAMA Working Paper 57/2018.

Bourassa, S.C., Hoesli, M. and Sun, J., 2004. What's in a view? *Environment and Planning A*, *36*(8), pp.1427-1450.

Brander, L.M. and Koetse, M.J., 2011. The value of urban open space: Meta-analyses of contingent valuation and hedonic pricing results. *Journal of environmental management*, *92*(10), pp.2763-2773.

Bureau of Infrastructure, Transport and Regional Economics. 2015. *Traffic and congestion cost trends for Australian cities*. Canberra: Department of Infrastructure and Regional Development. Available online at https://bitre.gov.au/publications/2015/is_074.aspx.

Caldera Sánchez, A. and Andrews, D., 2011. Residential Mobility and Public Policy in OECD Countries. *OECD Journal: Economic Studies*, *2011*(1).

Caldera, A. and Johansson, Å., 2013. The price responsiveness of housing supply in OECD countries. *Journal of Housing Economics*, *22*(3), pp.231-249.

Cameron, M., Moores, J., Harper, S., and Batstone, C., 2013. *Urban planning that sustains waterbodies: southern RUB case study*. Prepared by NIWA and Auckland Council Research, Investigations and Monitoring Unit. Auckland Council working report, WR2013/006.

Carruthers, J.I. and Ulfarsson, G.F., 2003. Urban sprawl and the cost of public services. *Environment and Planning B: Planning and Design*, *30*(4), pp.503-522.

Castalia Strategic Advisors, 2014. *Exploring the issues facing New Zealand's water, wastewater and stormwater sector*. An issues paper prepared for LGNZ.

Centre for International Economics and Arup, 2012. *Costs and benefits of alternative growth scenarios for Sydney: Focusing on existing urban areas*. A report for New South Wales Department of Planning and Infrastructure.

Centre for International Economics and Arup. 2015. *Auckland Cost of Residential Servicing Report*. A report for Auckland Council.

Centre for International Economics., 2010. *The benefits and costs of alternative growth paths for Sydney: Economic, social and environmental impacts*. A report for New South Wales Department of Planning.

Chan, K.M., Satterfield, T. and Goldstein, J., 2012. Rethinking ecosystem services to better address and navigate cultural values. *Ecological economics*, *74*, pp.8-18.

Chen, H., Jia, B. and Lau, S.S.Y., 2008. Sustainable urban form for Chinese compact cities: Challenges of a rapid urbanized economy. *Habitat international*, *32*(1), pp.28-40.
Cheshire, P.C., Nathan, M. and Overman, H.G., 2014. *Urban economics and urban policy: Challenging conventional policy wisdom*. Edward Elgar Publishing.
Chichilnisky, G., 1996. An axiomatic approach to sustainable development. *Social choice and welfare*, *13*(2), pp.231-257.
Coase, R.H., 1960. The problem of social cost. In *Classic papers in natural resource economics* (pp. 87-137). Palgrave Macmillan, London.
Coleman, A., 2017. *Housing, the 'Great Income Tax Experiment', and the intergenerational consequences of the lease*. Motu Working Paper 17-09.
Coleman, A. and Landon-Lane, J., 2007. *Housing markets and migration in New Zealand, 1962-2006* Reserve Bank of New Zealand Discussion Paper 2007/12.
COMEAP, 2010. The Mortality Effects of Long-Term Exposure to Particulate Air Pollution in the United Kingdom. A report by the Committee on the Medical Effects of Air Pollutants.
Couture, V., Duranton, G. and Turner, M.A., 2018. Speed. *Review of Economics and Statistics*, *100*(4), pp.725-739.
Covec and MRCagney, 2016. *Signals of Under-Capacity: the practicalities of monitoring price*
Covec, 2015. *Policies to Reduce Harmful Emissions from Vehicles: Costs and Benefits*. A report for the Ministry of Transport.
Cozens, P. and Love, T., 2015. A review and current status of crime prevention through environmental design (CPTED). *Journal of Planning Literature*, *30*(4), pp.393-412.
Cozens, P.M., Saville, G. and Hillier, D., 2005. Crime prevention through environmental design (CPTED): a review and modern bibliography. *Property management*, *23*(5), pp.328-356.
Cronon, W., 1992. *Nature's metropolis: Chicago and the Great West*. WW Norton & Company.
Curran-Cournane, F., Vaughan, M., Memon, A. and Fredrickson, C., 2014. Trade-offs between high class land and development: Recent and future pressures on Auckland's valuable soil resources. *Land Use Policy*, *39*, pp.146-154.
Cycle Safety Panel, 2014. *Safer journeys for people who cycle: Cycling safety panel final report and recommendations*.
Dalgaard, C.J., Kaarsen, N., Olsson, O. and Selaya, P., 2018. Roman Roads to Prosperity: Persistence and Non-Persistence of Public Goods Provision.
Davidoff, T., Pavlov, A. and Somerville, T., 2018. *Not In My Neighbor's Back Yard: External Effects of Density*. Working paper.
Davidson, A., 2003. "Reverse Sensitivity - Are No-Complaints Instruments a Solution?" *New Zealand Journal of Environmental Law*, *7*, p.203.
de Groot, H.L., Marlet, G., Teulings, C. and Vermeulen, W., 2015. *Cities and the urban land premium*. Edward Elgar Publishing.
de Vor, F. and de Groot, H.L. 2011. The impact of industrial sites on residential property values: A hedonic pricing analysis from the Netherlands. *Regional Studies*, *45*(5), pp.609-623.
Defra et al, 2007. An Economic Analysis to inform the Air Quality Strategy. Updated Third Report of the Interdepartmental Group on Costs and Benefits.
Ding, C., Simons, R. and Baku, E., 2000. The effect of residential investment on nearby property values: evidence from Cleveland, Ohio. *Journal of Real Estate Research*, *19*(1), pp.23-48.
DiPasquale, D. and Glaeser, E.L., 1999. Incentives and social capital: Are homeowners better citizens? *Journal of Urban Economics*, *45*(2), pp.354-384.
Donovan, G.H. and Butry, D.T., 2009. The value of shade: Estimating the effect of urban trees on summertime electricity use. *Energy and Buildings*, *41*(6), pp.662-668.
Donovan, S. and Munro, I., 2013. *Impact of urban form on transport and economic outcomes*. NZ Transport Agency Research Report 513.

Donovan, S., 2017. *Going with the flow – Using commuting data to identify the effect of walking and cycling travel-time on location choice in Australian cities*. MPhil Thesis, Tinbergen Institute / Vrije Universiteit Amsterdam.

Downs, A., 2005. *Still stuck in traffic: coping with peak-hour traffic congestion*. Brookings Institution Press.

Dümcke, C. and Gnedovsky, M., 2013. *The social and economic value of cultural heritage: literature review*. EENC working paper.

Duranton, G. and Puga, D., 2004. Micro-foundations of urban agglomeration economies. In *Handbook of regional and urban economics* (Vol. 4, pp. 2063-2117). Elsevier.

Duranton, G. and Turner, M.A., 2011. The fundamental law of road congestion: Evidence from US cities. *American Economic Review*, *101*(6), pp.2616-52.

Duranton, G. and Turner, M.A., 2012. Urban growth and transportation. *Review of Economic Studies*, *79*(4), pp.1407-1440.

Duranton, G. and Venables, A.J., 2018. *Place-based policies for development*. The World Bank.

Ewing, R. and Cervero, R., 2010. Travel and the built environment: a meta-analysis. *Journal of the American planning association*, *76*(3), pp.265-294.

Ewing, R., Meakins, G., Hamidi, S. and Nelson, A.C., 2014. Relationship between urban sprawl and physical activity, obesity, and morbidity–update and refinement. *Health & place*, *26*, pp.118-126.

Ewing, R., Pendall, R. and Chen, D., 2002. Measuring sprawl and its impact: The character and consequences of metropolitan expansion. *Washington, DC: Smart Growth America*.

Ewing, R., Schieber, R.A. and Zegeer, C.V., 2003. Urban sprawl as a risk factor in motor vehicle occupant and pedestrian fatalities. *American journal of public health*, *93*(9), pp.1541-1545.

Farber, S., Neutens, T., Miller, H.J. and Li, X., 2013. The social interaction potential of metropolitan regions: A time-geographic measurement approach using joint accessibility. *Annals of the Association of American Geographers*, *103*(3), pp.483-504.

Fischel, W.A., 2015. *Zoning rules!: The economics of land use regulation*. Lincoln Institute of Land Policy.

Fleming, D., Grimes, A., Lebreton, L., Maré, D. and Nunns, P., 2018. Valuing sunshine. *Regional Science and Urban Economics*, *68*, pp.268-276.

Frank, L.D. and Engelke, P., 2005. Multiple impacts of the built environment on public health: walkable places and the exposure to air pollution. *International Regional Science Review*, *28*(2), pp.193-216.

Frieling, M., 2018. *The Start of a Conversation on the Value of New Zealand's Social Capital*. New Zealand Treasury.

Fujita, M., Krugman, P.R. and Venables, A.J., 2001. *The spatial economy: Cities, regions, and international trade*. MIT press.

Ganong, P. and Shoag, D., 2017. Why has regional income convergence in the US declined?. *Journal of Urban Economics*, *102*, pp.76-90.

Garcia-López, M.A., 2012. Urban spatial structure, suburbanization and transportation in Barcelona. *Journal of Urban Economics*, *72*(2-3), pp.176-190.

Garrido-Cumbrera, M., Ruiz, D.G., Braçe, O. and Lara, E.L., 2018. Exploring the association between urban sprawl and mental health. *Journal of Transport & Health*, *10*, pp.381-390.

Genter, J.A., Donovan, S., Petrenas, B. and Badland, H., 2008. *Valuing the health benefits of active transport modes*. NZ Transport Agency research report 359.

Gerardi, K., Rosenblatt, E., Willen, P.S. and Yao, V., 2015. Foreclosure externalities: New evidence. *Journal of Urban Economics*, *87*, pp.42-56.

Glaeser, E. and Gyourko, J., 2003. The impact of building restrictions on housing affordability. *FRBNY Economic Policy Review*.

Glaeser, E. and Gyourko, J., 2018. The economic implications of housing supply. *Journal of Economic Perspectives*, *32*(1), pp.3-30.

Glaeser, E.L., 2001. The formation of social capital. *Canadian Journal of Policy Research*, *2*(1), pp.34-40.

Glaeser, E.L., 2008. *Cities, agglomeration, and spatial equilibrium*. Oxford University Press.

Glaeser, E.L., Gyourko, J. and Saks, R., 2005. Why is Manhattan so expensive? Regulation and the rise in housing prices. *The Journal of Law and Economics*, *48*(2), pp.331-369.

Glaeser, E.L., Kolko, J. and Saiz, A., 2001. Consumer city. *Journal of Economic Geography*, *1*(1), pp.27-50.

Gooder, C (2018). *Cultural Values Assessments. Negotiating kāwanatanga and rangatiratanga through local government planning processes in Aotearoa, New Zealand: a review of the literature*. Auckland Council technical report, TR2018/008.

Goujard, A., 2011. *The externalities from social housing, evidence from housing prices*. Mimeo.

Goux, D. and Maurin, E., 2005. The effect of overcrowded housing on children's performance at school. *Journal of Public Economics*, *89*(5-6), pp.797-819.

Graham, D.J., Couto, A., Adeney, W.E. and Glaister, S., 2003. Economies of scale and density in urban rail transport: effects on productivity. *Transportation Research Part E: Logistics and Transportation Review*, *39*(6), pp.443-458.

Graham, D.J., Melo, P.S., Jiwattanakulpaisarn, P. and Noland, R.B., 2010. Testing for causality between productivity and agglomeration economies. *Journal of Regional Science* 50:5, pp. 935–951.

Gray, A., 2001. Definitions of Crowding and the Effects of Crowding on Health. A Literature Review Prepared for the Ministry of Social Policy.

Grimes, A. and Aitken, A., 2004. *What's the beef with house prices? Economic shocks and local housing markets*. Motu Working Paper 04-08.

Grimes, A. and Aitken, A., 2010. Housing supply, land costs and price adjustment. *Real Estate Economics*, *38*(2), pp.325-353.

Grimes, A., 2011, September. Building Bridges: Treating a New Transport Link as a Real Option. In *ERSA conference papers* (No. ersa11p332). European Regional Science Association.

Grimes, A., Apatov, E., Lutchman, L. and Robinson, A., 2016. Eighty years of urban development in New Zealand: impacts of economic and natural factors. *New Zealand Economic Papers*, *50*(3), pp.303-322.

Guerra, E. and Kirschen, M., 2016. *Housing plus transportation affordability indices: Uses, opportunities, and challenges*. International Transport Forum Discussion Paper.

Hamidi, S., Ewing, R., Tatalovich, Z., Grace, J.B. and Berrigan, D., 2018. Associations between Urban Sprawl and Life Expectancy in the United States. *International journal of environmental research and public health*, *15*(5).

Handbury, J. and Weinstein, D.E., 2014. Goods prices and availability in cities. *The Review of Economic Studies*, *82*(1), pp.258-296.

Hannaby, R., Chiles, S., Worts, C., Whitlock, J., and Haigh, A., 2014. *State Highways noise mapping – Auckland motorways*. 26th ARRB Conference, Sydney, New South Wales 2014.

Harris, J.R. and Todaro, M.P., 1970. Migration, unemployment and development: a two-sector analysis. *The American economic review*, *60*(1), pp.126-142.

Harvey, E.P., Cardwell, R.C., McDonald, G.W., van Delden, H., Vanhout, R., Smith, N.J., Kim, J.H., Forgie, V.E. and van den Belt, M., 2018. Developing integrated models by coupling together existing models; land use, economics, demographics and transport in Wellington, New Zealand. *Computers, Environment and Urban Systems*.

Heblich, S., Redding, S.J. and Sturm, D.M., 2018. *The making of the modern metropolis: evidence from London* (No. w25047). National Bureau of Economic Research.

Helm, D., 2019. Natural capital: assets, systems, and policies. *Oxford Review of Economic Policy*, *35*(1), pp.1-13.

Hohenberg, P.M., 2004. The historical geography of European cities: an interpretive essay. In *Handbook of regional and urban economics* (Vol. 4, pp. 3021-3052). Elsevier.

Hornbeck, R. and Keniston, D., 2017. Creative destruction: Barriers to urban growth and the Great Boston Fire of 1872. *American Economic Review*, *107*(6), pp.1365-98.

Hortas-Rico, M. and Solé-Ollé, A., 2010. Does urban sprawl increase the costs of providing local public services? Evidence from Spanish municipalities. *Urban studies*, *47*(7), pp.1513-1540.

Hsieh, C.T. and Moretti, E., 2015. *Housing constraints and spatial misallocation* (No. w21154). National Bureau of Economic Research.

Irwin, E.G., 2002. The effects of open space on residential property values. Land economics, 78(4), pp.465-480.

Ivory, V., Witten, K., Salmond, C., Lin, E.Y., You, R.Q. and Blakely, T., 2012. The New Zealand index of neighbourhood social fragmentation: Integrating theory and data. *Environment and Planning A*, *44*(4), pp.972-988.

Jackson, K., 2016. Do land use regulations stifle residential development? Evidence from California cities. *Journal of Urban Economics*, *91*, pp.45-56.

James, P., Troped, P.J., Hart, J.E., Joshu, C.E., Colditz, G.A., Brownson, R.C., Ewing, R. and Laden, F., 2013. Urban sprawl, physical activity, and body mass index: Nurses' Health Study and Nurses' Health Study II. *American journal of public health*, *103*(2), pp.369-375.

Jane, J., 1961. *The death and life of great American cities*. Vintage.

Johnson, P., Leicester, A. and Stoye, G. 2012. *Fuel for Thought: The what, why, and how of motoring taxation*. A report for the RAC Foundation.

Jongeneel, M., 2017. *Evaluating the Auckland Cycle Model*. Paper presented at the 2017 IPENZ Transportation Group Conference. Hamilton, New Zealand.

Kahneman, D., 2011. *Thinking, fast and slow*. New York: Farrar, Straus and Giroux.

Kahneman, D., Knetsch, J.L. and Thaler, R.H., 1990. *Experimental tests of the endowment effect and the Coase theorem*. Journal of Political Economy, pp.1325-1348.

Kämpfer, S. and Mutz, M., 2013. On the sunny side of life: Sunshine effects on life satisfaction. *Social Indicators Research*, *110*(2), pp.579-595.

Kelly, J.F., 2011. *The housing we'd choose*. Grattan Institute. Available online at https://grattan.edu.au/report/the-housing-wed-choose/.

Kelly, S. 2010. Effects of stormwater on aquatic ecology in the Auckland region: a literature review. *Auckland Regional Council Technical Report TR2010/021*.

Kerr, G.N. and Sharp, B.M.H. 2003a. Transfer of choice model benefits: a case study of stream mitigation. Occasional Paper No.4, Environmental Management and Development Programme, National Centre for Development Studies, Australian National University.

Kerr, G.N. and Sharp, B.M.H. 2003b. Community Mitigation Preferences: A Choice Modelling Study of Auckland Streams. Research Report No. 256, Agribusiness and Economics Research Unit, Lincoln University.

Kerr, G.N. and Sharp, B.M.H. 2008. Evaluating off-site environmental mitigation using choice modelling. *The Australian Journal of Agricultural and Resource Economics* 52:381-399.

Kline, P. and Moretti, E., 2014. People, places, and public policy: Some simple welfare economics of local economic development programs. *Annu. Rev. Econ.*, *6*(1), pp.629-662.

Kolokotroni, M., Giannitsaris, I. and Watkins, R., 2006. The effect of the London urban heat island on building summer cooling demand and night ventilation strategies. *Solar Energy*, *80*(4), pp.383-392.

Kurvinen, A.T. and Tyvimaa, T., 2016. The impact of senior house developments on surrounding residential property values. *Property Management*, *34*(5), pp.415-433.

Kuschel, G., Metcalfe, J., Wilton, E., Guria, J., Hales, S., Rolfe, K. and Woodward, A., 2012. Updated Health and air pollution in New Zealand study. *Accessed on http://www.hapinz.org.nz/*.

Ladd, H.F., 1992. Population growth, density and the costs of providing public services. *Urban Studies*, *29*(2), pp.273-295.

Lazrak, F., Nijkamp, P., Rietveld, P. and Rouwendal, J., 2009. *Cultural heritage: hedonic prices for non-market values*. Working paper.

Lazrak, F., Nijkamp, P., Rietveld, P. and Rouwendal, J., 2014. The market value of cultural heritage in urban areas: an application of spatial hedonic pricing. *Journal of Geographical Systems*, *16*(1), pp.89-114.

Lee, I.M., Shiroma, E.J., Lobelo, F., Puska, P., Blair, S.N., Katzmarzyk, P.T. and Lancet Physical Activity Series Working Group, 2012. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *The lancet*, *380*(9838), pp.219-229.

Leyden, K.M., 2003. Social capital and the built environment: the importance of walkable neighborhoods. *American journal of public health*, *93*(9), pp.1546-1551.

Litman, T., 2015. *Analysis of Public Policies That Unintentionally Encourage and Subsidize Urban Sprawl*. Victoria Transport Policy Institute, supporting paper commissioned by LSE Cities at the London School of

Economics and Political Science, on behalf of the Global Commission on the Economy and Climate (www.newclimateeconomy.net) for the New Climate Economy Cities Program.

Liu, S. and Stern, D.I., 2008. *A meta-analysis of contingent valuation studies in coastal and near-shore marine ecosystems*. Working paper.

Lu, F., Xu, D., Cheng, Y., Dong, S., Guo, C., Jiang, X. and Zheng, X., 2015. Systematic review and meta-analysis of the adverse health effects of ambient PM2. 5 and PM10 pollution in the Chinese population. *Environmental research*, *136*, pp.196-204.

Macmillan, A., Connor, J., Witten, K., Kearns, R., Rees, D. and Woodward, A., 2014. The societal costs and benefits of commuter bicycling: simulating the effects of specific policies using system dynamics modeling. *Environmental health perspectives*, *122*(4), p.335.

Mare, D. and Timmins, J., 2003. Moving to jobs? Regional Employment Growth and Internal Migration 1986-2000. *Public Sector* 26(1), pp. 16-18.

Maré, D.C. and Graham D. J. 2009. *Agglomeration elasticities in New Zealand*. Wellington, Motu Economic and Public Policy Research.

Maré, D.C. and Stillman, S., 2009. *The impact of immigration on the labour market outcomes of New Zealanders*. Motu Working Paper 09-11.

Maré, D.C., 2008. *Labour productivity in Auckland firms*. Motu Working Paper 08-12.

Maré, D.C., 2016. Urban productivity estimation with heterogeneous prices and labour. Motu Working Paper 16-21.

Maré, D.C., Grimes, A. and Morten, M., 2009. Adjustment in local labour and housing markets. *Australasian Journal of Regional Studies, The*, *15*(2), p.229.

Market Economics, 2013. *The Costs of Physical Inactivity: Toward a regional full-cost accounting perspective*. A report for Wellington Regional Strategy, Waikato Regional Council and Auckland Council.

Mattingly, K. and Morrissey, J., 2014. Housing and transport expenditure: socio-spatial indicators of affordability in Auckland. *Cities*, *38*, pp.69-83.

Mayer, C.J. and Somerville, C.T., 2000a. Residential construction: Using the urban growth model to estimate housing supply. *Journal of Urban Economics*, *48*(1), pp.85-109.

Mayer, C.J. and Somerville, C.T., 2000b. Land use regulation and new construction. *Regional Science and Urban Economics*, *30*(6), pp.639-662.

Mayo, S. and Sheppard, S., 1996. Housing supply under rapid economic growth and varying regulatory stringency: An international comparison. *Journal of Housing Economics*, *5*(3), pp.274-289.

Mazumdar, S., Learnihan, V., Cochrane, T. and Davey, R., 2018. The built environment and social capital: A systematic review. *Environment and Behavior*, *50*(2), pp.119-158.

McDonald, C., 2013. *Migration and the housing market*. Reserve Bank of New Zealand research note.

McLaughlin, R.B., 2011. Metropolitan growth policies and new housing supply: evidence from Australia's capital cities. *Australasian Journal of Regional Studies*, p.60.

McMillen, D.P. and McDonald, J., 2002. Land Value in a Newly Zoned City. *The Review of Economics and Statistics, Vol.* 84, No. 1, pp. 62-72.

Melo, P.C., Graham, D.J. and Noland, R.B., 2009. A meta-analysis of estimates of urban agglomeration economies. *Regional Science and Urban Economics,* Vol. 39, Issue 3, pp.332- 342.

Melo, P.C., Graham, D.J., Levinson, D. and Aarabi, S., 2017. Agglomeration, accessibility and productivity: Evidence for large metropolitan areas in the US. *Urban studies*, *54*(1), pp.179-195.

Metz, D., 2008. The myth of travel time saving. *Transport Reviews*, *28*(3), pp.321-336.

Meurk, C.D., Blaschke, P.M. and Simcock, R., 2013. Ecosystem services in New Zealand cities. *Ecosystem services in New Zealand: conditions and trends. Manaaki Whenua Press, Lincoln*, pp.254-273.

Ministry of Business, Innovation, and Employment, 2017. *Urban Development Capacity: Price Efficiency Indicators Technical Guides*. Available online at https://mbienz.shinyapps.io/urban-development-capacity/.

Montgomery, C., 2013. *Happy city: transforming our lives through urban design*. Macmillan.

Moores, J., Gadd, J., Yalden, S., and Batstone, C., 2016. *Urban Development and the NPS-FM: Lucas Creek Catchment Case Study*. A report for the Ministry of Primary Industries.

Morris, E.A. and Pfeiffer, D., 2017. Who Really Bowls Alone? Cities, Suburbs, and Social Time in the United States. *Journal of Planning Education and Research*, *37*(2), pp.207-222.

MRCagney, 2016. *The agglomeration and productivity impacts of alternative urban growth scenarios for Auckland*. A report for Auckland Council.

Ndebele, T. and Forgie, V., 2017. Estimating the economic benefits of a wetland restoration programme in New Zealand: A contingent valuation approach. *Economic Analysis and Policy*, *55*, pp.75-89.

Nelson, J.P., 2004. Meta-analysis of airport noise and hedonic property values. *Journal of Transport Economics and Policy (JTEP)*, *38*(1), pp.1-27.

New Zealand Transport Agency, 2010. *Reverse Sensitivity*. Wellington: New Zealand Transport Agency. Available online at http://www.nzta.govt.nz/resources/reverse-sensitivity/reverse-sensitivity.html.

New Zealand Transport Agency, 2018. *Economic Evaluation Manual*. Available online at https://www.nzta.govt.nz/resources/economic-evaluation-manual.

Newman, O., 1973. *Defensible Space: People and Design in the Violent City*. London, UK: Architectural Press.

Nijkamp, P., 2012. Economic valuation of cultural heritage. *The Economics of Uniqueness*.

Noonan, D.S., 2003. Contingent valuation and cultural resources: a meta-analytic review of the literature. *Journal of Cultural Economics*, *27*(3-4), pp.159-176.

Nunns, P. and Denne, T., 2016. *The costs and benefits of urban development: A theoretical and empirical synthesis*. Paper presented at the New Zealand Association of Economists Conference 2016, Auckland, New Zealand.

Nunns, P., 2018a. *The causes and economic consequences of rising regional housing prices in New Zealand*. Centre for Applied Research in Economics Working Paper No 005. Auckland, New Zealand.

Nunns, P., 2018b. *The determinants of housing supply responsiveness in New Zealand regions*. Paper presented at the 2018 New Zealand Association of Economists conference, Auckland, New Zealand.

Nunns, P., Allpress, J., and Balderston, K., 2016. How Do Aucklanders Value Their Parks? A hedonic analysis of the impact of proximity to open space on residential property values. Auckland Council Technical Report 2016/031.

Nunns, P., Donovan, S., Adli, S., Raichev, A., and Cooper, G., 2014. *Location Affordability in New Zealand Cities: An Intra-urban and Comparative Perspective*. Paper presented at the New Zealand Association of Economists 2014 Annual Conference.

Nunns, P., Hitchins, H. and Balderston, K. 2015. *The value of land, floorspace and amenities: a hedonic price analysis of property sales in Auckland 2011-2014*. Auckland Council technical report, TR2015/012.

NZIER, 2013. *Regional government expenditure Estimates of core crown spending by region*. A report for MBIE and Treasury.

NZIER, 2018. *What's the use of non-use values? Non-Use Values and the Investment Statement*. A report for the Treasury.

NZIER. 2009. *The value of air quality standards. Review and update of cost benefit analysis of National Environmental Standards on Air Quality*. Report to Ministry for the Environment.

Office of the Mayor of Auckland, 2017. *Mayoral Housing Taskforce Report*. Auckland, New Zealand.

Oja, P., Titze, S., Bauman, A., De Geus, B., Krenn, P., Reger-Nash, B. and Kohlberger, T., 2011. Health benefits of cycling: a systematic review. *Scandinavian journal of medicine & science in sports*, *21*(4), pp.496-509.

Ooi, J.T. and Le, T.T., 2013. The spillover effects of infill developments on local housing prices. *Regional Science and Urban Economics*, *43*(6), pp.850-861.

Oum, T.H. and Zhang, Y., 1997. A note on scale economies in transport. *Journal of Transport Economics and Policy*, *31*(3), pp.309-315.

Paciorek, A., 2013. Supply constraints and housing market dynamics. *Journal of Urban Economics*, *77*, pp.11-26.

Peen, J., Schoevers, R.A., Beekman, A.T. and Dekker, J., 2010. The current status of urban-rural differences in psychiatric disorders. *Acta Psychiatrica Scandinavica*, *121*(2), pp.84-93.

Pierce, G. and Shoup, D., 2013. Getting the prices right: an evaluation of pricing parking by demand in San Francisco. *Journal of the American Planning Association*, *79*(1), pp.67-81.

Pough, B. and Wan, Q., 2017. Data Analytics and the Fight against Housing Blight: A Guide for Local Leaders.

Preston, K., Mare, D., Grimes, A., and Donovan, S., 2018. *Amenities and the attractiveness of New Zealand cities*. Motu Working Paper 18-14.

Productivity Commission, 2018. *Low emissions economy inquiry: Final report*. Wellington, New Zealand.

Productivity Commission. 2017. *Better urban planning inquiry: Final report*. Wellington, New Zealand.

Pucher, J., Buehler, R., Bassett, D.R. and Dannenberg, A.L., 2010. Walking and cycling to health: a comparative analysis of city, state, and international data. *American journal of public health*, *100*(10), pp.1986-1992.

Putnam, R.D., 2001. *Bowling alone: The collapse and revival of American community*. Simon and Schuster.

Rappaport, J., 2009. The increasing importance of quality of life. *Journal of Economic Geography*, *9*(6), pp.779-804.

Roback, J., 1982. Wages, rents, and the quality of life. *Journal of political Economy*, *90*(6), pp.1257-1278.

Rogers, S., Aytur, S., Gardner, K. and Carlson, C., 2012. Measuring community sustainability: exploring the intersection of the built environment & social capital with a participatory case study. *Journal of Environmental Studies and Sciences*, *2*(2), pp.143-153.

Rogers, S.H., 2011. Examining the Relationship Between Social Capital and the Built Environment: A Case Study in Measuring Community Sustainability. Doctoral Dissertations. 621. https://scholars.unh.edu/dissertation/621

Rohani, M. 2012. *Impact of Hauraki gulf amenity on land price of neighbourhood properties: an empirical hedonic pricing method, case study North Shore, Auckland.* Auckland Council Technical Report.

Rohani, M. and Kuschel, G., 2017. *An assessment of potential impacts of different growth scenarios on Auckland's natural environment*. Auckland Council technical report, TR2017/022.

Rosenthal, S.S. and Strange, W.C., 2003. Geography, industrial organization, and agglomeration. *Review of Economics and Statistics*, *85*(2), pp.377-393.

Rosenthal, S.S. and Strange, W.C., 2004. Evidence on the nature and sources of agglomeration economies. In *Handbook of regional and urban economics* (Vol. 4, pp. 2119-2171). Elsevier.

Roskruge, M., Grimes, A., McCann, P. and Poot, J., 2013. Homeownership, social capital and satisfaction with local government. *Urban Studies*, *50*(12), pp.2517-2534.

Rossi-Hansberg, E., Sarte, P.D. and Owens III, R., 2010. Housing externalities. *Journal of Political Economy*, *118*(3), pp.485-535.

Rouwendal, J., and Van Der Straaten, W., 2008. The costs and benefits of providing open space in cities. *Tinbergen Institute Discussion Paper No. 2008-001/3*.

Rypkema, D., Cheong, C. and Mason, R., 2011. Measuring economic impacts of historic preservation. *Advisory Council on Historic Preservation*.

Saiz, A., 2003. Room in the kitchen for the melting pot: Immigration and rental prices. *Review of Economics and Statistics*, *85*(3), pp.502-521.

Saiz, A., 2007. Immigration and housing rents in American cities. *Journal of Urban Economics*, *61*(2), pp.345-371.

Saiz, A., 2010. The geographic determinants of housing supply. *The Quarterly Journal of Economics*, *125*(3), pp.1253-1296.

Salomons, E.M. and Pont, M.B., 2012. Urban traffic noise and the relation to urban density, form, and traffic elasticity. *Landscape and Urban Planning*, *108*(1), pp.2-16.

Sandhu, H.S., Wratten, S.D., Cullen, R. and Case, B., 2008. The future of farming: the value of ecosystem services in conventional and organic arable land. An experimental approach. *Ecological economics*, *64*(4), pp.835-848.

Satyanath, S., Voigtländer, N. and Voth, H.J., 2017. Bowling for fascism: Social capital and the rise of the Nazi Party. *Journal of Political Economy*, *125*(2), pp.478-526.

Savage, I., 1997. Scale economies in United States rail transit systems. *Transportation Research Part A: Policy and Practice*, *31*(6), pp.459-473.

Schiff, N., 2014. Cities and product variety: evidence from restaurants. *Journal of economic geography*, *15*(6), pp.1085-1123.

Schwartz, A.E., Ellen, I.G., Voicu, I. and Schill, M.H., 2006. The external effects of place-based subsidized housing. *Regional Science and Urban Economics*, *36*(6), pp.679-707.
Schwartz, J., 1994. Air pollution and daily mortality: a review and meta analysis. *Environmental Research*, *64*(1), pp.36-52.
Seaton, A., Godden, D., MacNee, W. and Donaldson, K., 1995. Particulate air pollution and acute health effects. *The Lancet*, *345*(8943), pp.176-178.
Shah, A.S., Langrish, J.P., Nair, H., McAllister, D.A., Hunter, A.L., Donaldson, K., Newby, D.E. and Mills, N.L., 2013. Global association of air pollution and heart failure: a systematic review and meta-analysis. *The Lancet*, *382*(9897), pp.1039-1048.
Shaw, C., Randal, E., Keall, M. and Woodward, A., 2018. Health consequences of transport patterns in New Zealand's largest cities. *New Zealand Medical Journal*, *131*(1472), pp.64-72.
Shoup, D., 2005. *The High Cost of Free Parking*. APA Planners Press.
signals under the National Policy Statement on Urban Development Capacity. A report for the Ministry of Business, Innovation and Employment and Ministry for the Environment.
Sinning, M., & Stillman, S. 2012. Where Should I Live? The Locational Choices of Australians and New Zealanders. University of Otago Economics Discussion Papers No. 1204.
Small, K.A. and Verhoef, E.T., 2007. *The economics of urban transportation*. Routledge.
Smith, V.K. and Huang, J.C., 1995. Can markets value air quality? A meta-analysis of hedonic property value models. *Journal of political economy*, *103*(1), pp.209-227.
Solari, C.D. and Mare, R.D., 2012. Housing crowding effects on children's wellbeing. *Social science research*, *41*(2), pp.464-476.
Song, Y. and Knaap, G.J., 2004. Measuring the effects of mixed land uses on housing values. *Regional Science and Urban Economics*, *34*(6), pp.663-680.
Stieb, D.M., Judek, S. and Burnett, R.T., 2002. Meta-analysis of time-series studies of air pollution and mortality: effects of gases and particles and the influence of cause of death, age, and season. *Journal of the Air & Waste Management Association*, *52*(4), pp.470-484.
Stillman, S. and Maré, D., 2008. Housing markets and migration: evidence from New Zealand. Motu Working Paper 08-06.
Stillman, S., Velamuri, M. and Aitken, A., 2010. The long-run impact of New Zealand's structural reform on local communities. *Journal of Comparative Economics*, *38*(4), pp.432-448.
Strømann-Andersen, J. and Sattrup, P.A., 2011. The urban canyon and building energy use: Urban density versus daylight and passive solar gains. *Energy and Buildings*, *43*(8).
Sturm, R. and Cohen, D.A., 2004. Suburban sprawl and physical and mental health. *Public health*, *118*(7), pp.488-496.
Stutzer, A. and Frey, B.S., 2008. Stress that doesn't pay: The commuting paradox. *Scandinavian Journal of Economics*, *110*(2), pp.339-366.
Tabuchi, T. and Yoshida, A., 2000. Separating urban agglomeration economies in consumption and production. *Journal of Urban Economics*, *48*(1), pp.70-84.
Tax Working Group, 2018. *Future of Tax: Interim Report*.
Throsby, D., 2003. Determining the value of cultural goods: How much (or how little) does contingent valuation tell us? *Journal of Cultural Economics*, *27*(3-4), pp.275-285.
Tipa, G. and Teirney, L., 2006. *A Cultural Health Index for Streams and Waterways: A tool for nationwide use*. A report for the Ministry for the Environment.
US Environmental Protection Agency, 2011. *The Benefits and Costs of the Clean Air Act from 1990 to 2020*. Final Report Rev A.
van den Belt, M. and Cole, A. 2014. Ecosystem goods and services in marine protected areas (MPAs). Department of Conservation, Science for Conservation 326.
Van den Belt, M. and Cole, A.O., 2014. *Ecosystem goods and services in marine protected areas (MPAs)*. A report for the Department of Conservation.

Van den Belt, M., 2004. *Mediated modeling: a system dynamics approach to environmental consensus building*. Island press.

Van Zyl, S. and Au, J., 2018. *The Start of a Conversation on the Value of New Zealand's Natural Capital*. New Zealand Treasury Living Standards Series: Discussion Paper 18/03.

Wallis, I.P. and Lupton, D.R., 2013. *The costs of congestion reappraised*. NZ Transport Agency Research Report 489.

Wong, S.K., Chau, K.W., Yau, Y. and Cheung, A.K.C., 2011. Property price gradients: the vertical dimension. *Journal of Housing and the Built Environment*, *26*(1), pp.33-45.

Wood, L., Frank, L.D. and Giles-Corti, B., 2010. Sense of community and its relationship with walking and neighborhood design. *Social Science & Medicine*, *70*(9), pp.1381-1390.

Yau, Y., Wing Chau, K., Chi Wing Ho, D. and Kei Wong, S., 2008. An empirical study on the positive externality of building refurbishment. *International journal of housing markets and analysis*, *1*(1), pp.19-32.

Yeo, J., Park, S. and Jang, K., 2015. Effects of urban sprawl and vehicle miles traveled on traffic fatalities. *Traffic injury prevention*, *16*(4), pp.397-403.

Yeoman, R. and Akehurst, G., 2015. *The Housing We'd Choose: A Study of Housing Preferences, Choices and Trade-offs in Auckland*. Auckland Council Technical Report.

Zahirovich-Herbert, V. and Gibler, K.M., 2014. The effect of new residential construction on housing prices. *Journal of Housing Economics*, *26*, pp.1-18.

8 Appendix 1: Previous estimates of the costs and benefits of urban development

Several recent studies have attempted to comprehensively assess the costs and benefits that arise from urban development in Australia, the US, and New Zealand. These studies typically compare what happens when development occurs in different locations within a city. For instance, they may assess and compare the effects of developing new 'greenfield' suburbs on previously undeveloped land with the effects of redeveloping and intensifying existing suburbs.

These studies are often undertaken as an input to strategic planning decisions, such as the development of regional spatial plans or major zoning code reviews. They typically employ a mix of methods to measure and value different effects, rather than attempting to address them all within a single urban economics model.

8.1.1 Sydney (Centre for International Economics, 2010; Centre for International Economics and Arup, 2012)

In 2010, the Centre for International Economics (CIE) assessed the costs of alternative growth paths for Sydney. They compared three alternative scenarios for the distribution of future growth from 2011 to 2036 that allocated different shares of growth to greenfield areas on the edge of the city or infill or intensification within the existing urbanised area. Total population growth was held constant, meaning that the results reflect differences in the costs of a similar amount of development occurring in different locations.

CIE's assessment focused principally on the costs to supply new transport infrastructure, utility services, and social facilities such as schools, hospitals, and open spaces, impacts on transport network congestion, environmental impacts such as greenhouse gas emissions and air quality, and the 'transformation' benefits associated with rezoning and developing different areas (which are internalised by landowners, developers and/or residents). [16] It did not consider impacts on economic productivity via increased or reduced agglomeration economies, environmental impacts related to development of open space, or positive or negative amenity impacts on from new development.

Table 8 summarises CIE's key results. They find that the urban renewal-focused scenario (column 3) results in the lowest costs, while the greenfield-focused scenario (column 2) results in the highest costs. Transport infrastructure costs and water / wastewater costs are the main driver of this difference. Some categories of costs are higher in the urban renewal-focused scenario, such as primary and secondary school construction costs. These costs reflect capacity constraints in existing schools that result in a need to build new schools on expensive urban land.

This table summarises costs in present value terms over a multi-decade period.

[16] Transformation benefits were valued by examining the difference in land values between comparably-located and -sized sites with different zoning. They appear to reflect the uplift in land values that may arise if existing zoning and infrastructure restrictions were eased to permit either redevelopment or greenfield expansion. This raises questions about whether this is measuring the impact of an alternative growth path, or the cost of existing limits to development.

Table 8: CIE's estimates of the costs of alternative growth paths for Sydney

Category	*2005 Metropolitan Strategy*	*Focused on fringe/ Greenfield*	*Focused on urban renewal*	*Deviations from Metropolitan Strategy*	
Ratio – Infill: Greenfield	70/30	50/50	90/10	50/50	90/10
	$m	$m	$m	$m	$m
Transport					
Connecting transport	2 446	4 235	1 382	1 789	-1 065
Major infrastructure/congestion	11 057	11 599	10 786	542	-271
Physical infrastructure					
Electricity	1 903	1 919	1 898	16	-5
Water and sewerage	5 912	6 620	5 204	708	-708
Social infrastructure					
Primary education	2 064	1 922	2 186	- 142	122
Secondary education	1 247	1 164	1 298	- 84	51
Health	8 651	8 656	8 645	5	-5
Other social infrastructure	103	99	108	-4	5
Local council	6 529	6 695	6 419	167	-110
Environmental					
GHG emissions (relative to Metropolitan Strategy)	0	116	-116	116	-116
Air pollution	889	1 010	857	121	-33
Noise pollution	314	356	302	43	-12
Total costs	41 115	44 391	38 969	3 276	-2 145
Transformation benefits relative to Scenario 1	0	-1 716	-1 351	-1 716	-1 351
Net benefits relative to Scenario 1				-4 992	795

Notes: The benefits and costs presented in this table reflect the net present value of costs from 2011 to 2036 using a 7 per cent real discount rate.
Source: The CIE.

CIE and Arup (2012) conducted a follow-up study that compared alternative scenarios for the location of future infill and redevelopment in existing urban areas, holding the quantity and location of greenfield development constant.

In addition to the costs identified in the previous study, CIE and Arup also valued impacts on economic productivity via increased/decreased agglomeration economies and social impacts related to the health benefits of changes to active transport participation and social inclusion benefits from being able to reach more (or fewer) destinations.

As shown in Table 9, they find that the net benefits of growth vary between scenarios. These are driven mostly by differences in the value of land use change, which is described as 'transformation benefits' in the above table. Productivity spillovers and transport costs are also important drivers of differences.

This table summarises costs and benefits per added dwelling in present value terms over a multi-decade period.

Table 9: CIE and Arup's estimates of the costs and benefits of alternative scenarios for urban intensification

8.1.2 United States cities (Litman, 2015)

Litman (2015) compares the magnitude of costs arising from development patterns in denser and more sprawling US cities. He focuses on several channels through which low-density 'sprawl' development can generate external costs, relative to higher-density development focused in existing urban areas. First, it increases consumption of open space and undeveloped land; second, it increases average travel distances and hence affects people's transport behaviours; and third, it can affect the cost to supply infrastructure and public services.

Litman quantifies transport impacts and costs for infrastructure and public services based on empirical estimates of how these costs scale in urban locations with different average population density. He divides these costs between transport costs that are internalised by users (such as the financial cost of owning and operating motor vehicles), and external costs (such as air pollution and increased road crashes). As shown in Table 10, he estimates that external costs tend to be higher in lower-density cities.

This table summarises costs in annual terms on a per-person basis. As context for this table, most New Zealand and Australian cities would fall into the first quintile ('smartest growth'). 2013 Census data indicates that Auckland's built-up area has an average density of around 27 people per hectare, while Christchurch has an average density of around 22 people per hectare.

Litman also notes, but does not quantify, some other effects of sprawl development, including benefits of living in different places that are internalised by residents, impacts on economic productivity (via increased or decreased agglomeration economies), social impacts (eg equity of access to services), and housing affordability (which may be beneficial to individual households).

Table 10: Litman's estimates of the costs of low-density sprawl development in the US

			Sprawl Index Quintile				
Impact	**Units**	**Sprawl Factor[1]**	**1**	**2**	**3**	**4**	**5**
			Smartest Growth		**Average**		**Most Sprawled**
Urban density[2]	People/hectare	40%	23.5	16.8	12.0	7.2	4.3
Infrastructure capital costs[3]	Annualized $/capita	10%	$502	$558	$620	$682	$750
Public service costs[4]	Annual $/capita	10%	$1,201	$1,334	$1,482	$1,631	$1,794
Motor vehicle travel[5]	Annual km/capita	17%[6]	10,389	13,182	15,174	17,684	22,896
Fuel consumption[7]	Annual litres/capita	17%	1,039	1,318	1,517	1,768	2,290
Vehicle internal costs[8]	Annual $/capita	17%	$4,603	$5,840	$6,723	$7,835	$10,144
Vehicle external costs[7]	Annual $/capita	17%	$3,082	$3,911	$4,502	$5,246	$6,793
Active transport[9]	Annual walk-bike km/ca.	20%	360	300	250	200	160
Active transport benefit[10]	$/km walked/biked	$1.00	-$360	-$300	-$250	-$200	-$160
Traffic fatalities	Deaths/100,000 pop.	28%	4.3	5.9	8.2	10.5	13.4
			Total Per Capita Costs				
Internal costs			*$4,414*	*$5,730*	*$6,683*	*$7,866*	*$10,239*
Incremental internal costs			*$0*	*$1,316*	*$2,270*	*$3,453*	*$5,825*
External costs			*$4,615*	*$5,614*	*$6,394*	*$7,328*	*$9,082*
Incremental external costs			*$0*	*$999*	*$1,779*	*$2,713*	*$4,467*
Total costs			**$9,028**	**$11,343**	**$13,077**	**$15,194**	**$19,321**
Total incremental costs			**$0**	**$2,315**	**$4,049**	**$6,165**	**$10,293**

8.1.3 Auckland (Nunns and Denne, 2016)

Nunns and Denne (2016) estimate the magnitude of external costs and benefits arising from urban intensification or greenfield development in Auckland. Unlike the above studies, they focus on marginal changes – ie the impact of adding a small number of dwellings and residents – rather than changes to the overall distribution of future growth.

Nunns and Denne attempt to measure and value a wider range of costs and benefits than the above studies. In addition to infrastructure costs, congestion costs, air quality impacts, and agglomeration economies, they also estimate the cost of overshadowing and blocked views from development of taller buildings, the cost of consuming open space at the edge of cities, and the cost of impacts on water quality. They report a range of estimates for each location to highlight uncertainty about the magnitude of some effects.

Table 11 summarises their findings. They find that external costs are likely to be lower for urban intensification than for greenfield development, but that intensification in high-impact locations can have larger negative effects than greenfield development in low-impact locations.

This table summarises costs and benefits per added dwelling in present value terms over a multi-decade period.

The costs of intensification are more likely be localised, eg overshadowing of neighbouring properties, whereas the costs of greenfield development are more likely to arise at a regional level, eg due to consumption of open space or increased traffic congestion on major roads.

Lastly, Nunns and Denne find that once agglomeration benefits are factored in, the net direction of externalities arising from urban development may be positive, rather than negative. Even under relatively conservative assumptions about the link between city size / density and economic productivity, agglomeration benefits are comparable in magnitude to external costs of development.

Table 11: Nunns and Denne's estimates of the external costs and benefits of urban development in Auckland

Externalities	**Urban intensification**		**Greenfield**	
	Low (PV $/dwelling)	**High (PV $/dwelling)**	**Low (PV $/dwelling)**	**High (PV $/dwelling)**
External infrastructure costs				
• Transport	$0	$0	-$6,800	-$10,300
• Water / wastewater	-$3,200	-$12,700	-$3,200	-$21,400
• Stormwater	$0	-$1,600	$0	-$1,600
• Open spaces and community facilities	$0	$0	-$2,100	-$3,200
Congestion	-$22,700	-$29,700	-$35,200	-$49,000
Overshadowing from tall buildings	$0	-$9,800	$0	$0
Blocked views from tall buildings	$0	-$10,200	$0	$0
Loss of peri-urban open space	$0	$0	-$2,700	-$4,700
Air quality	-$3,800	-$4,200	-$3,200	-$3,800
Freshwater quality	$0	-$2,200	-$1,800	-$3,600
Coastal water quality	$0	-$800	-$1,900	-$3,800
Noise, smells, and nuisances from incompatible activities	(Unknown)	(Unknown)	(Unknown)	(Unknown)
Agglomeration economies in production	$92,900	$46,400	$92,900	$46,400
Agglomeration economies in consumption	(Unknown)	(Unknown)	(Unknown)	(Unknown)
Total	**$63,800**	**-$24,800**	**$36,000**	**-$55,000**
Total excluding agglomeration economies	*-$29,100*	*-$71,200*	*-$56,900*	*-$101,400*

9 Appendix 2: Costs and benefits that are internalised to residents

9.1 How these effects arise

We identify two broad types of costs and benefits that are internalised to the people who live in new urban developments:

- Costs to live in a certain location, which include the price of housing, the cost of travelling to destinations such as work, school, retail, including car ownership and parking costs, and other location-specific costs, such as utility services (water, home heating, etc).
- Benefits from living in that location, which reflect the subjective value that people derive from their home, the environmental amenities that are offered by their location (eg sunshine, clean air), and their opportunities to access work, recreational destinations, etc. For people with low incomes or few housing options, the alternative may be overcrowded housing or homelessness.

Similarly, businesses internalise costs and benefits as a result of their location choices. The costs that they incur from operating in a given location include the cost of renting or buying premises, the costs to obtain inputs and serve customers, and the wages that they must pay to hire workers. The benefits they receive from that location are reflected in firm profitability, rather than subjective benefits. For simplicity, our discussion here focuses on residents.

It is usually easier to measure differences in costs of living between locations than it is to measure differences in benefits. A reasonable assumption is that the benefits that people derive from their choices about where to live outweigh the costs that they face, at least when considered against their other alternatives. As a result, evidence of high costs to live in a certain location does not indicate that it is undesirable for people to live there. They may simply derive large benefits from being there – and be willing to pay more for them, relative to their income and wealth (Roback, 1982).

9.2 Evidence on the cost of living in different locations

The costs that people incur to live in different locations can be measured using data or estimates of expenditures on housing, transport, and other location-related costs such as utility services. This is conceptually straightforward, although it can be subject to measurement error or data gaps.

Using housing prices to compare cities or regions

Housing prices are frequently used to compare cost of living between different cities or regions (Covec and MRCagney, 2016). Some common measures of housing prices include:

- Average or median house prices, ie the total cost to buy a typical home in a city;
- Mortgage servicing costs for a typical home in a city, which reflect average house prices and current mortgage interest rates; and
- Average or median rents, ie the cost to rent a typical home in a city.

In general, locations with high house prices also tend to have high rents. The price for a house should reflect the capitalised value of current and future rents. This means that we would expect to see a higher ratio of prices to rents when real interest rates are low.[17] Similarly, if rents are expected to rise more rapidly in the future, we would expect to observe a higher ratio.

Table 12 compares average house prices and rents in five New Zealand cities. Differences in current rents between Auckland and the other cities are smaller than differences in house prices. For instance, average house prices in Christchurch were only 54% of Auckland levels, but average rents in Christchurch were 71% of Auckland levels.

This suggests that high house prices in some locations may also reflect expectations about future housing market conditions.[18] For instance, if people expect a city to grow rapidly in the future, they may be willing to pay more to buy a home today to benefit from expected future increases in house prices.

Table 12: Average house prices and rents in New Zealand's five largest urban areas

Urban area	Average house price (Q3 2018)	... relative to Auckland	Average weekly rent (Q3 2018)	... relative to Auckland
Auckland	$830,000	100%	$523	100%
Greater Christchurch	$450,000	54%	$370	71%
Greater Hamilton	$555,000	67%	$385	74%
Greater Tauranga	$623,000	75%	$408	78%
Greater Wellington	$595,000	72%	$438	84%

Source: https://mbienz.shinyapps.io/urban-development-capacity/

A second common approach is to construct measures of housing affordability that capture relative level of housing prices and incomes in different regions. Covec and MRCagney (2016) summarise several measures that are in use. However, these measures can be challenging to interpret. Urban economic theory suggests that, if a region has high housing prices and low incomes, it is likely to indicate that it offers amenities, such as an attractive climate or good public education, that are not priced directly. We discuss this point below when considering the benefits that people receive from their location choices.

Housing and transport cost indices

Within cities, places with low housing prices may not necessarily have a low overall cost of living. Other location-related costs, such as transport costs or utility costs, may be higher in these locations.[19] As a result, housing prices are not a good basis for comparing the private costs that people incur to live in different places *within* cities.

Transport costs required to reach key destinations, such as work, education, retail, and friends and family, can differ between locations, especially in large cities. The availability of public transport and walking and cycling options can also influence the costs of car ownership and parking in different locations. In addition, the cost of utility services such as water, power (eg for home heating), and communications can vary between locations, reflecting providers' charging policies and servicing costs as well as the local climate.

[17] By real interest rates we mean adjusting nominal interest rates for inflation and taxation.
[18] An alternative explanation would be systematic differences in the relative quality of rented and owned homes in different regions.
[19] Differences in tax rates between local government areas will also tend to be capitalised into house prices.

Simple urban economic models imply that overall location-related costs will be equalised across all locations in the same city (Glaeser, 2008).[20] In other words, lower rents in one location may be balanced out by higher transport costs, and vice versa. A corollary is that transport investments and policies that flatten out the commuting cost gradient and make more places accessible will also tend to reduce housing prices.

Empirical data appears to bear out this hypothesis. A number of studies have attempted to quantify the sum of housing costs and transport costs incurred by people living in different places within cities, using either microdata from household expenditure and travel surveys or suburb-level data from the Census.

In the US, the Center for Neighbourhood Technology has developed a Housing and Transport Cost Index for a range of cities (Guerra and Kirschen, 2016).[21] The US Department of Housing and Urban Development and Department of Transport later extended and updated their work in their Location Affordability Index.[22]

In New Zealand, Mattingly and Morrissey (2014) developed suburb-level estimates of housing and transport costs for Auckland using 2006 Census data. Nunns et al (2014) updated these estimates using 2013 Census data and extended them to Auckland, Wellington and Christchurch. Both studies estimate housing costs using rents and transport costs based on commuting distances and modes and car ownership levels in different locations, as the Census does not provide information on house prices or travel for non-commute purposes.

Consistent with urban economic theory, these studies find that housing costs fall with distance from the centre of these cities, while transport costs rise with distance. The net effect is that overall location-related costs per household are similar for households that are closer or further away from the city centre.[23]

Figure 9 summarises average estimated costs per household in different locations in Auckland, Wellington, and Christchurch. In Auckland and Wellington, average housing costs fall with distance to the city centre, but there is no clear rising or falling trend for overall location-related costs. In Christchurch, total location-related costs appear to rise with increasing distance to the city centre. As costs were estimated using 2013 Census data, this may reflect the short-run impact of the 2010 Canterbury earthquakes on household and firm location patterns.

Mattingly and Morrissey (2014) and Nunns et al (2014) also find that household incomes tend to fall with distance from the city centre. This suggests that different types of households are 'sorting' into different locations. As a result, location-related costs may (on average) account for a larger share of incomes in outlying suburbs than in central suburbs. It is unclear what is driving these trends, and what consequences they have for wellbeing.

Nunns et al (2014) highlighted some important limitations for analysing location-related costs using Census data grouped at the suburb level. First, Census data only captures information on car ownership and commuting patterns, and hence does not account for all transport costs. Second, it uses rents as a proxy for housing prices, although there is evidence that the ratio of rents to house prices can differ between locations (as shown in Table 12). Third, suburb-level Census data may fall prey to the ecological fallacy, which is that outcomes for individuals may vary significantly from suburb-level averages.

As a result, Nunns et al suggest that microdata from the Household Economic Survey, which captures households' overall spending patterns, could be used to make a more comprehensive and reliable estimate of location-specific housing, transport, and utility costs.

[20] The Alonso-Mills-Muth model, which is a standard urban economics model explained by Glaeser (2008), predicts that the housing price gradient will be determined by the transport cost gradient. The simplest version of this model assumes that everybody shares the same income and preferences. If people's incomes or preferences vary, different types of people may sort into different locations depending upon their taste for different amenities or their ability to pay for them.
[21] Available online at https://htaindex.cnt.org/.
[22] https://www.hudexchange.info/programs/location-affordability-index/
[23] These calculations do not include non-monetary costs of transport. If time spent commuting is also included, then more distant locations may be more 'costly' overall. However, this depends upon the subjective value that people with different commutes place on travel time.

Figure 9: Estimated housing and transport costs per household, by distance to city centre (Nunns et al, 2014)

Factors that determine the rental price of housing

Housing prices reflect the influence of a range of supply and demand factors. Andrews, Caldera Sanchez and Johansson (2011) review the drivers of changes to house prices in OECD countries, which include demand-side factors like the increased availability of cheap mortgage credit, tax policies that incentivise home-buying, and rapid population growth, and supply-side factors that make it difficult to build more homes in response to increased demand. Following the previous section, transport costs within cities can also influence housing prices.

Glaeser, Gyourko and Saks (2005) focus on supply-side drivers of house prices. They argue that house prices (or apartment prices) can be decomposed into:

- The underlying cost to build housing, which principally comprise the physical costs to construct it, but also include ancillary costs such as project management, design, consenting, and fees to connect to infrastructure networks; and
- Price distortions driven by scarcity of housing in that location (either current or expected), which in turn indicate that there are barriers to building more housing there. The resulting price distortions are capitalised into land prices and can push the price of residential land up above the underlying cost to convert it from non-residential uses.

Barriers to building new housing can in turn reflect:

- Frictions arising from the presence of existing buildings or land titles that raise the cost and difficulty of acquiring and redeveloping sites;
- Zoning rules that limit new development or increase the cost or difficulty of developing; and/or
- Infrastructure constraints that limit new development, including a lack of transport infrastructure that pushes up transport costs as cities grow.

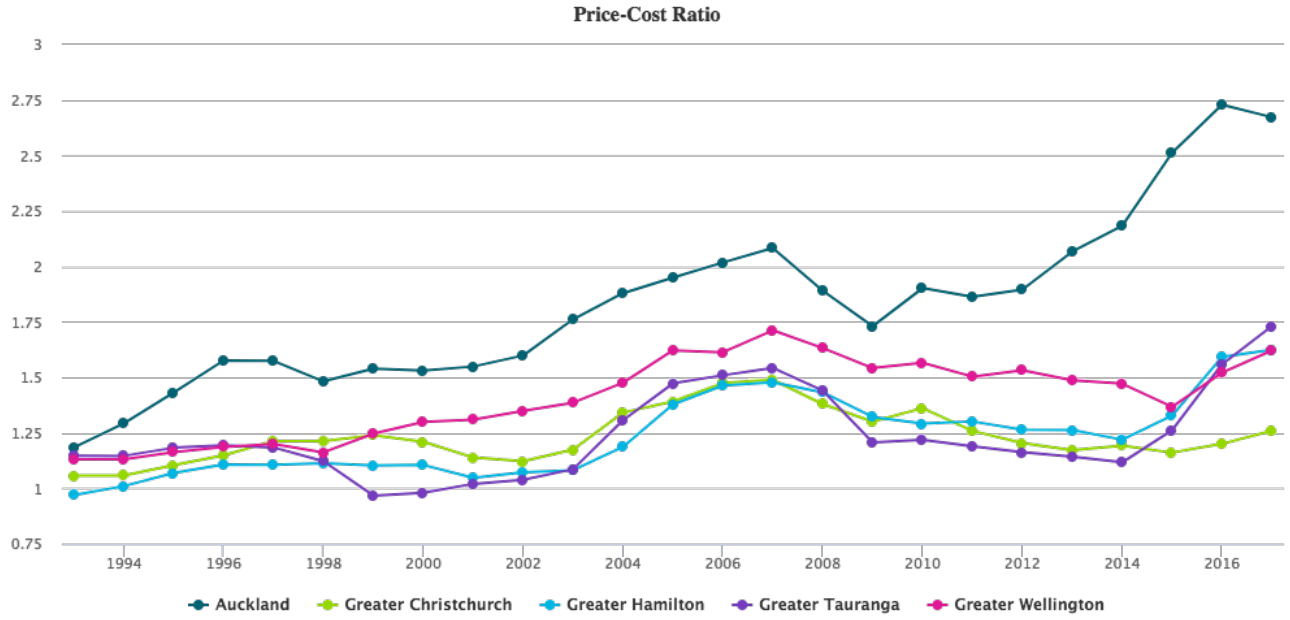
In a growing city, we would expect house prices to be above the cost of construction. That is, the price that people pay for housing should be sufficient to cover the cost to develop housing, including any charges for infrastructure that are applied to new development.[24] However, prices can also be *higher* than the underlying costs of construction, which means that they cover underlying development costs *plus* a 'scarcity rent'.

Following this principle, MBIE (2017) calculated the ratio of house prices to construction costs for New Zealand cities and regions. They suggest that a reasonable ratio would be in the range of 1 to 1.5, and when house prices are above this range, it indicates that they are being driven up by scarcity.

Figure 10 summarises data for five large New Zealand cities, four of which have experienced an increasing price to cost ratio in recent years. In Auckland, average house prices are over 2.5 times as high as construction costs, which indicates that there is a substantial shortfall of housing supply relative to demand. In Hamilton, Tauranga, and Wellington, prices are over 1.5 times construction costs, which is evidence of emerging scarcity. Christchurch, by contrast, has house prices that are much more in line with construction costs.

[24] Glaeser and Gyourko (2018) also note that, because housing is durable, places that have experienced substantial declines in housing demand may have house prices that fall below the underlying cost to build it.

Figure 10: Ratio of house prices to construction costs in five New Zealand cities



Source: https://mbienz.shinyapps.io/urban-development-capacity/

In cities where housing is scarce, due to the barriers mentioned above, urban development that alleviated that scarcity would increase the wellbeing of people who are renting dwellings or seeking to buy a first home in that city. These people would continue to enjoy the benefits of living in that city, while paying lower prices for housing. However, broad changes to house prices (either up or down) would have significant distributional impacts – a topic we address in a later appendix.

Lowering the cost of living may improve wellbeing

There may be opportunities to improve wellbeing by enabling additional urban development, or different types of development.

First, there is evidence that legacy urban planning policies and infrastructure supply have limited the overall supply of housing in areas with high demand for housing. This can arise from both constraints on developing medium-density and high-density dwellings in attractive areas and constraints on the total amount of residentially zoned and serviced land available for development. As described above, this raises housing prices and means that new entrants have to pay more to experience the benefits of living in attractive areas.

Glaeser and Gyourko (2003) describe this as a 'regulatory tax' on the price of housing. They further note that policies that limit the availability of housing may not be justified by offsetting benefits. (See Nunns and Denne (2016) for a summary of New Zealand-specific evidence on this point.)

Second, legacy policies have often constrained the types of dwellings that can be built. For instance, they have often limited the supply of 'missing middle' housing typologies like low-rise or mid-rise flats, or required new dwellings to be bundled with a large amount of parking (Shoup, 2005; http://missingmiddlehousing.com/). As a result, people who would prefer these dwelling choices have not been able to maximise their wellbeing.

Furthermore, if some dwelling types are not currently available in a city, people may not be aware of all of their options, and hence may not be able to identify the living option that best meets their needs.

9.3 Evidence on the benefits of living in different locations

The benefits people derive from living in a given location are subjective in nature and hence are difficult to measure and value.

To illustrate, consider a hypothetical case of three neighbours in an Auckland suburb. Although they incur similar housing costs and transport costs to live there, they have very different reasons for preferring to live in Auckland.

The first person may value living in Auckland because it offers them better job opportunities than other cities. The second may like living there because they can enjoy a pleasant climate and good access to beaches. The third may prefer to be in Auckland because it allows them to be close to their extended family, who also live there.

Each neighbour may react differently to other opportunities. The first may be equally happy to live in Christchurch or Wellington if the right job came up, while the second might be equally happy to live in another beachfront city like Tauranga or Nelson. The third may choose to relocate if their extended family moved to, say, Hamilton or Whangārei.

Moreover, people with low incomes, disabilities, or other socioeconomic risk factors may have limited housing options. For these people, the alternative may be living in overcrowded accommodation, living in garages or other informal housing, or homelessness.

Factors that may make some locations more attractive

The empirical literature suggests that there are two broad factors that make some locations more attractive than others:

- First, it may offer **advantages for production**, such as access to natural resources (eg productive farmland, mines), access to national or international markets (eg due to the presence of a port or airport), or agglomeration economies arising from proximity between firms and workers in a larger or denser urban place, which are discussed in a separate appendix. These advantages can often be measured as higher economic productivity and wages for firms and workers in some places.
- Second, it may offer **consumption amenities**, such as an attractive natural environment, pleasant climate, good public services such as schools and transport systems, agglomeration economies leading to more variety in goods and services, or proximity to friends, family, or potential partners. These advantages are more difficult to measure as they mostly relate to 'unpriced' amenities for which there is not a market.

Some of these advantages are fixed, as they arise from natural characteristics, but others can be affected by urban development. For instance, urban development that increases traffic congestion may reduce the attractiveness of some places for new development, while urban development that supports increased agglomeration benefits may increase a city's attractiveness. We summarise this distinction in Table 13.

Table 13: Factors that make locations more attractive

	Natural factors	**Man-made factors**
Consumption	Example: Sunny and warm climate	Example: Attractive architecture

Production	Example: Productive farmland	Example: Road and rail connections to other cities

Moreover, different people may place a different value on these benefits. Advantages in production are likely to be particularly important for working-age people, while retired people may seek places that offer better consumption amenities.

Evidence from aggregate data

Economists often use aggregate data to identify whether some cities or regions generally offer higher benefits for residents (or firms). This analysis sheds light on the types of factors that may matter for these internalised benefits. These studies typically use 'revealed preference' data to identify locations that offer higher benefits (Glaeser, 2008):

- Long-run population growth is often used as a proxy to identify locations that offer high benefits to residents, as attractive locations are likely to attract more people. However, some attractive places may grow slowly due to the presence of constraints on the supply of new housing that make it difficult for them to accommodate more residents (Hsieh and Moretti, 2015) or because taxes on labour income reduce the private benefits that people obtain from living in productive locations (Albouy et al, 2018).[25]
- Quality of life indices can be derived by analysing wages adjusted for local housing prices (Roback, 1982; Preston et al, 2018). If people are willing to accept low wages or pay high housing prices to live somewhere, that location must offer them some offsetting benefits. (Analogously, high wages and rents indicate locations that offer productivity benefits for businesses.)

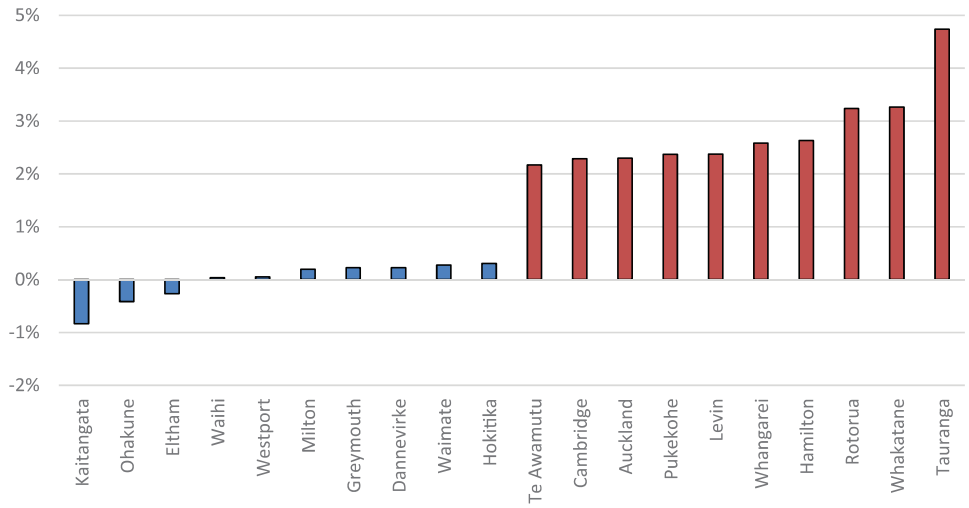
Two recent studies have used these methods to identify factors that contribute to higher or lower quality of life in New Zealand cities. These studies suggest that people derive benefits from access to natural amenities, such as a warm and sunny climate and coastal environments. They also derive benefits from access to economic opportunities, including links to large cities, in particular Auckland, as well as the availability of productive soils. Locations with higher levels of human capital (eg education levels) or better public services (eg education and health) and consumer goods and services (eg hospitality establishments) may also provide benefits.

Grimes et al (2016) analyse the determinants of long-run population growth in 56 New Zealand towns and cities over the period from 1926 to 2006. They assess the impact of a set of natural factors (sunshine hours, versatility of agricultural soils), infrastructure and public service provision (road network distance to major centres, distance to the nearest port, presence of universities / polytechnics, and presence of airports), and demographic factors (starting population, immigration, and historical share of Maori population).

Figure 11 compares long-run population growth rates in New Zealand's fastest- and slowest-growing towns and cities. The upper North Island, which is comparatively warm and sunny and has good inter-regional and international connections, is fast-growing, while smaller towns in less accessible and colder locations have grown more slowly.

[25] A further challenge is that high levels of natural amenity can be correlated with increased restrictions on development, eg due to rules put in place to preserve attractive natural landscapes, or with geographic features like harbours and hills that limit the amount of land available for development. Saiz (2010) provides empirical evidence that suggests that this is the case in US cities.

Figure 11: Annualised population growth rates in New Zealand's 10 slowest and 10 fastest growing towns, 1926-2006 (Grimes et al, 2016)



Consistent with the intuition from the above chart, Grimes et al find evidence that population growth is higher in towns and cities that:

- Have more versatile agricultural soil (measured by higher land use capability scores), a natural factor that contributes to higher productivity
- Have more annual sunshine hours, a natural factor that improves amenity
- Are closer or better connected to Auckland, which indicates the presence of positive spillovers from proximity to a large urban area
- Have higher levels of human capital. Grimes et al use historical Maori population share as a proxy for human capital, as past and present inequities have led to lower educational attainment among Maori. Apatov and Grimes (2016) demonstrate that higher levels of university enrolment led to higher regional growth over a shorter time period (1986-2013).

Preston et al (2018) use Census data on wages and housing costs to construct a 'revealed preference' quality of life index for 130 New Zealand towns and cities over the 1976-2013 period. They then investigate factors that lead to higher or lower quality of life.

Preston et al find that natural amenities, such as sunny and dry climates near the sea or lakes, contribute to higher quality of life. They also find some evidence that the composition of the local economy affects quality of life. Attractive places had relatively high shares of the workforce engaged in education and (to a lesser extent) health, as well as high employment shares in the food, accommodation, arts and recreation service sectors. They also find that, after controlling for other measurable amenities, larger urban places had lower quality of life on average. This may reflect increased congestion and crowding, ie the external costs of urban development. However, these results seem to be at odds with Grimes et al's finding that Auckland and other large cities in the upper North Island have grown especially fast.

Studies of housing preferences and trade-offs

People's housing preferences can be measured using a 'choice experiment' approach in which they are asked to choose between alternative options for dwelling type and location, subject to their own financial constraints. Two recent studies use this approach to analyse preferences for dwelling type and location in Australia (Kelly, 2011) and Auckland (Yeoman and Akehurst, 2015).

These studies provide a snapshot of preferences at a point in time, but do not necessarily indicate how preferences may change over time. Likewise, they do not provide information on the outcomes that people experience as a result of their choices. There is some evidence, discussed in a later appendix on social and cultural impacts, that people who, say, choose long commuting distances underestimate the negative impact that it will have on their wellbeing (Stutzer and Frey, 2008; Montgomery, 2013).

The Auckland *Housing We'd Choose* study asked people to choose whether they would prefer to rent or buy twelve different types of new dwelling in eight locations throughout Auckland. Dwellings were offered to respondents at 2014/15 prices, which are likely to have been driven up by market-wide scarcity of housing (see Figure 10). This meant that almost one-quarter of respondents were not able to afford *any* new dwelling options.[26]

The study provides insights into what aspects of dwellings and locations people value, and how they resolve trade-offs between competing alternatives. Table 14 reports the types of dwellings that respondents ultimately chose. Half of the respondents chose detached ('standalone') houses, one-quarter chose attached houses (terraced houses), and one-quarter chose apartments, predominantly in mid-rise buildings of up to four storeys.

Because preferences are not homogenous, urban development that provides a variety of dwelling choices can potentially be very beneficial.

However, there was a widespread preference for large or medium-sized dwellings – only 12% of respondents chose a small dwelling.[27] This indicates that most people prefer dwellings that offer them more living space, and that they are willing to trade off other attributes, such as location or dwelling type, to obtain it. Cheshire, Nathan, and Overman (2014) highlight this as a fundamental driver of urban development – as people become wealthier, their demand for living space rises.

Table 14: Respondents' final choices by dwelling type (Yeoman and Akehurst, 2015)

	Buy	Rent	Total
Detached	54	50	52
Attached	21	31	25
Apartment (building up to 4 storeys)	18	11	15
Apartment (in building 5 storeys or more)	7	8	8
Total	**100**	**100**	**100**

Yeoman and Akehurst also asked respondents to rank how important 58 different characteristics of dwellings, neighbourhoods, and location accessibility were to them. They found that:

- Respondents were most likely to rank features of the local environment as important. Factors that were particularly important were a safe neighbourhood ('very important' to 87% of respondents), living in an unpolluted area and being away from industrial areas.
- Property and dwelling characteristics were the next most important overall. Aspects like freehold titles, standalone dwellings, north-facing aspect, security, natural light, and energy efficiency were more likely to be seen as important.

[26] This is a potential limitation of this study's approach – the results may not be valid if prices change significantly. However, analysis of the impact of price increases using a conditional logit modelling approach suggests that choices of different dwelling types are inelastic with respect to price.
[27] Note that 'small dwelling' was defined differently for different dwelling types. A small apartment was defined as a one-bedroom apartment, a small attached dwelling was defined as a two-bedroom house, and a small detached dwelling was defined as a three-bedroom house.

- Features related to convenience and access (to work, to school, to the city centre, etc), and proximity to facilities (eg gyms, community centres and sports clubs) were important to fewer people.
- There were differences between age groups and household types. For instance, households with children tended to rank the number of bedrooms, bathrooms, and living spaces as more important.

Overcrowding and homelessness

For some people, the choice is not between living in a more attractive location or a less attractive one, but between having a home and not having a home.

A rising number of New Zealanders lack adequate accommodation as a result of insufficient supply of housing and high prices. Amore (2016) measures housing distress by estimating the number of people who are sleeping rough, living in temporary accommodation like shelters or camping grounds, or living in overcrowded accommodation.

Based on Census data, she estimates that almost 41,000 New Zealanders were severely housing deprived in 2013. Housing deprivation is likely to have risen since 2013.

Table 15 shows that two out of every three people without adequate accommodation lived in a crowded dwelling. While rough sleeping is the most visible manifestation of housing distress, it is only the tip of the iceberg.

Living in a crowded dwelling is associated with higher risk of infectious diseases and worse life outcomes for children (Gray, 2001). In a systematic review, Baker et al (2013) find that crowding is associated with increased risk of gastroenteritis, pneumonia / lower respiratory tract infection, Haemophilus influenzae (Hib) disease, and respiratory syncytial virus bronchiolitis. They estimate that:

> *1,343 (CI 182-2843) hospitalisations per year in NZ are attributed to household crowding. This total is 10% of the 13,680 hospital admissions a year from these diseases (which represent about one fifth of the total 75,706 annual ID [infectious disease] hospitalisations in NZ over the 2004-08 period).*

There is also evidence that children living in crowded houses experience lower wellbeing, worse educational outcomes, and lower adult living standards (Goux and Marin, 2005; Solari and Mare, 2012).

In short, there may be large social benefits from urban development that makes housing more available, or less expensive, for people who would otherwise face housing distress.

Table 15: Prevalence of severe housing deprivation in New Zealand, 2001-2013 (Amore, 2016)

Broad living situation			Specific living situation	2001		2006		2013	
				Count	Prev. per 10,000 pop'n	Count	Prev. per 10,000 pop'n	Count	Prev. per 10,000 pop'n
1	Living *without habitable accommodation* due to a lack of access to minimally adequate housing		Living rough / improvised dwelling	660	1.8	1,464	3.6	1,413	3.3
			Mobile dwelling	633	1.7	3,567	8.9(1)	2,784	6.5(1)
			Subtotal	**1,296**	**3.5**	**5,031**	**12.5**	**4,197**	**9.9**
2	Living in a *non-private dwelling* due to a lack of access to minimally adequate housing	Emergency accomm. (NGO-run)(2)	Night shelter	47	0.1	49	0.1	26	0.1
			Women's refuge	43	0.1	260	0.6	30	0.1
			Other accomm. targeted at people who LAMAH	177	0.5	342	0.8	493	1.2
			Subtotal	**267**	**0.7**	**651**	**1.7**	**549**	**1.3**
		Commercial accomm.	Camping ground / motor camp	2,494	6.7	1,144	2.8	1,724	4.1
			Boarding houses, hotels, motels	5,486	14.7	5,089	12.6	6,127	14.4
			Subtotal	**7,980**	**21.4**	**6,233**	**15.5**	**7,851**	**18.5**
		Marae		92	0.2	26	0.1	43	0.1
3	Living as a *temporary resident in a severely crowded, permanent private dwelling* due to a lack of access to minimally adequate housing			19,284	51.6	22,005	54.6	28,563	67.1
Total				**28,917**	**77.4**	**33,946**	**84.3**	**41,207**(3)	**97.1**(3)

Notes:

(1) The drop in the mobile dwelling category may be largely attributable to a coding change – see main text.

(2) Emergency accommodation count and prevalence figures should not be compared over time because of small numbers and varying response rates.

(3) These counts have been revised since an earlier press release (University of Otago, 2016).

Data sources: Statistics New Zealand and emergency housing providers

9.4 How these effects can be measured and valued

The costs that people incur to live in certain locations are likely to be easier to measure than the benefits that they receive from living in those locations. If location-related costs are valued and reported, it is important to include a caveat that high costs will often coincide with high benefits, and vice versa.

Moreover, we highlight challenges interpreting evidence on costs of living and in understanding factors that determining house prices and rents.

Based on the above discussion, we suggest that the following approach could be explored to measure and value location-related costs and benefits.

Measurement

- To measure location-related costs: we suggest using microdata from the Household Economic Survey (HES) on Expenditure to estimate how housing, transport, and utility costs vary between locations. Microdata enables the impact of household and individual characteristics to be controlled for.
- However, only 5,000 households are surveyed for the Household Economic Survey. This limits the amount of spatial detail that can be derived from HES-based estimates. Rather than estimating location-related costs at a suburb level, it may only be possible to make estimates at the council ward or community board level.[28]
- Additional data sources from Statistics New Zealand's *Integrated Data Infrastructure* could also be considered to expand the sample or fill gaps in the data.
- A tentative suggestion for measuring location-related benefits would be to analyse microdata from the New Zealand General Social Survey (NZGSS) to estimate how life satisfaction varies by location and urban form variables, controlling for the impact of household and individual characteristics. This could be used as a proxy for the net benefits that people receive from living in different places.
- However, a challenge for interpreting the resulting estimates is that they will be calculated net of costs of living and costs and benefits such as agglomeration and congestion.
- We note that the Treasury's *Living Standards Framework* includes self-reported life satisfaction as an outcome measure.

Valuation

- The suggested approach for measuring location-related costs would provide estimates in monetary terms, so there would be no need for an additional step to value them.
- If location-related benefits are measured using NZGSS data on life satisfaction or a similar source, it would be necessary to devise an approach to valuing differences in life satisfaction, eg based on an estimated equivalence between increased life satisfaction and increased income.

[28] There are over 2000 Census area units or SA2s, meaning that HES would only survey two or three households in the average area unit. By contrast, there are a total of around 250 council wards, meaning that HES would survey an average of around twenty households per ward.

10 Appendix 3: Agglomeration benefits

10.1 How these effects arise

Agglomeration economies refer to the external *benefits* (or positive 'spillovers') that arise from being closer to other people, especially in larger or denser cities.

The existence of cities is strong evidence for the existence of agglomeration benefits. In the absence of agglomeration, most people would disperse to smaller towns and rural areas to avoid urban congestion costs and crowding, and cities would not exist. In reality, most New Zealanders live in a small number of cities, occupying a very small fraction of the country's total land area.

People concentrate in a small number of places due to the benefits they experience from doing so (Glaeser, 2008). As discussed in an earlier appendix on costs and benefits that are internalised by residents, these benefits could reflect the unique *natural* advantages that attract people there, such as harbours, abundant productive land, or a pleasant climate. There is evidence that these natural factors affect the distribution of population growth in New Zealand (Grimes et al, 2016; Preston et al, 2018).

A second reason for concentration in cities is that urban development generates agglomeration economies that increase the benefits that cities offer to firms and workers (Fujita, Krugman and Venables, 1999). We identify and discuss two broad categories of agglomeration benefits that can offset the costs associated with living in larger or denser cities:

- Agglomeration in production: This refers to the advantages that firms and workers experience as a result of proximity to each other. Producers' ability to share inputs, match with better workers and customers, and generate and share knowledge can lead to increased productivity, higher wages, and higher profitability.
- Agglomeration in consumption: This refers to the advantages that households experience from proximity, in terms of the increased availability and variety of consumer goods and services. Better consumption amenities can result in higher quality of life, although this can be offset by congestion and crowding in larger or denser cities.

Although agglomeration in production and agglomeration in consumption affect wellbeing in different ways, they arise through similar microeconomic channels. Duranton and Puga (2004) describe three specific mechanisms:

- Sharing: Indivisible goods and facilities; gains from variety; gains from individual specialisation; sharing risk
- Matching: Improved quality of matches; improved chances of matching; mitigating hold-up problems
- Learning: Knowledge generation; knowledge diffusion; knowledge accumulation

Agglomeration economies are influenced by both urban scale and urban structure. Larger cities tend to offer more opportunities for sharing, matching, and learning, as do denser locations within cities. Agglomeration is also likely to be mediated by the efficiency of transport networks and the design of urban spaces, as these affect how easy it is for people in different parts of the city to interact with each other.

Agglomeration economies are typically measured at a macro (regional or city) or meso (suburb) level. However, in recent years some attention has been given to agglomeration at a micro (within-suburb) level.

10.2 Evidence on agglomeration in production

There is a large empirical literature focused on measuring agglomeration economies in production. Studies typically estimate the impact of various measures of city size, density, or proximity to other firms and workers affect measurable economic outcomes such as productivity, wages, new business startups, or prices for business land or floorspace. More sophisticated recent studies use micro-data on firms and workers, measures of agglomeration potential that capture spatial variations in proximity to other firms, and controls for reverse causality between productivity and density (eg Graham et al, 2010).

Melo, Graham, and Noland (2009) undertake a meta-analysis of 34 studies of urban agglomeration economies covering the period from 1965 to 2002. The mean estimated agglomeration elasticities (which measure how responsive productivity is to an increase in size/density) was 0.058, with standard deviation 0.115. This indicates that, on average, doubling city size or density leads to a 5.8% increase in productivity. They find evidence that agglomeration economies are higher in service industries (eg retail and finance), and that they may vary in strength between different countries. Moreover, they find that controlling for reverse causality and endogeneity does not significantly affect estimates.

Rosenthal and Strange (2004) suggest that agglomeration elasticities often fall in the 0.03 to 0.08 range, meaning that doubling city size or density leads to a 3-8% increase in productivity. Studies that investigate the spatial structure of agglomeration spillovers often find that they decay rapidly with distance (Rosenthal and Strange, 2003; Arzaghi and Henderson, 2008; Melo, Graham and Levinson, 2017). This suggests that close proximity, potentially within a few kilometres or a 20-minute driving distance, is important for agglomeration.

Several papers use firm and worker microdata from Statistics New Zealand's *Integrated Data Infrastructure* (IDI) to measure agglomeration in New Zealand.

Maré (2008) finds that after controlling for variations in the characteristics of firms in different places, the Auckland urban area enjoys a productivity premium relative to other New Zealand regions, and that the Auckland city centre is more productive than other parts of the city. Maré (2016) re-examines these findings, using additional controls to account for the fact that workers with different skills and motivation 'sort' themselves into different places, and finds a smaller but still positive productivity premium in Auckland and Wellington.

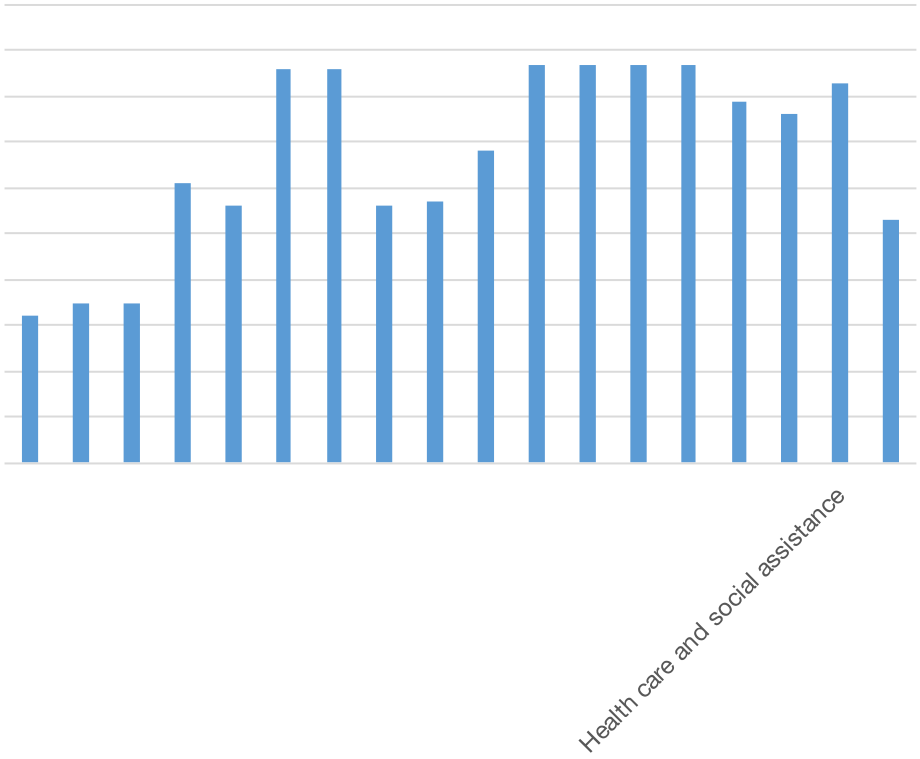
Graham and Maré (2009) estimate agglomeration elasticities for New Zealand industries. They use a spatially-varying measure of agglomeration potential, effective job density (EJD), that assigns a higher 'weight' to nearby employment and a lower weight to more distant employment.[29] This measure varies between cities – larger cities tend to have higher EJD than smaller cities – and within cities – dense locations near the middle of cities tend to have higher EJD than low-density places on the urban fringe.

Consistent with the international literature, Graham and Maré estimate an average agglomeration elasticity across all industries is 0.065. This suggests that doubling EJD is associated with a 6.5% increase in productivity. Figure 12 shows that industry-level agglomeration elasticities vary from a low of 0.032 in agriculture, forestry and fishing, which is a largely rural, resource-based industry, to a high of 0.087 in finance and insurance services, an industry that tends to cluster in cities and depends upon skilled labour.

Lower elasticities for land- and natural-resource-based industries and higher elasticities for service sectors like finance, professional services, and public administration are a key reason why the economic importance of large cities tends to rise as countries develop larger and more sophisticated service sectors.

[29] Formally, effective job density of location i is calculated as follows: $EJD_i = \sum_j \frac{E_j}{d_{ij}}$, where E_j is employment in location j and d_{ij} is the distance between locations i and j.

Figure 12: Agglomeration elasticities in New Zealand (Source: NZ Transport Agency, 2018)



Maré and Graham's (2009) findings have been incorporated into the NZ Transport Agency's *Economic Evaluation Manual* (EEM) and used to estimate the impact how improved transport accessibility between firms and workers may affect economic productivity. In the following case study, we demonstrate how the EEM approach can be used to estimate agglomeration benefits at both a city-wide level and within cities.

10.3 Case study: Modelling agglomeration benefits in New Zealand cities

We use results from Maré and Graham's research on agglomeration elasticities in New Zealand to illustrate the potential magnitude of agglomeration benefits arising from growth in urban employment. We simulate the impact of adding another 1000 workers to a number of large- to medium-sized New Zealand cities, assuming that new workers are distributed in a similar way to existing workers and hence that EJD will increase proportionately.

The following table reports these estimates for selected urban areas (defined using SNZ's 2018 urban rural classification). The first two columns report 2016 employment in each urban area (based on SNZ Business Demography data) and estimated GDP per worker (based on SNZ Regional GDP data). The third column estimates the change in productivity resulting from adding another 1000 workers to each urban area, based on the elasticity formula $((Employment + 1000)/Employment)^{0.065} - 1$. The percentage change in productivity is estimated to be larger in smaller cities, as adding 1000 workers will have a larger proportional impact on a smaller city.

The final column multiplies the first three columns together to estimate the uplift in GDP for existing workers. An important finding from this analysis is that the agglomeration benefits of adding a fixed number of workers fall in a similar range for all urban areas. However, these benefits appear to be largest in Wellington and Auckland. For instance, the agglomeration impact of adding 1000 workers to Wellington is around 40% larger than the impact of adding a similar number of workers in Palmerston North.

Table 16: Estimated agglomeration impacts of adding 1000 workers to selected NZ cities

Urban area	Total employment (2016)	Estimated GDP per worker (2016 NZD)	Increase in productivity from adding 1000 workers (%)	Annual impact on GDP for existing workers ($m)
Auckland	663,010	$120,269	0.01%	$7.8m
Hamilton	81,945	$106,355	0.08%	$6.9m
Tauranga	58,085	$99,586	0.11%	$6.4m
Whangarei	25,355	$104,674	0.25%	$6.7m
Christchurch	202,084	$104,872	0.03%	$6.8m
Dunedin	48,915	$93,195	0.13%	$6.0m
Palmerston North	45,240	$88,965	0.14%	$5.7m
Greater Wellington	215,574	$126,526	0.03%	$8.2m

Based on average tax rates and the labour share of GDP, these gains are likely to be split roughly equally between workers, firms, and government.

Maré and Graham's results can also be used to investigate the impact of employment growth that occurs in different locations within cities. Adding an additional 1000 workers in a central area near many other workers will result in more positive spillovers than adding them to an outlying area where there are few other workers.

MRCagney (2016) used Maré and Graham's findings to analyse the impact of alternative urban form scenarios on economic productivity in Auckland. They used Auckland's strategic transport model to model the impact of three alternative land use scenarios on access between firms, holding transport infrastructure constant, and then calculated agglomeration benefits from each scenario using EEM procedures. Total city population is held constant across all three scenarios, and the use of transport model outputs ensures that congestion impacts are taken into account. Moreover, scenarios assume that employment location will change if population location changes – for instance, a scenario with more people living in northwest Auckland will also see more employment in or near that area.

As shown in Table 17, a more 'intensive' scenario in which the central isthmus area roughly doubled in population and employment by 2046 would result in an annual net increase in GDP of around $100 million relative to the base case land use scenario. Conversely, a more 'expansive' scenario would decrease GDP, because increases in agglomeration potential in outer suburbs would be outweighed by the loss of economic mass in central areas.[30]

[30] However, MRCagney note that these increases are small relative to Auckland's regional GDP, and hence individual firms are unlikely to perceive aggregate agglomeration impacts as an important driver for location decisions.

The 'intensive' scenario would result in a net reallocation of almost 70,000 people, and a corresponding share of workers, from other parts of the Auckland region into the isthmus area, relative to the base case land use scenario. This implies that the average agglomeration benefits from relocating one resident / worker from an outlying area to a more central area are around $1,500 per annum. Conversely, in the 'expansive' scenario, there is a net relocation of 50,000 people from central areas to outlying areas, mainly in greenfield development on the fringe. This implies that the average agglomeration *disbenefits* from relocating one resident / worker from the central area to the urban fringe are roughly $7,000 per annum.

Table 17: Estimated changes in annual economic output relative to base case land use scenario

Scenario	**Modelled annual change in GDP (2046), by area**				
	North	**West**	**Central**	**South**	**Total**
With congestion pricing					
Intensive	-$8 million	-$8 million	$128 million	-$6 million	$106 million
Expansive	$43 million	$11 million	-$551 million	$127 million	-$369 million
Without congestion pricing					
Intensive	-$13 million	-$15 million	$149 million	-$22 million	$99 million
Expansive	$34 million	$7 million	-$503 million	$112 million	-$350 million

10.4 Evidence on agglomeration in consumption

The empirical literature on agglomeration in consumption is growing but less well developed at this stage. Glaeser, Kolko and Saiz (2001) identify four important consumption amenities that may attract people to live in cities, and provide evidence of their increasing importance for US urban growth:

- Variety in consumer goods and services, especially 'non-tradable' goods and services like hospitality, cultural attractions, and dating opportunities;
- Aesthetics and natural settings, including the quality of the city's architecture, public parks, natural environment, and climate;
- Good public services such as schools and low crime rates;
- The quality and speed of transport systems, which affect the opportunities people can access within cities.

For many people, but not all, the diversity of personal, social and consumption experiences is the key attraction of cities. It is easier to provide a diverse range of consumption services and experiences in large urban area as there is larger demand, enabling providers to cover fixed costs. The range of different goods and services appears to rise exponentially with the size of an urban area (Beinhocker, 2006).

People vary in their taste for diversity. People who like diversity tend to be attracted to large cities, whereas people who are a content with a more limited range of goods, services, and experiences may find towns or smaller cities more attractive. There are quite different price vectors in large and small urban areas: small urban areas may have lower prices for many goods, but they have much higher prices for goods that are not available in their city and which can only be purchased elsewhere. The benefits of variety in larger cities will depend on the diversity of preferences for diverse goods and services across the population.

Sometimes, the social experiences that cities facilitate are frowned upon by people living in non-urban areas or outlawed or discouraged by governments. Urban areas often provide a setting for non-conformist behaviour. An example would be San Francisco's role as a hub for the gay, lesbian, and transgender communities during a time when the US as a whole banned or discriminated against them.

Similarly, large cities can provide people with protection against discrimination or interference from central government (Hohenberg, 2004). They provide anonymity that enables political protest and fosters political change, offer the legal resources necessary to oppose political oppression, and foster news media.

The variety of consumption opportunities and social experiences that cities offer appear to be routinely mis-measured, in part because statistical agencies do not measure the diversity of the goods and services produced in an economy particularly well, and thus do not measure the value of this diversity. (See Beinhocker, 2006, chapters 1 and 2 on this point.) The freedom and anonymity benefits of cities may also be poorly measured. If these benefits are systematically under-estimated, then it will bias a quantitative analysis against finding that cities offer net social benefits.

Revealed preference measures of agglomeration in consumption

Agglomeration in consumption is often measured using 'revealed preference' measures of people's willingness to pay for consumer amenities in cities. These may include population growth rates, which indicate people 'voting with their feet' (Glaeser, Kolko and Saiz, 2001), residential land values, which reflect the value of access to both consumption and production opportunities (Donovan and Munro, 2013), or wages adjusted for local housing costs, which indicate whether people are willing to pay a premium to locate in certain places (Preston et al, 2018).

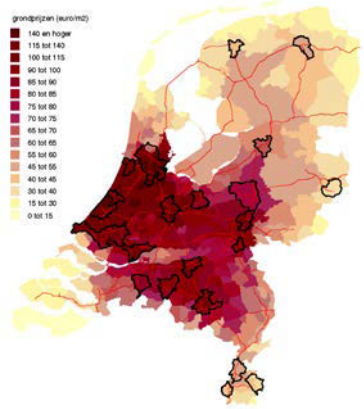
Tabuchi and Yoshida (2000) use the latter approach to measure the relative size of agglomeration in consumption and production in Japanese cities. They find that doubling city size is associated with a 10% increase in wages. This reflects agglomeration in production, as firms are willing to pay more to hire similar workers in larger cities. However, doubling city size *decreases* workers' incomes by 7% to 12% after housing costs are factored in. This reflects agglomeration in consumption, as workers are willing to pay more to access consumption opportunities in larger cities.

De Groot et al (2015) measure the impact that access to employment opportunities and to various consumption opportunities, such as theatre shows or restaurants, has on residential land values in the Netherlands. (They measure access via transport networks.) Figure 13 illustrates their results – darker purple colours indicate a stronger positive impact. The leftmost two panels show that the benefits of access to jobs by car and public transport arise at a regional level, reflecting the fact that people living outside cities can use regional transport networks to access urban labour markets. For context, the Netherlands have a similar land area to Canterbury Region.

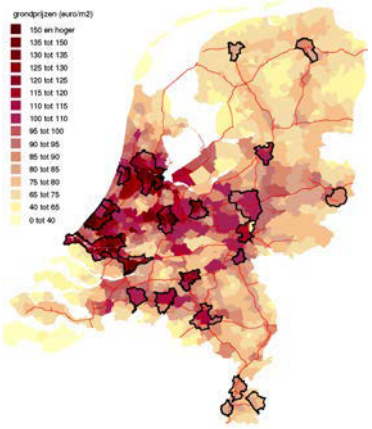
The rightmost panel shows that the positive impact of access to theatre shows, a consumer amenity that is more abundant in larger cities, is concentrated in the core areas of larger cities.

Figure 13: Impact of agglomeration on land values in the Netherlands (Source: de Groot et al, 2015)

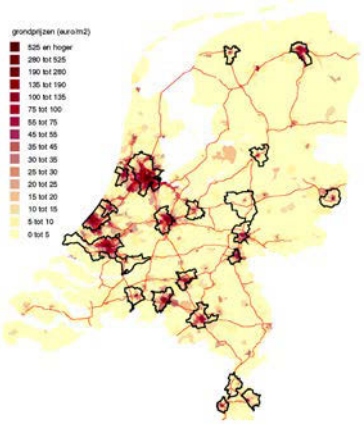
Impact of access to jobs by car



Impact of access to jobs by PT



Impact of access to theatre shows



De Groot et al (2015) find that better consumption opportunities in cities account for around half of the urban land premium in the Netherlands. This percentage varies between cities, demonstrating that some cities (eg Amsterdam) provide relatively more benefits for consumers as opposed to producers than others (eg Rotterdam). They do not attempt to measure *why* those consumption opportunities are more abundant in some places than others. However, some papers have found that larger or denser cities offer a greater variety of products in grocery stores (Handbury and Weinstein, 2014) and a greater variety of cuisines in restaurants (Schiff, 2014).

There is relatively little New Zealand-specific evidence on agglomeration in consumption. Preston et al (2018) use Census data on wages and housing costs to construct a 'revealed preference' quality of life index for New Zealand towns and cities over the 1976-2013 period. Like Tabuchi and Yoshida (2000), they interpret lower post-housing cost incomes as evidence that people are willing to pay more to access consumption opportunities in certain places.

Preston et al find that natural amenities, such as sunny and dry climates near the sea or lakes, contribute to higher quality of life. They also find some evidence that the composition of the local economy matters: attractive places had relatively high shares of the workforce engaged in education and (to a lesser extent) health, as well as high employment shares in the food, accommodation, arts and recreation service sectors. This is consistent with Glaeser, Kolko and Saiz (2001)'s suggestion that variety in consumer goods and services and good public services can contribute to agglomeration in consumption.

However, Preston et al also find that, after controlling for other measurable amenities, larger urban places had lower quality of life on average. This is likely to capture increased congestion and crowding, which we address elsewhere when considering the external costs of urban development. However, we note that this is at odds with other revealed preference information, such as faster growth in Auckland and other larger upper North Island cities (Grimes et al, 2016).

Population density and local consumption opportunities

Preston et al (2018) do not investigate factors that might cause one location to have more consumption opportunities than another. Here, we present some high-level analysis on the topic. We use SNZ *Business Demography* data and *Subnational Population Estimates* to measure the relationship between local population

density and local density of cafes, bars, and restaurants. We use instrumental variables regression to estimate the causal effect of population density on hospitality density.[31]

We find that a 10% increase in suburb-level population density causes a 3.9% increase in the number of cafes, bars, and restaurants in the same suburb, and a 5.6% increase in employment in those firms. Both effects are highly statistically significant. We also find some evidence that the positive impacts of population density on hospitality density spills over to surrounding suburbs.

This quick analysis suggests that urban development will increase the availability of local consumer amenities, potentially supporting agglomeration in consumption. However, the elasticity of hospitality density with respect to local population density is below one, implying that hospitality establishments in denser areas are more intensively patronised. Because the elasticity of hospitality employment with respect to local population density is also below one, it is also likely that they are more productive as a result.

It is likely that hospitality establishments in denser areas offer greater variety of cuisines, although SNZ data is not detailed enough to test this hypothesis.

10.5 How these effects can be measured and valued

Based on the above evidence and case studies, the following approach could be used to measure and value the external benefits of urban growth that arise as a result of agglomeration economies.

A key finding is that although agglomeration in consumption is potentially important, it is likely to be challenging to comprehensively and accurately measure and value.

Measurement

- The NZTA EEM approach can be used to estimate and value agglomeration benefits in production that arise from a change in city size or a shift in the distribution of population and employment within a region.
- This entails define alternative scenarios for the distribution of future population and employment growth within a region. These scenarios should be consistent with scenarios used to estimate transport network effects. Strategic transport models can then be used to estimate the impact of each scenario on effective job density, which is a measure of agglomeration potential.
    - Relevant models include Auckland's Macro Strategic Model (MSM), Wellington's Strategic Transport Model (WSTM), and the Christchurch Transport Model (CTM). Same caveats apply as in transport effects section.
- There is no widely accepted way to measure agglomeration in consumption. Further research is required to understand:
    - Which man-made amenities make the most important contribution to supporting agglomeration benefits in consumption. The research cited above suggests that health and educational services, restaurants, and cultural attractions may play an important role. Variety of consumption goods and services also appears to be important.

[31] Based on Grimes et al's (2016) finding that proximity to universities and human capital levels have influenced urban population growth over the last century, we use the straight-line distance to the closest and second-closest 1964 university as instruments for local population density. We reason that historical decisions about where to place universities are unlikely to have been made with knowledge of the full range of factors that influence present-day population density. We test the instrument relevance condition with a weak instruments test (rejecting the null of weak instruments with a p-value of less than 1% for both outcome variables) and a Sargan chi test of instrument exogeneity (failing to reject the null of exogeneity at a 10% level in both cases). However, we have not yet included other controls, such as territorial authority fixed effects or local income levels.

    - How urban development processes (eg city scale and density) influence the production of these amenities. For instance, local population density appears to lead to higher density of cafes, bars, and restaurants, and potentially an increase in variety of hospitality establishments.
- A significant challenge to understanding agglomeration in consumption is the need to consider the benefits of increased variety of social opportunities and consumer goods and services in cities. Variety, and the benefits of variety, is easily mis-measured.

Valuation

- The NZTA EEM approach can be used to value agglomeration benefits in production. SNZ data on regional economic output and employment can be used to value changes to productivity resulting from changes to effective job density. The above case study provides an indication of how this can be done.
- To value agglomeration in consumption, other proxies are required. The research cited above suggests that 'revealed preference' quality of life indices or residential land values could provide a basis for doing so. If land values are used as a proxy, it is important to control for the impact of production-side agglomeration economies. (As well as distortions in land prices arising from insufficient development capacity.)

11 Appendix 4: Social and economic benefits of growth in 'declining' regions

11.1 How these effects arise

Economic growth is often spatially uneven. Even when incomes and employment are growing at the national level, some regions may have high unemployment or declining populations. This may reflect the impact of industry-specific shocks that are especially concentrated in some regions. A New Zealand example would be the recent fall in world coal prices that led to the financial failure of Solid Energy and the closure or downsizing of a number of coal mines. The resulting economic impacts were concentrated in the West Coast, because most coal mines are located there.

There are a range of responses that cushion the impact of negative economic shocks. New business formation can offset reduction in local employment, while out-migration to other regions reduces the size of the local labour force and hence reduces the impact on local unemployment rates.

However, 'stickiness' in people's location choices means that regions that experience negative economic shocks can experience persistent increases in unemployment rates and persistent reductions in living standards. There are a number of reasons why people may choose not to move in response to a loss of local job opportunities, including:

- Existing community and family ties that make it socially costly to move elsewhere
- Unwillingness to sell homes or other assets at a loss (if house prices fall in regions that experience negative shocks)
- Availability of unemployment benefits, healthcare services, and housing subsidies that make it financially viable to stay in place.

This can in turn contribute to worsening social and economic outcomes, such as persistently high unemployment, increases in property crime, and increasing dependency on drugs and alcohol (Austin, Glaeser, and Summers, 2018). However, it is unclear whether this reflects negative externalities from decline, or selection effects in which people with better social or economic prospects leave declining areas (a 'people' versus 'place' problem).

In principle, new urban development in 'declining' areas that leads to increased local employment can generate social and economic benefits by reducing these effects. This has often spurred interest in policies to regenerate places that have experienced economic decline. However, we note that these benefits are somewhat speculative, and it is unclear whether they are currently relevant in New Zealand.

11.2 Evidence on declining regions

There is little clear evidence on the existence and magnitude of these benefits in New Zealand. Moreover, although a number of towns cities have experienced slow or no growth over the last generation, few have actually *declined* in population. While some regions have experienced negative economic shocks, inter-regional mobility and new business creation appear to have cushioned many of the impacts.

This review therefore focuses on theoretical attempts to outline the impacts of place-based policy on regions that have experienced persistent social and economic costs from negative economic shocks. 'Place-based' policies target government spending or social welfare assistance to specific regions that are experiencing poor

economic or social outcomes. New Zealand's Provincial Growth Fund, for instance, is a type of place-based policy.

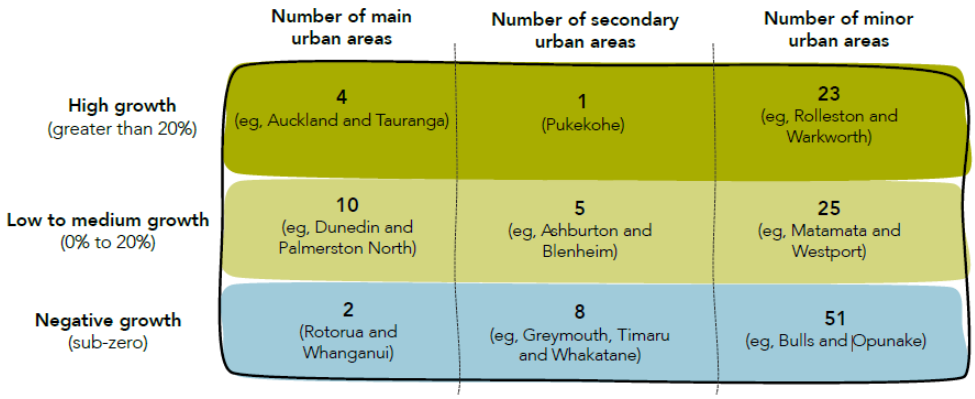
Regional growth, decline, and mobility

There are almost no places in NZ that have experienced major decline over the last century. Grimes et al (2016) find that only Kaitangata, Ohakune, and Etham experienced an absolute decline in population over the 1926-2006 period. The country is divided between areas that are growing, often rapidly, and areas that are standing still.

The Productivity Commission (2017) found that only three secondary urban areas (with a population between 10,000 and 30,000) experienced population decline between 1996 and 2015. However, an increasing number of urban areas are projected to decline in population in upcoming decades.

As shown in Figure 14, smaller towns are more likely to decline than larger cities. Most main urban areas are not projected to decline, although 8 of the 14 secondary urban areas are projected to decline. On the whole, roughly 9% of New Zealanders live in urban areas that are projected to decline in coming decades.

Figure 14: Projected population change of urban areas, 2013-2043 (Productivity Commission, 2017)



Source: Productivity Commission analysis of Statistics New Zealand data.

As noted in Section 2.2, New Zealanders are relatively mobile compared with other OECD countries. Between 2008 and 2013, Census data indicates that almost one-third of New Zealanders moved houses while staying in the same region, 8% moved between regions, and 7% moved to New Zealand from overseas. Historically, people appear to have been willing to move in response to high local unemployment or better economic opportunities elsewhere (Sinning and Stillman, 2010).

Impacts of regional economic shocks in New Zealand

Several studies have examined the impact of previous regional employment shocks in New Zealand.

Grimes and Aitken (2004) examined the impact of exogenous shocks on community outcomes, using house prices as the community outcome variable. They find that each of price, production and demographic variables, measured at the local level, affects local outcomes. Income growth is not solely related to growth of real economic output, as house price developments are also important.

Grimes and Aitken's results confirm the common impression that communities in New Zealand are to some extent at the mercy of macroeconomic trends in commodity prices and other exogenous economic shocks

affecting the locality. For instance, a person living in South Waikato and working in the forestry industry has industry-specific skills. If forestry undergoes an economic downturn (reflected in falling commodity prices) the value of their skills are likely to decline (reflected in declining real wages and higher likelihood of unemployment).

Mare, Grimes and Morten (2009) analyse local labour and housing market adjustment in New Zealand from 1989 to 2006. They examine the adjustment of employment, employment rate, participation rate, wages, and house prices in response to employment shocks. They find that out-migration is a major adjustment response to employment shocks at both a national and regional level. However, the pattern of adjustment varies at different spatial scales. For example, nationally, a 1 percent positive employment shock leads to a long-run level of employment 1.3 percent higher, with approximately half of these extra jobs filled by migrants. In contrast, a 1 percent region-specific shock causes the long-run regional share of employment to be 0.5 percent higher, with the adjustment to the employment shock entirely explained by migration into the region.[32]

Maré and Timmins (2003) examine whether New Zealand residents move from low-growth to high-growth regions, using New Zealand Census data from the 1986-2001 period. They find that people move to areas of high employment growth, but that the probability of leaving a region is less strongly related to that region's fortunes. Sinning and Stillman (2010) analyse trans-Tasman migration patterns using Australian and New Zealand Census data for the 1996-2006 period, finding that higher local incomes and higher employment tended to attract people in to regions, and vice versa.

Stillman, Velamur, and Aitken (2010) find that communities which experienced smaller negative employment shocks have higher employment rates and a more skilled workforce in the medium and long-term.

On the whole, this research suggests that regional economies in New Zealand are periodically subject to negative shocks, and that this can have a persistent impact on some economic outcomes. However, people appear to move away from regions that have experienced shocks, which will tend to cushion the resulting economic impacts.

Theoretical rationales for place-based policy to offset regional shocks

Economists have traditionally dismissed 'place-based' policies as a useful approach to addressing the impacts of negative regional shocks. For instance, Glaeser (2008) recommends to 'help poor people, not poor places'.

However, in recent years there has been increased awareness of persistent regional disparities in economic and social outcomes. In the US, declining inter-regional mobility appears to have contributed to diverging economic outcomes between high-wage coastal states like California and New York and areas in the Midwest and South (Ganong and Shoag, 2017). As a result, there has been a renewed interest in place-based policies.

As Austin, Glaeser and Summers (2018) observe, the case for place-based policies rests upon 'stickiness' in people's location choices. When people are unwilling or unable to move to opportunity, new spending (public or private) can generate larger social and economic benefits.

Austin, Glaeser and Summers estimate that a dollar spent to reduce unemployment will have a larger impact in an area with a high rate of people who are unemployed or out of the labour force, relative to an area with a high employment rate. As they explain, this can either justify increasing public spending in distressed, more responsive areas, or shifting public spending to programmes that favour employment in those areas.

[32] Interestingly they also find that nationally, a one percent employment shock raises long run house prices by six percent (as may be expected with an upward sloping housing supply curve) however, this relationship did not hold at the regional level.

In a similar vein, Kline and Moretti (2014) develop a simple spatial equilibrium model designed to analyse the welfare effects of place based policies on the local and the national economy.

Duranton and Venables (2018) set out a framework for analysing the effects of place-based policies and assessing their social value. As a part of this they examine both the direct and indirect effects of policies in 'lagging regions'. They note that as a wide range of policy tools are often used it extremely hard to assess the results empirically unless each instrument is assessed individually.

Because these papers are theoretical in nature, and focused on outcomes currently experienced in the US, it is difficult to use them to form specific conclusions about what might happen in New Zealand. However, they highlight that increased development in declining locations can in principle lead to social and economic benefits.

11.2.1 How these effects can be measured and valued

These effects are speculative and hence it is not possible to measure and value them at the moment. Identifying how urban decline generates social and economic costs in New Zealand is difficult due to the fact that few places have declined in the past. Evidence from other jurisdictions may help to shape thinking, but differences in the scale of different countries and differences in social welfare policies, eg between New Zealand and the US, make comparisons difficult.

12 Appendix 5: External infrastructure and public service costs

12.1 How these effects arise

To be viable, urban development requires access to 'development' infrastructure such as transport, water, and wastewater networks. After it happens, urban development must also be provided with community facilities and public services such as schools and hospitals.

We identify the following categories of infrastructure and public services that are relevant to urban development:

- Transport infrastructure and services: These include state highways (provided by central government and funded primarily out of road user charges and petrol taxes), local roads (provided by territorial authorities, with part-funding from central government), and public transport services (provided by regional councils and funded by a mix of user charges and central and local government subsidies).[33]
- Water, wastewater, and stormwater infrastructure (the 'three waters'): These are typically funded by local government.[34]
- Power and communications infrastructure: Electricity and gas supply and internet / telephone lines are provided by private companies. (Lines companies are regulated monopolies.)
- Community facilities: These include parks, libraries, community centres, and sports facilities provided by local government.
- Public service provision: These include provision and operation of schools and hospitals by central government, as well as other services like social welfare, policing, national defence, etc.

An additional, emerging issue is that (existing or new) development in low-lying coastal areas may require infrastructure (eg seawalls and pump stations) to protect against flooding and sea level rise.[35]

The cost to service development with infrastructure can vary significantly between locations, depending upon natural factors like topography and soil conditions that influence the costs to build it. Economies of scale can also reduce per-person or per-household infrastructure costs. These arise when there are significant fixed costs to supply new infrastructure that do not vary (much) depending upon usage.

In principle, infrastructure costs to serve urban development can be fully recouped from users through a mix of up-front charges (eg development contributions that are levied on new construction) and ongoing user charges (eg fuel taxes or water charges). If this were the case, then these costs would be fully internalised by new residents and businesses.

In practice, existing fees and charges do not always cover the full cost of providing infrastructure to serve urban development. Infrastructure costs are therefore partly subsidised by central or local government or cross-subsidised by other users. This can create a negative externality from urban development that varies by location. (Development in some locations could also be over-charged – resulting in a positive externality.)

[33] This excludes transport infrastructure such as ports and airports and services such as airlines, as they are provided on a commercial basis.
[34] These infrastructures are intended to manage the flow of water through urban areas and provide water for human use. There is a separate issue around outflow of water into streams and coastal and marine areas, and provision of sufficient water to maintain natural ecosystems that we address in the appendix on air and water impacts.
[35] For reporting on this issue, see https://interactives.stuff.co.nz/2018/11/beach-road/

12.2 Key considerations for assessing infrastructure costs

There are several factors that make it challenging to measure the full cost to serve urban development with infrastructure and hence identify an optimal charging policy.

Infrastructure is 'lumpy'

Infrastructure provision typically involves comparatively high up-front (fixed) costs and lower ongoing costs for maintenance and operation. Moreover, infrastructure tends to be long-lived, and with proper maintenance can continue to serve users for many decades.

New infrastructure is typically built to serve future levels and patterns of urban development, and hence the up-front costs must be compared against both current and future users. For instance, consider a new wastewater treatment plant and associated trunk sewers that are designed to serve up to an additional 10,000 households. The trigger to build the treatment plant may be a new subdivision of only 500 homes – but it does not mean that the full cost of the plant should be divided among those 500 homes.

A corollary is that new development in areas that are already serviced by infrastructure is not 'costless', unless the costs to build that infrastructure have already been fully recouped from user charges.

In economic terms, we are interested in the *long run average cost* to serve urban development with infrastructure, rather than the *marginal cost*.

Timing of development can affect financing costs

Central government, local governments, and private infrastructure providers often finance new infrastructure development. That is, they borrow money (or raise equity) to pay for the up-front costs of infrastructure development, and then pay back lenders (or investors) from future user charges.

If development occurs more slowly than expected, or ramps up over time, then financing costs will rise. This will in turn increase the per-user cost to provide infrastructure.

For instance, consider a hypothetical example of a $100 million infrastructure facility with capacity to serve 10,000 new households. In one scenario, growth occurs in a constant fashion, with an additional 1000 households joining the network every year for ten years. By charging $12,950 for each new connection, the provider can fully recoup the capital costs and financing costs, assuming a 5% interest rate.

In another scenario, growth ramps up more slowly, starting with around 220 added households in the first year and reaching 2000 added households by year ten. Although the facility still reaches capacity in ten years, lower revenue in early years means that a connection charge of $12,950 is no longer sufficient to pay the financing costs. The result would be a financial deficit of around $9 million, or around $900 per household.

There is often uncertainty about the pace of new development. Housing construction has historically followed a boom-and-bust pattern in New Zealand (Office of the Mayor of Auckland, 2017). If new infrastructure is opened just before a 'bust', actual financing costs may be significantly higher than predicted costs. In principle, this uncertainty could be addressed by using a higher cost of capital when calculating financing costs for user charge-funded infrastructure.

Infrastructure can be adapted or expanded

Although infrastructure involves high up-front costs, it can often be future-proofed for expansion or adapted to meet changing demands (Grimes, 2011). This may reduce the cost to serve new development in areas that already have infrastructure networks.

An example of future-proofing would be designating a new 'greenfield' transport corridor that contains extra space for future expansion. A two-lane road may be sufficient to serve expected medium-term demands, but if the area develops faster or more densely than expected, then the designation would allow the road to be widened or a rapid transit corridor added at a lower cost.

An example of adaption would be reallocating existing road space to public transport or 'active' modes in places with sufficiently high transport demands. On a four-lane urban arterial road, converting two lanes from parking to dedicated bus lanes can increase the total number of people who can use the corridor. For instance, Auckland Transport recently reported that:

> *On Mt Eden Rd, only 4% of the vehicles on the road in the morning peak are buses, but they carry 56% of the people travelling along the road. That means that the 43 buses during this time carry more than the 1165 cars.*[36]

Conversely, expanding at-capacity infrastructure in existing urban areas can be more disruptive than building new infrastructure in 'greenfield' areas. For instance, replacing and expanding water mains and sewers can be costly due to the need to dig up streets, relocate other underground services, and manage effects on households and businesses in the affected area.

Some infrastructure demands are localised, but others are not

Demand for some types of infrastructure is likely to be localised to specific catchments, and hence can be measured at the meso (suburb/catchment) level. For instance, the amount of classroom space required in a given suburb is a function of the number of school-aged children living there. A similar principle applies for water and wastewater infrastructure, and the local electricity grid.

Demand for other infrastructure may be more difficult to measure as it may arise at a macro (regional / city-wide level). Transport infrastructure is the primary example of this. Most people in cities travel outside of their 'home' suburb for work, shopping, or recreation, and hence new development increases demand for regional transport infrastructure. These effects can be hard to predict, although transport modelling offers some basis for doing so.

Operating, maintenance, and renewal costs must also be considered

The costs to build or upgrade infrastructure tend to be 'front of mind' for councils and infrastructure providers. However, in the long run costs to operate, maintain, and renew infrastructure are also large, and hence should be considered.

These costs tend to scale according to the size of the network. This means that expanding networks to new greenfield areas will tend to lead to a proportional increase in long-term operating, maintenance, and renewal costs. Geology will also affect operating costs – for instance, more pump stations are required to provide water networks in hilly areas.

[36] https://twitter.com/AklTransport/status/1065013202860351488

When existing infrastructure needs to be renewed, the incremental cost to upgrade it to accommodate further growth in existing catchments may be negligible. This seems to be particularly true for water infrastructure, where doubling pipe capacity can often be achieved without doubling installation costs.

Councils typically rely upon rates from new residents to cover long-term operating, maintenance, and renewal costs for infrastructure extensions. However, if rates from new residents are used to fund maintenance and renewal of existing, under-funded infrastructure, then this approach may, at best, involve cross-subsidies between new and existing residents or, at worst, become unsustainable if growth ceases.[37]

12.3 Evidence on overall infrastructure costs and urban form

Cross-sectional studies suggest that per-person infrastructure costs are, on average, slightly lower in denser cities. This reflects the fact that lower-density urban areas require a greater length of roads and water / wastewater pipes per person. In addition, it may be necessary to travel longer distances to provide a similar length of public services (Litman, 2015).

Ladd (1992) and Carruthers and Ulfarsson (2003) analyse the impact of density on public service costs and capital spending in a cross-section of US local governments, controlling for other factors that may influence spending. Ladd finds a U-shaped relationship between density and per-capita public spending, meaning that spending initially decreases and then increases again as density rises. Carruthers and Ulfarsson analyse spending on different types of infrastructure and public services, finding that density tends to reduce overall public spending, overall capital spending, and spending on roads, police services, and education.

Hortas-Rico and Sole-Olle (2010) investigate the relationship between the amount of urbanised land per capita and infrastructure and public service costs in a cross-section of 2500 Spanish municipalities. They find that density has a non-linear impact on per-capita costs, with some ranges of density where costs do not vary much. Lower-density urban areas generally have higher per-capita public service and infrastructure costs. However, density did not have a statistically significant effect on some individual categories of spending, including transport and utility services.

In an analysis of 45 Chinese cities, Chen, Jia, and Lau (2008) find that higher population density is associated with lower per-capita spending on roads and drainage, but that these associations are not statistically significant.

Adams and Chapman (2016) present an exploratory analysis of the relationship between population density and per-capita costs for local roads, water and wastewater infrastructure, stormwater infrastructure, and water supply in New Zealand territorial authorities.[38] They find that infrastructure costs tend to be lower in denser areas, and that these effects may be more pronounced in faster-growing regions, as shown in Figure 15.

Adams and Chapman's analysis does not control for other factors that may influence spending and it is unclear whether their estimates are statistically significant.

[37] In the US context, *StrongTowns*' Charles Marohn has described infrastructure funding as a 'growth Ponzi scheme'. See https://www.strongtowns.org/the-growth-ponzi-scheme/.
[38] They use depreciation costs as a proxy for the value of infrastructure.

Figure 15: Population density and per-capita roading costs in New Zealand territorial authorities (Adams and Chapman, 2016)

In short, the available empirical literature suggests that the shape of urban development may affect infrastructure and public service costs. In general, higher-density built forms appear to be cheaper to serve. However, as the following case study shows, infrastructure costs can be highly site-specific and hence it is not possible to generalise from aggregate relationships.

12.4 Case study: Infrastructure costs and charges in Auckland

Several recent studies have attempted to quantify the costs to provide new infrastructure to serve recent or future housing development in Auckland. They provide an indication of average costs per dwelling that can be compared with current development contributions and water charges.

Consistent with international studies, new infrastructure costs tend to be higher for 'greenfield' developments on the urban fringe than for 'infill' or 'brownfield' development in existing urban areas. This reflects the fact that existing urban areas often, but not always, have existing infrastructure with spare capacity or the ability to be adapted or expanded.

On average, infrastructure costs are lower for higher-density developments. This reflects economies of scale in provision of some types of infrastructure. For instance, when distances between dwellings are lower, less water and sewer pipes are required per dwelling.

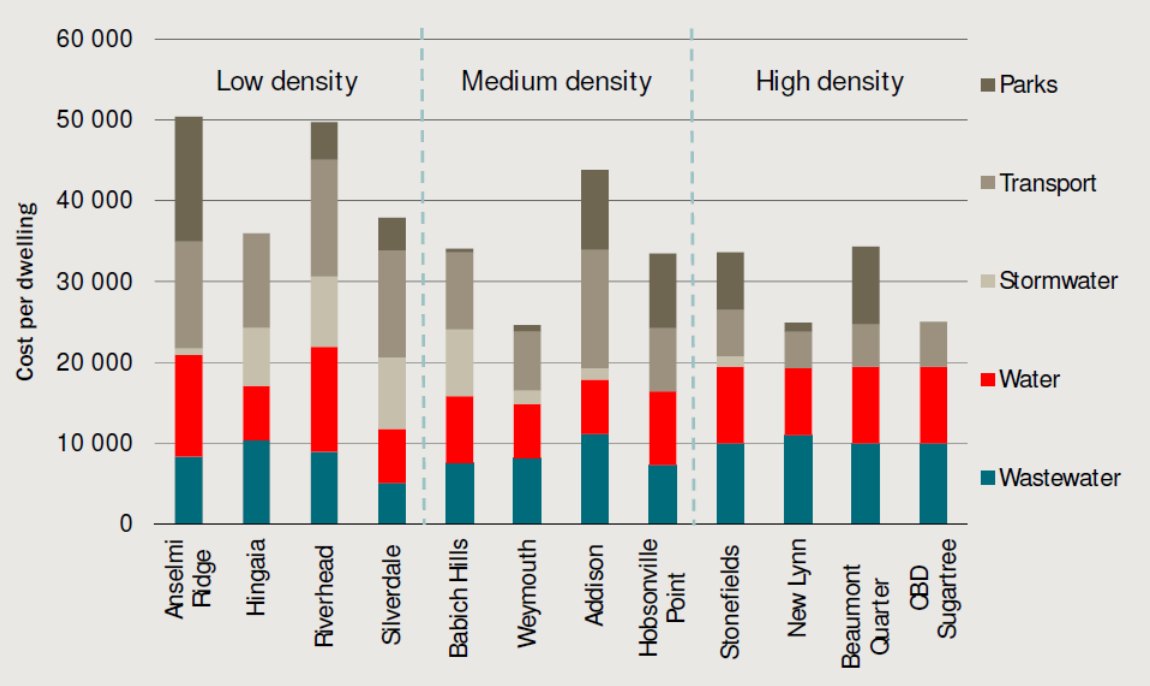
Notwithstanding these trends, infrastructure costs can vary significantly between sites. Some low-density greenfield developments will be cheaper to serve than some higher-density brownfield developments.

These trends are illustrated in Figure 16, which is drawn from 2015 research undertaken by the Centre for International Economics and Arup for Auckland Council. This research assessed per-dwelling costs to provide new transport, water, and park infrastructure for twelve new developments in various locations. Infrastructure costs ranged from $25,000 to $50,000 per dwelling, and the composition of costs varied significantly between locations.

Based on conversation with the Auckland Council staff who commissioned the work, we understand that there were a number of practical challenges to undertaking this study. Obtaining data on the cost of new infrastructure,

and attributing those costs to specific developments, was the primary challenge. This meant that it was only possible to analyse costs for a limited number of developments. The high degree of variation between sites in turn means that it is difficult to extrapolate these results to other developments.

Figure 16: Summary of infrastructure costs by density and asset type (CIE and Arup, 2015)



Auckland Council's (2015) *Future Urban Land Supply Strategy* (FULSS) provided a high-level estimate of the cost to service greenfield areas with bulk infrastructure, such as arterial roads, water treatment plants, and water mains, but local roads and pipes within subdivisions that are built by developers. Like the CIE and Arup study, it excludes costs for schools and hospitals.

The FULSS covers 11,000 hectares of 'Future Urban' zoned land that is expected to be developed over the next three decades. This land is expected to accommodate between 88,000 and 110,000 new homes, as well as space for up to 50,000 workers. By comparison, Auckland currently has around 500,000 households and 700,000 workers. Some of this infrastructure may also have capacity for further growth beyond three decades.

The 2015 FULSS study estimates that the total (undiscounted) cost to supply new bulk infrastructure is around $17 billion. Transport infrastructure accounts for roughly 35% of total costs, water / wastewater costs for 28%, stormwater costs for 9%, and open space / community facilities for 28%. Informal discussions with Auckland Council staff suggest that these costs have escalated following further investigation, although updated figures are not publicly available.

Table 18 estimates the per-dwelling cost of infrastructure in FULSS areas. We have attributed all costs to households rather than businesses, and hence these figures should be treated as an overestimate. Average costs per greenfield dwelling range from $153,000 to $193,000, which is much higher than the costs estimated by CIE and Arup.

Table 18: Bulk infrastructure costs per dwelling in greenfield growth areas identified in Auckland Council's Future Urban Land Supply Strategy (Auckland Council, 2015)

Type of bulk infrastructure	Low dwelling capacity scenario (87,600 dwellings)	High dwelling capacity (110,200 dwellings
Transport	$68,500	$54,400
Water / wastewater	$53,700	$42,700
Stormwater	$17,100	$13,600
Open space / community	$53,700	$42,700
Total	**$193,000**	**$153,400**

We now compare the above infrastructure cost estimates against current Auckland Council development contributions (DCs) policy and Watercare Infrastructure Growth Charges (IGCs). DCs are applied to new developments to cover (some of) the costs to provide transport infrastructure, stormwater infrastructure, open spaces, and other council-funded community facilities. Watercare's IGCs are used to recover the cost of new water and wastewater facilities.

According to Auckland Council's finance team, current DCs have been calculated based on the expected cost to provide new council-funded infrastructure to serve growth in different areas. These calculations exclude:

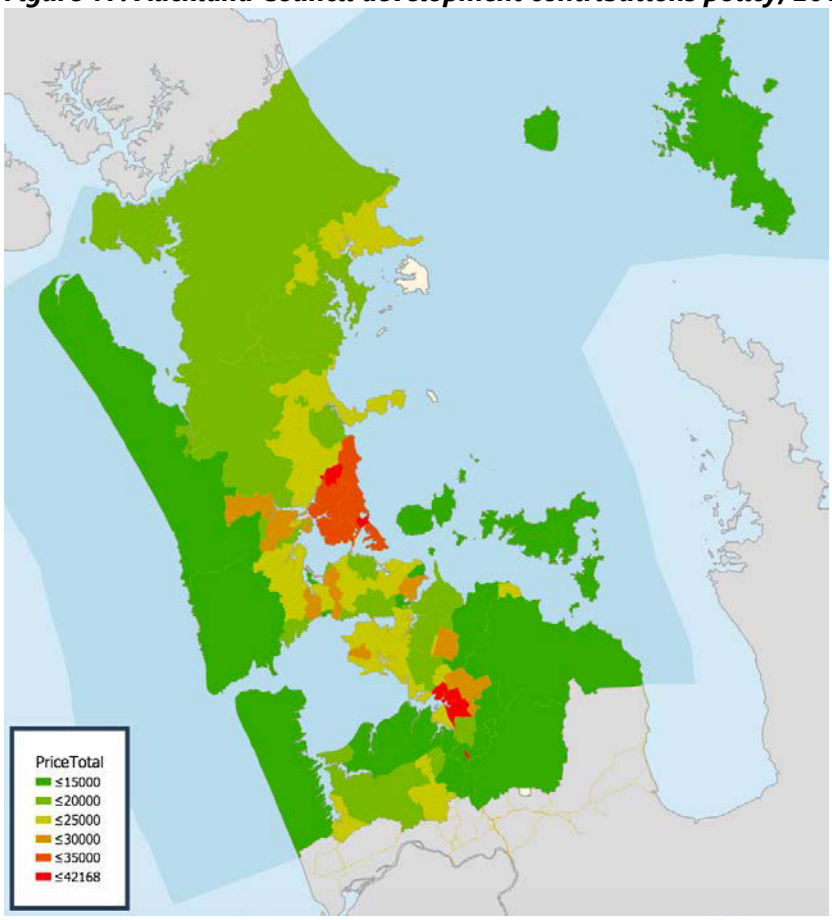
- Costs for non-council-funded infrastructure, such as state highways and some major public transport infrastructure
- Costs for some council-funded infrastructure that has a separate earmarked funding source
- Costs associated with improving level of service for existing residents, for instance by renewing a stormwater pipe that serves an existing suburb.

Figure 17 illustrates spatial variation in 2019 development contributions between different parts of the Auckland region.[39] DCs are under $15,000 per dwelling in rural areas that are not expected to be serviced with major new infrastructure, and under $20,000 per dwelling in some urbanised areas with capacity in existing infrastructure networks. They are over $35,000 in the North Shore and around Papakura, where infrastructure cost are expected to be especially high.

Watercare current (2019) IGCs are $11,680 in the 'metropolitan' area, which includes most of the existing urbanised area plus some greenfield areas.[40] IGCs are higher in some areas that are more expensive to serve, eg $22,080 in Helensville and Parakai and $18,740 in the non-urban parts of the former Franklin District.

[39] https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-policies/Pages/development-contributions-policy.aspx
[40] https://www.watercare.co.nz/Water-and-wastewater/Building-and-developing/Fees-and-charges/Infrastructure-growth-charge-(IGC)

Figure 17: Auckland Council development contributions policy, 2019



This implies total infrastructure charges of around $30,000 for new dwellings in and around the Auckland city centre, and charges up to around $50,000 in some areas of north and south Auckland. If costs fall in the range suggested by the CIE and Arup (2015) study, then these charges may be sufficient to recoup infrastructure costs in many areas. However, this simple comparison does not account for financing costs that may be incurred if there is a lag between infrastructure construction and development contributions revenue, or other user revenues such as petrol taxes.

However, if infrastructure costs in greenfield areas are more in line with the FULSS estimate, and alternative pricing tools are not used, then significant subsidies may be needed to fund greenfield development.

12.5 Evidence on transport infrastructure and services

Transport infrastructure and services provided by central or local governments are funded primarily from the following sources:[41]

- The National Land Transport Fund (NLTF), which is replenished from fuel excise duty ('petrol tax'), road user charges (levied on diesel vehicles but currently waived for electric vehicles), and vehicle and driver registration and licensing fees. The NLTF is a 'hypothecated' fund, meaning that all revenue collected from transport users is returned to the transport system.

[41] https://www.nzta.govt.nz/planning-and-investment/planning-and-investment-knowledge-base/planning-and-investment-principles-and-policies/investment-and-funding-assistance-policy/funding-sources/

- Local government funding shares for local roads, public transport facilities, public transport services, etc, which are drawn from rates, development contributions, and (in some cases) landowner contributions.
- Additional Crown funding and loans, which are funded from general tax revenues.
- Other funding sources and user charges, ranging from public transport fares to financial contributions from landowners who benefit from transport improvements.

State highways are fully funded from the NLTF (or additional Crown funding), while local roads and other local transport infrastructure are part-funded from the NLTF and part-funded from local government contributions at varying rates. NZTA's public transport farebox recovery policy sets a target that 50% of operating costs should be covered by fares, with the remainder funded by the NLTF and local governments, but this has not yet been achieved in most regions.[42]

The following table summarises NZTA data on overall transport funding in 2016/17.[43] The NLTF (plus some Crown funding) contributes around 78% of total transport spending, while local authority funding shares contribute 22%. In other words, most transport spending is funded from transport user revenues hypothecated to the NLTF.

Table 19: Land transport funding sources, 2016/17

Provider	Funding source	Total spending	Share of total spending
Local authorities	Local funding	$872m	22%
	NLTF / Crown	$1,163m	30%
NZTA (state highways)	Local funding	$0m	0%
	NLTF / Crown	$1,896m	48%
Total	Total	$3,931m	

However, this does not mean that new roads (or other transport facilities) are self-funding. They are likely to be cross-subsidised from petrol taxes and road user charges paid elsewhere in the system.

To illustrate this point, we undertake a simple calculation comparing the marginal cost to expand roads in Auckland against the expected revenue that users pay when driving on those roads.

According to Wallis and Lupton (2013), the cost of new motorway capacity in Auckland ranges from $10 million to $100 million per lane-kilometre, depending upon location and type of infrastructure (eg tunnels and viaducts are more expensive). Assuming a typical fuel economy of 10 litres of petrol per 100km, the average vehicle will use around 0.1 litre of petrol to travel one kilometre. Petrol taxes in Auckland, including the regional fuel tax, are currently around 80c per litre, for an average tax of 8c per km.

At a 6% discount rate, and ignoring operating and maintenance costs, this suggests that between 8 million and 80 million cars per annum will need to use the road in order for petrol taxes to repay the full cost to build it. This equates to 21,000 to 210,000 cars per day for a single lane. By comparison, the eight-lane Auckland Harbour Bridge currently handles around 180,000 vehicles per day, or an average of 22,000 vehicles per lane. This example suggests that it is unlikely for an individual road extension to 'pay its way' in a financial sense, unless it can be constructed very cheaply or if it stimulates a broader increase in traffic on the network.

[42] https://www.transport.govt.nz/mot-resources/tmif/headlineindicators/
[43] https://www.nzta.govt.nz/planning-and-investment/learning-and-resources/transport-data/activity-funding/. This data appears to exclude funding for road policing.

Substitution between transport infrastructure investment and congestion costs

In principle, rising congestion is a substitute for transport infrastructure investment (Downs, 2005). When new urban development occurs, building new transport infrastructure may help to moderate growth in traffic delays. However, in practice traffic seems to expand to fill the available road capacity – a phenomenon known as induced demand (Metz, 2008; Duranton and Turner, 2012). This reflects changes in people's choices about when to travel and what transport mode to use, and also changes in their choice of where to live and what destinations to travel to.

In short, there is a relationship between the availability of transport infrastructure, the location of urban development, and congestion levels. It is therefore important to assess transport infrastructure provision and congestion costs in an integrated fashion, eg by incorporating changes in transport infrastructure provision into alternative land use scenarios evaluated using strategic transport models.

Impacts on public transport operating subsidies

Public transport fares are subsidised to offset congestion externalities and also to take advantage of economies of scale in service provision (Allison, Lupton, and Wallis, 2013). The NZ Transport Agency's farebox recovery policy sets a target for recovering 50% of operating costs from fares, with the remainder subsidised by fuel taxes and rates. However, subsidy ratios vary significantly between routes. A busy urban bus corridor may be able to cover 80-100% of its costs from fares, while a service that provides coverage to a low-density suburban area may only recover 10-30% of costs.[44]

It can be more cost-effective to serve higher-density or higher-demand areas because public transport provision is characterised by economies of density. This means that a 10% increase in ridership can be served without increasing operating costs to a comparable degree (Savage, 1997).

As new public transport users tend to pay the same fare as existing users, increases in demand for existing public transport routes, eg due to new development along these routes, will reduce operating subsidy ratios.[45] Conversely, extending routes to serve low-density suburbs that generate relatively low ridership will tend to increase operating subsidies.

A number of empirical studies have studied the existence and magnitude of economies of scale and economies of density in public transport provision (Oum and Zhang, 1997; Savage, 1997; Graham et al, 2003), focusing on urban rapid transit systems. Savage (1997) estimates that the elasticity of short run variable costs (ie excluding the costs of fixed infrastructure) with respect to load factor is approximately 0.59.[46] This implies that a 10% increase in ridership will lead to a 10% increase in fares, but only a 5.9% increase in operating costs. As a result, the subsidy per passenger will decrease.

12.6 Evidence on water, wastewater, and stormwater infrastructure

'Three waters' infrastructure is provided by local governments and funded, to varying degrees, out of general rates revenues, development contributions, and user charges.

[44] There is little publicly-available data on public transport cost recovery at a route level due to transport agency and bus operator concerns about commercial sensitivity. These figures are drawn from our experience analysing unpublished transport agency data.
[45] However, other user costs, such as travel time and time spent waiting for services, may still increase as demand increases. This could be interpreted, for example, as new public transport users living further from their destinations than existing users. Consequently, we have assumed that overall private costs, $C_1(q)$, tend to increase with increasing demand.
[46] Graham et al (2003) measure output as passenger journeys per annum and model the relationship between output and fixed and variable inputs. Their estimate of returns to density is equivalent to an elasticity of approximately 0.745. Savage's estimate accounts for a greater range of variable costs.

Figure 18 indicates how various councils funded water and wastewater services as of early 2014. A number of councils, including fast-growing councils like Christchurch, Queenstown-Lakes, and Kapiti Coast, funded water entirely through rates. Others, including Auckland, Tauranga, and Whangārei, fund water services entirely from user charges. Since this table was compiled, Kapiti Coast introduced water metering, with users being charged water rates based on their actual use.

Development contributions or other infrastructure charges also play a significant role in funding construction of new water infrastructure to serve urban development.

Figure 18: Share of water infrastructure funding from rates (Source: Castalia Strategic Advisors, 2014)

Auckland	South Taranaki*	Hamilton	Thames-Coromandel	Christchurch
Tauranga*	Waikato	Wellington	Hastings	Queenstown-Lakes
Whangarei*	Whakatane	Palmerston North	Selwyn	Waitaki
Hauraki	Otorohanga	Upper Hutt	Napier City	Masterton
Kaipara*	Westland*	Dunedin	Wairoa	Waimakariri
		Porirua	Central Otago	Ashburton
		Lower Hutt	Waitomo	Waipa
		Rotorua	Rangitikei	Kapiti Coast
		Western Bay of Plenty	Opotiki	Clutha
		New Plymouth	Tararua	Hurunui
		Matamata-Piako	Kaikoura	South Wairarapa
		Timaru	South Waikato	Ruapehu
		Southland	Stratford	Grey District*
		Taupo	Gore	Mackenzie
		Manawatu	Central Hawke's Bay	
		Wanganui	Kawerau	
		Horowhenua	Buller	
		Invercargill		

*Note: Councils indicated with an * recover a different proportion of wastewater costs through rates*

In Auckland, Watercare's charging policy includes two key components:[47]

- An Infrastructure Growth Charge (IGC) that is levied on all new water connections (eg new dwellings). This is intended to recover the cost of new infrastructure required to serve additional demand, but currently may not fully recoup costs.
- An annual charge for water and wastewater network use that is intended to recover the costs of operating the system and providing services. Where water metres are available, this is calculated on a volumetric basis.

12.7 Evidence on power and communications infrastructure

Electricity supply, reticulated gas supply, and communications infrastructure are provided by private companies.

[47] https://www.watercare.co.nz/Water-and-wastewater/Building-and-developing/Fees-and-charges/Infrastructure-growth-charge-(IGC)

These providers aim to recover the costs of providing and maintaining infrastructure and providing services from user charges. This typically includes both connection fees for new homes / businesses and ongoing charges for infrastructure services.

Network infrastructure, such as local electricity distribution networks and telecommunications networks, tends to be a 'natural monopoly' as the fixed costs to provide networks are large enough for it to be inefficient for two companies to serve the same customers. Local monopolies are regulated to ensure that they do not set excessively high charges.

Infrastructure services, such as electricity generation and retail and internet and telephone services, are provided on a competitive basis by multiple companies that have equal access to distribution networks. These companies are subject to competition regulation.

Power and communications infrastructure providers are currently profitable, meaning that user charges are sufficient to cover the full cost of providing and operating infrastructure. On average, there do not appear to be any external costs associated with this infrastructure. However, development in some locations may be cross-subsidised by other users, although this is difficult to assess.

12.8 Evidence on community facility costs

Councils also provide a range of community facilities, including public parks and regional open spaces, libraries, community centres, and recreational facilities like public pools.

New urban development can trigger creation of new community facilities or upgrading of existing facilities to serve new suburbs or increased demand in existing suburbs. Some of these costs are borne by private developers, who may set aside land for parks that are then vested with the council. However, costs for many community facilities rest with councils, and councils are constrained from levying development contributions to fund many types of community facilities.

Utilisation of community facilities may be higher in areas with higher population density, and hence cost per resident may be lower. For instance, in Auckland, suburbs with higher-density housing do not tend have more land devoted to parks.[48] This suggests that parks in higher-density areas are likely to be more intensively used, resulting in lower costs of provision per user. Higher-density areas also tend to have higher land values, meaning that councils are unlikely to buy land to provide new parks in these areas.

12.9 Evidence on public service costs

The New Zealand government provides a number of public services that are funded primarily by tax revenues, including income tax, company tax, and goods and service tax. According to the Treasury, core Crown expenditure equalled 28% of gross domestic product in 2018. Social security and welfare spending, principally superannuation, accounted for around one-third of this expenditure (9% of GDP). Health (5.9% of GDP) and education (4.7%) were the next-largest categories.

Some public service costs are unlikely to change as a result of the location of urban development. For instance, superannuation and social welfare costs reflect the country's demographic profile (ie the number of retirees),

[48] We analysed the correlation between population density and park density in Auckland area units, excluding areas with less than three people per hectare. Population density has been calculated by dividing 2013 Census population by the area of each suburb, excluding areas devoted to parks. Park density was identified using data from Proposed Auckland Unitary Plan shapefiles. There was no statistically significant relationship between population density and park provision, indicating that the share of land devoted to parks did not rise or fall with local population density.

current economic conditions (ie the number of unemployed people), and policies around the level of benefits. Similarly, defence costs are unlikely to be driven by urban development.

However, urban development could in principle affect the level of central government spending on public services like health and education. These effects could be either positive or negative, depending upon the location of urban development and the type of public service being provided.

On one hand, there may be economies of scale in the provision of some public services that mean that they can be provided more cheaply in larger or denser cities. This could be due to the presence of fixed costs that can be used more efficiently in larger places, such as hospital facilities or expensive medical equipment, or reduced travel costs to supply some services.

Conversely, some public services may be more expensive to provide in larger or denser cities. This could reflect crowding and higher land costs that make it more difficult to secure land for service provision, eg school grounds, or the need to offer public sector workers higher wages to cover higher costs of living.

A comprehensive assessment would require detailed information on the costs to build and operate new schools and public hospitals in different locations, taking into account spare capacity in existing facilities and expected renewal needs. CIE and Arup (2012) undertake such an assessment in their analysis of infrastructure costs to arising from alternative growth paths in Sydney.

To provide an aggregate view on the potential impact of urban development in different locations on public service costs, we draw upon NZIER's (2013) *Regional Expenditure Report*. This provides information on central government's total and per-capita operating expenditures and capital spending in all sixteen New Zealand regions, broken down into twelve categories, including health and education.

We undertook a high-level analysis of the association between different socio-economic variables, including population density and projected population growth rates, and central government operating expenditures (opex) and capital expenditures (capex).[49] Due to the limited number of observations, we could only analyse the impact of one variable at a time, and hence results should be seen as illustrative only. These findings highlight correlations, but it is not clear whether any of these variables cause spending to be higher or lower.

Table 20 summarises this analysis, which indicates that:

- There is a modest negative correlation between higher population density and per-capita operating expenditures (column 1). This is consistent with the idea that there are economies of scale in providing (some) public services. There is no statistically significant association between higher density and per-capita capital expenditures.
- Regions with higher GDP per capita tend to have lower opex per capita (column 2). This appears to reflect the fact that lower-income regions have higher social welfare costs, including superannuation and unemployment benefits. Capex does not appear to be correlated with income levels.
- Regions with a greater share of young people (age 0-14) or old people (aged 65+) appear to have higher opex per capita (column 3). However, these correlations are not precisely estimated. There is also some evidence that regions with more old people have lower capex per capita, but we suspect that this reflects the fact that older regions tend to be slower-growing and hence require less investment for the future.
- Faster-growing regions have higher per-capita capital spending (columns 4 and 5). Medium-term population growth appears to have a stronger positive association with capex than long-term growth. Faster-growing regions do not appear to receive more opex per capita. This is consistent with the idea

[49] NZIER used two alternative approaches to allocate spending to regions: by location of expenditure, and by services provided to different regions. We used the second set of estimates in this analysis.

that faster-growing regions require more capital investment, but not necessarily more operating spending.

We conducted a similar analysis of health and education spending. The results were qualitatively consistent with findings for overall government spending. For health spending, faster-growing regions received more capex, but not necessarily more opex, and age structure and incomes affected opex levels. Age structure was the main driver of education spending, as regions with more children received more opex and capex per capita. However, projected growth rates did not influence education capex.

Taken together, these results imply that faster-growing regions tend to require higher capital spending, but that the level and composition of operating costs are influenced primarily by socio-economic factors such as age structure and income levels.

Table 20: High-level analysis of the determinants of public service costs in NZ regions (n=16)

Outcome variable	**log(central government operating expenditures per capita)**				
Explanatory variable(s)	**log(population density)**	**log(GDP per capita)**	**Share aged 0-14; share aged 65+**	**Pop growth rate 2013-2023**	**Pop growth rate 2013-2043**
Var1	-0.025* (0.012)	-0.235** (0.087)	1.741 (1.043)	-0.265 (0.251)	-0.158 (0.108)
Var2			0.567 (0.883)		
Constant	9.794*** (0.036)	12.277*** (0.940)	9.285*** (0.288)	9.770*** (0.041)	9.767*** (0.030)
R^2	0.224	0.344	0.178	0.074	0.132
Outcome variable	**log(central government capital expenditures per capita)**				
Explanatory variable(s)	**log(population density)**	**log(GDP per capita)**	**Share aged 0-14; share aged 65+**	**Pop growth rate 2013-2023**	**Pop growth rate 2013-2043**
Var1	0.042 (0.044)	0.125 (0.341)	-1.052 (2.816)	1.423* (0.747)	0.604* (0.335)
Var2			-7.173** (2.383)		
Constant	7.066*** (0.126)	5.821 (3.706)	8.543*** (0.777)	6.963*** (0.122)	7.035*** (0.094)
R^2	0.061	0.009	0.418	0.206	0.188

*Notes: Statistical significance: *p<0.1; **p<0.05; ***p<0.01*

12.10 How these effects can be measured and valued

As described above, long-run average cost is the ideal approach to calculate infrastructure costs to serve urban development. This reflects the fact that infrastructure is lumpy and long-lived, meaning that the costs to provide

it are expected to be shared across a large number of users, current and future. Current and historic charging policies attempt to recover some, but not necessarily all, of the costs of infrastructure provision from users.

However, marginal costs to build new infrastructure in areas where infrastructure does not exist or where existing infrastructure is at capacity can also provide useful information to decision-makers. It can signal locations where infrastructure costs are likely to be low in the near- to medium-term, which may be relevant if infrastructure providers are facing funding or financing constraints.

A 'first best' assessment of the long-run average cost to serve development in different locations with infrastructure would require information on:

- The cost of existing infrastructure at the time that it was constructed, and expected or actual capacity of that infrastructure
- The timing of historic development in those infrastructure catchments, which may have influenced the cost to finance existing infrastructure
- The cost to supply new or proposed infrastructure, and the expected capacity of that infrastructure
- The expected timing of development that is expected to occur in areas served by new infrastructure, which may influence costs to finance it.

Urban infrastructure often has a multi-decade lifespan, and hence comprehensive records of historic infrastructure costs are unlikely to be available. We therefore believe that it would be prohibitively difficult to develop a theoretically ideal estimate of the external costs of infrastructure provision to serve urban development.

However, 'second best' approaches to calculating external infrastructure costs may be more feasible to implement and would also provide useful information for decision-makers. We outline two potential approaches.

Quantity surveying approach

One approach would be to take a 'quantity surveying' approach to calculating infrastructure costs to serve recent or expected urban development. This would focus on estimating costs to develop new infrastructure in areas that lack it (eg greenfield areas) or upgrade infrastructure in areas with no remaining capacity. Infrastructure costs incurred before a certain date (either the current year or 5-10 years ago to capture recent expenditures) would be treated as sunk costs. In effect, this approach would focus on the costs of enabling near-future urban development, taking as given infrastructure services that already exist.

This approach was used by CIE (2010) in their study of the costs of alternative urban growth scenarios for Sydney, and by CIE and Arup (2015) in their analysis of infrastructure costs in Auckland.

Measurement

- The following approach can be applied to most public infrastructure networks, although implementing it for transport networks would require some 'judgment calls' about how to address the relationship between development in one location and transport investments in another 'downstream' location.
- The first step would be to estimate remaining capacity in existing infrastructure networks, stated in terms of the number of additional users or households that infrastructure can accommodate. If information on remaining capacity is not available, a yes/no indicator of whether there is remaining capacity could be used.

- The second step would be to identify proposed, planned, or recently developed infrastructure from data in long term plans or business cases. Then, calculate the estimated capacity that these are expected to serve, and identify the location expected to be served.
- Third, use SNZ population projections (or other relevant projections) to estimate the timing of development in these catchments and hence the cost of financing new infrastructure.
- This would enable an estimate of the per-user costs to extend infrastructure networks where they do not exist or upgrade them where existing networks are at capacity. It would not account for the costs of past infrastructure extensions.

Valuation

- To calculate the magnitude of the resulting external costs, it would be necessary to compare total infrastructure costs per user (or per dwelling) against existing user charges and development contributions.
- The above review suggests that user revenues include development contributions, fuel taxes / road user charges, and, for some councils, charges for water services.
- Development contributions can be estimated spatially using GIS shapefiles of charging areas, which are available from councils.
- Road user charges and petrol taxes tend vary based on the distance that people drive, and hence they can be estimated based on transport model estimates of average distances driven by people living in different places.

Econometric approach

An alternative approach would be to use econometric analysis to identify the relationship between the form and location of urban development and the costs of existing infrastructure. This would be similar to the empirical studies of density and infrastructure costs discussed above, but at a more disaggregated spatial scale.

The results from econometric analysis could then be used to predict changes in infrastructure costs resulting from new development. This has the advantage of being an empirical, rather than theoretical, approach. However, as infrastructure provision shapes as well as responds to urban development there may be significant challenges in identifying the effects of interest.

Measurement

- The first step would be to measure infrastructure costs at a disaggregated spatial scale, such as Statistics New Zealand's SA2 geography.
- Adams and Chapman (2016) suggest that annual depreciation costs can be used to estimate capital costs for infrastructure networks. It would therefore be necessary to allocate disaggregated data on asset values or depreciation from infrastructure providers' asset management databases to individual areas. This is likely to pose challenges in most councils. Another major challenge would be how to address regionally significant infrastructure that might be used by people who live elsewhere.
- The second step would be to identify a set of location and urban form variables that may influence infrastructure costs. This could include, for instance, population and employment density, distance to major centres, and distance to (eg) wastewater treatment plants or reservoirs.
- The third step would be to undertake an econometric analysis of the impact of urban form and location variables on infrastructure costs. This should start with simple multivariate regression (ie controlling for the impact of multiple variables at the same time) and explore methods for addressing bias created by reverse causality between infrastructure provision and urban development.

- Finally, results from this analysis could be used to estimate the annual infrastructure cost per user (or per dwelling) of urban development in different locations.

Valuation

- The above approach could also be used to value external costs arising from infrastructure provision using this method.

13 Appendix 6: Transport network effects

13.1 How these effects arise

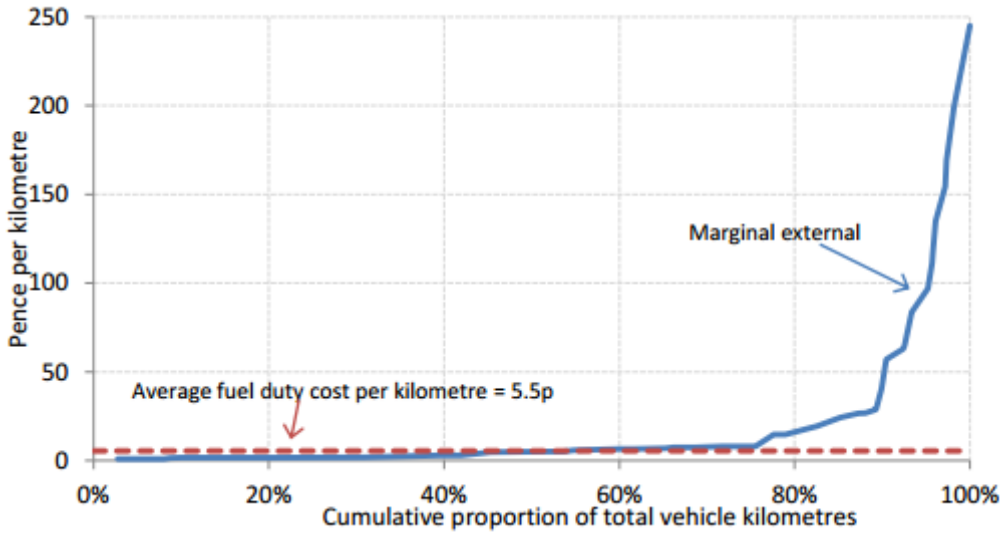
We identify several external costs of urban growth that arise principally in transport networks:

- Congestion externalities, which arise due to the fact that traffic speeds decline when more people attempt to use the road network at peak times, increasing journey times for all users (Small and Verhoef, 2007);[50]
- Noise externalities from increased road traffic, which affect properties alongside busy roads.

In addition, growth in vehicular transport demand can also affect air pollution and human health, while changes to walking and cycling behaviour can influence human health. We discuss those effects in separate appendices but note that they are strongly related to transport behaviours.

Congestion externalities and public transport subsidy requirements arise due to the fact that transport networks are inefficiently priced. Each additional person who chooses to join the road network imposes some delays on other users. In principle, users could be charged a toll that is equal to the marginal external cost they impose on other users, which vary by time and location. In practice, this is seldom achieved. For instance, Figure 19 shows that congestion externalities are over ten times as high as fuel taxes for around 10% of total vehicle kilometres travelled in the UK.

Figure 19: Distribution of the marginal external cost of driving in the UK (Johnson et al, 2012)



Not all congestion is inefficient. Within limits, 'queuing' can indicate that infrastructure has been efficiently provided, as it means that people want to use it. However, because congestion costs are not fully internalised by users, there is often an inefficiently high amount of traffic on some roads, at some times.[51]

[50] Other transport facilities are also congestible, but in different ways. For example, public transport vehicles can become crowded (ie all seats full, people standing in the aisles), which reduces comfort for users but does not affect travel speed.
[51] In congested conditions, trips taken by people who place a low value on travel time will tend to 'crowd out' trips taken by people with a higher value of travel time. This may mean, for instance, recreational trips substituting for freight or business trips.

Congestion externalities can be mitigated or exacerbated by urban scale, urban form, and the availability of transport infrastructure. Well-designed congestion charges can also internalise the external costs of traffic delay, thereby obtaining a more socially efficient outcome.

In general, larger cities tend to be more congested, as more people drive longer distances on average. However, several land use and transport infrastructure responses tend to moderate growth in congestion due to city size. Land use responses include the development of a more 'polycentric' distribution of employment, which can mitigate the need for people in fringe areas to drive longer distances for commuting, retail trips, etc (Anas and Kim, 1996). Transport infrastructure responses include development of new road infrastructure and rapid transit infrastructure, which can give people an alternative to travelling on congested roads.[52]

Transport network effects arise at the level of regional transport networks, ie principally at a macro level. This reflects the fact that most people travel out of their home neighbourhood for a range of purposes – work, shopping, education, recreation, etc. In doing so, they can affect people travelling from (or living in) a range of other locations. While noise impacts are experienced primarily around busy roads, traffic on those roads may originate from various places in the city.

13.2 Evidence on congestion externalities

Congestion and city size

The available empirical evidence suggests that cities tend to become more congested as they grow, but that these effects are moderated by land use and transport investment responses. Existing transport models may over-state growth in congestion because they do not account for these dynamics.

Couture, Duranton and Turner (2018) use household travel survey microdata to investigate the determinants of traffic speed in US metropolitan statistical areas. They estimate that the elasticity of traffic speed with respect to total length of roads is 0.09, while the elasticity with respect to total time spent travelling is -0.13. This indicates that a 10% increase in the total quantity of travel leads to a 1.3% reduction in average traffic speed. They also present suggestive, but not conclusive, evidence that traffic speeds are lower in cities that have a larger share of population or employment within 20 kilometres of the city centre.

Aggregate data for Auckland and five large Australian cities also indicates that congestion costs are higher in larger cities, but that they may increase at a lower rate than city size. Table 21 presents 2014 data on city size and estimated 'deadweight' costs of congestion for these cities.[53] In the cross-section, congestion costs per capita are almost twice as large in Sydney as in Auckland.[54]

We conducted an exploratory econometric analysis of changes in city population and congestion costs over the 2003-2014 period. We estimate an elasticity of total congestion costs with respect to city size of 0.62, indicating that a 10% increase in population is associated with a 6.2% increase in congestion costs.[55] However, the effect of increased city size is not precisely estimated. Inspection of the data suggests that there may be a stronger

[52] As Baum-Snow (2007), Duranton and Turner (2012), and Garcia-Lopez (2012) demonstrate, new road and rail infrastructure also catalyses changes to population and firm location, meaning that long-run impacts on congestion are minimal.
[53] Australian data was obtained from BITRE (2015) and the Australian Bureau of Statistics; Auckland-specific estimates were derived using Ministry of Transport data on traffic volumes, average delays for road users, and regional population, plus some adjustments to be consistent with the BITRE methodology described below. These figures are not fully comparable – the New Zealand data appears to use a higher value of travel time, but this is likely to be offset by the inclusion of added vehicle operating costs and emissions in the Australian data. These figures are calculated as 'avoidable' or 'deadweight' congestion costs – ie the portion of congestion that would be eliminated if users were charged tolls equal to the marginal external cost of the delays that they imposed on others. BITRE estimates that deadweight congestion costs are equal to 50-60% of total congestion costs and as a result we assume that, for Auckland, deadweight congestion costs are equal to 55% of the total cost of delays. See Wallis and Lupton (2013) for a more in-depth discussion of this point.
[54] Observed congestion costs for Auckland are similar to Wallis and Lupton's (2013) model-based estimates of congestion costs, which equate to around $700 per resident per annum.
[55] We estimated a first-differences panel regression model of the following form: $\Delta\ln(congestion)_{i,t} = \alpha + \beta\Delta\ln(population)_{i,t} + \varepsilon_{i,t}$. This approach controls for unobserved, time-invariant characteristics of cities but does not control for other factors that might be changing in cities, such as new transport investments.

positive relationship between population growth and growth in congestion in Auckland than in the Australian cities.

We contrast these results with estimates from the Australian Bureau of Infrastructure, Transport, and Regional Economics (2015). BITRE used transport modelling to forecast that the 30% expected increase in the size of Australia's major cities over the 2015-2030 period will lead to a 127% increase in congestion costs. This is higher than our estimate of the impact of recent population growth in these cities.

Table 21: Urban population and costs of congestion in Australasia

City	Urban population (million)	Estimated deadweight cost of congestion ($bn, 2015 NZD)	Deadweight cost of congestion per capita[56]
Sydney	4.45	$6.08	$1,366
Melbourne	4.27	$4.71	$1,102
Brisbane	2.18	$2.28	$1,045
Perth	1.95	$2.00	$1,026
Adelaide	1.28	$1.13	$883
Auckland	1.53	$1.18	$770

Urban form and travel behaviour

Urban form also influences people's travel behaviour, including how far they travel and whether they drive or use public transport, walking, or cycling instead. Different travel behaviours can in turn lead to different outcomes for congestion and public transport cost recovery. This means that the location and design of new urban development can influence aggregate outcomes for congestion.

Ewing and Cervero (2010) undertake a comprehensive meta-analysis of empirical studies of the impact of urban form on travel behaviour, considering factors such as density, diversity of land uses, design of street networks, destination accessibility, and distance to public transport facilities.

They find that travel behaviour is generally inelastic with respect to urban form. For instance, a 10% increase in distance to the city centre leads to a roughly 2% increase in vehicle kilometres travelled on average. Specific findings are as followed:

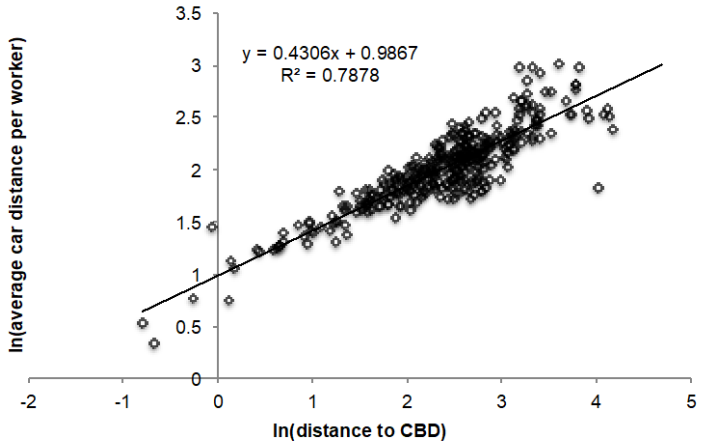
- Vehicle kilometres travelled is most strongly related to destination accessibility (ie distance to the city centre or or number of jobs accessible within a 30-minute commute) and secondarily to street network design
- Walking is most strongly related to land use diversity (ie the mix of housing and business in the area), intersection density, and the number of destinations within walking distance
- Public transport use is most strongly related to proximity to transit and street network design variables, and secondarily to land use diversity
- Population and job density is only weakly associated with travel behaviour after controlling for other urban form variables.

[56] These per-capita figures do not account for the share of population that is exposed to traffic congestion. For instance, retired people who seldom travel at peak times are unlikely to experience congestion, and nor are workers who only commute by train. Intensity of exposure to congestion may also vary between cities.

Ewing and Cervero consider whether these results might be driven by residential sorting ('people vs place'). For instance, people who prefer to walk may choose to locate in walkable neighbourhoods, while people who prefer to drive long distances may locate in outlying suburbs. However, based on a review of 38 studies that use different approaches to control for this selection bias, they conclude that 'place' effects are likely to account for a majority of the measured impacts of urban form on travel behaviours. Residential sorting reduces the magnitude of effects but does not eliminate them.

Local outcomes appear to be consistent with the international literature. Figure 20 presents an illustrative analysis of the impact of proximity to the city centre on average car commuting distances in Auckland suburbs, based on 2013 Census data.[57] On average, a 10% increase in distance to the city centre is associated with a 4.3% increase in car commuting distance.

Figure 20: Relationship between distance to the Auckland city centre and average car commuting distance



Decentralisation of employment

In a purely 'monocentric' city, where all jobs and services are concentrated in the city centre, somebody who lives ten kilometres further away must also commute an extra ten kilometres. However, jobs also tend to decentralise when cities expand, which moderates but does not eliminate this relationship.

We used suburb-level data on population and employment to understand trends in five fast-growing New Zealand cities over the 2001-2018 period.[58] To avoid being confined by council boundaries, our analysis included all locations within a reasonable straight-line distance of city centres.[59]

Figure 21 shows results for Auckland and Christchurch. In both cities, employment growth was more centralised than population growth. In Auckland, one-quarter of total employment growth occurred within five kilometres of the city centre. In Christchurch, the 2010 Canterbury Earthquakes demolished the city centre and spurred a wave of greenfield development in Selwyn and Waimakariri, more than 20 kilometres from the city centre. However, two-thirds of total employment growth still occurred within 10 kilometres of the city centre.

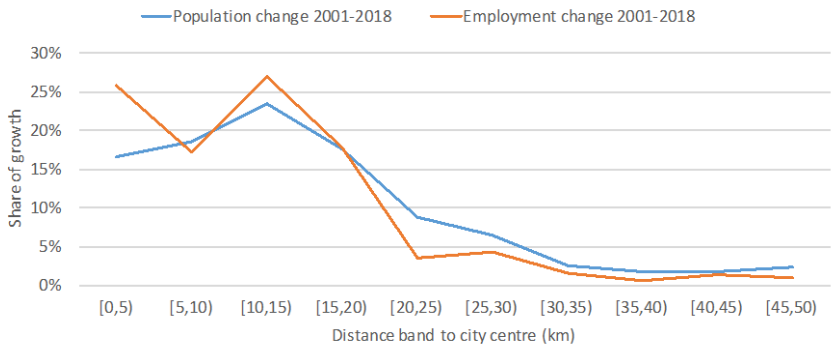
[57] This data was analysed in Nunns et al (2014). We excluded Auckland area units with low density (defined as less than 1 household per hectare) ande log-transformed both variables to normalise them.
[58] Data was sourced from Statistics New Zealand's *Subnational Population Estimates* and *Business Demography Statistics* and aggregated at the SA2 level.
[59] We used distances that capture the majority of cities' commuting zones. This was 50km for Auckland and Wellington, 35km for Christchurch, 25km for Tauranga, and 20km for Hamilton.

We also observed similar patterns in Wellington, Hamilton, and Tauranga. In all five cities we examined, the average new job was located closer to the city centre than the average new resident. This implies that job decentralisation has not fully offset the impact of longer commuting distances on the urban fringe.

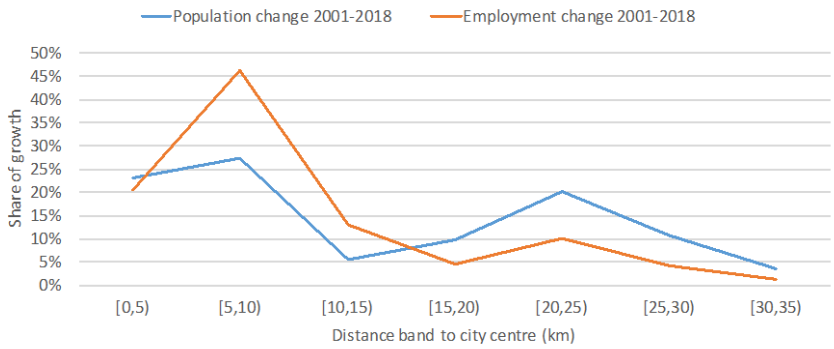
It also indicates the presence of 'centrifugal forces' that continue to attract job growth towards relatively central locations even when population growth is spreading out. These may include agglomeration economies that generate positive productivity spillovers in denser or more accessible locations (Rosenthal and Strange, 2003). We discuss these effects in a separate appendix.

Figure 21: Changes to population and employment by distance to city centre, 2001-2018

Panel A: Auckland



Panel B: Christchurch



These outcomes appear to be driven by business demand rather than restrictions on the supply of business-zoned land outside of existing centres. For instance, two major 'greenfield' centres were zoned around twenty kilometres away from the Auckland city centre during this period (Albany and Westgate).

To test this, we compared the amount of vacant business zoned in each Auckland ward with the amount of new business floorspace developed over the 2013-2017 period.[60] Table 22 shows that vacant business land is relatively more abundant on the urban fringe. 61% of the total vacant business land is in the Rodney, Franklin, Albany, Waitakere, and Manurewa-Papakura wards.

The distribution of new business activity varies by industry and does not follow the availability of vacant land:

[60] Data on vacant business land was drawn from Auckland Council's 2017 *Housing and Business Assessment*, while data on new business floorspace consented was gathered from Statistics New Zealand's *Building Consents Data*.

- New retail floorspace (shops, restaurants, and bars) is concentrated in peripheral areas where major new shopping centres are being developed. Albany and Waitakere wards account for almost half of total consented retail floorspace.
- Almost half of new office floorspace is located in the Waitemata ward, which includes the city centre. This highlights the importance of centrality for office-based industries.
- New industrial floorspace is principally located in the south Auckland industrial belt. Roughly three-quarters is located in the Maungakiekie-Tamaki, Howick, Manurewa-Papakura, and Manukau wards.

Table 22: Share of vacant business land and building consents for new business floorspace, by ward

Ward	Share of vacant business land	Share of new retail floorspace, 2013-2017	Share of new office floorspace, 2013-2017	Share of new industrial floorspace, 2013-2017
Albert-Eden-Roskill Ward	1.4%	3.8%	1.0%	1.0%
North Shore Ward	1.4%	4.3%	3.7%	1.1%
Franklin Ward	8.9%	2.0%	1.2%	2.3%
Waitakere Ward	8.6%	22.8%	5.9%	3.0%
Albany Ward	18.3%	23.5%	8.7%	10.1%
Howick Ward	7.1%	5.3%	5.5%	13.9%
Manurewa-Papakura Ward	13.5%	9.3%	1.4%	13.9%
Manukau Ward	15.0%	3.5%	14.4%	34.1%
Maungakiekie-Tamaki Ward	5.2%	2.2%	8.0%	12.5%
Orakei Ward	1.4%	1.4%	0.0%	0.3%
Rodney Ward	12.0%	4.1%	1.5%	3.1%
Waitemata and Gulf Ward	4.8%	8.7%	47.5%	2.2%
Whau Ward	2.4%	9.1%	1.3%	2.4%

13.3 Case study: Modelling congestion impacts of urban form

Several studies have used strategic transport models to simulate the impact of alternative urban growth patterns on congestion costs in Auckland and Christchurch. These models simulate trip distribution and assignment to routes and transport modes (eg car or public transport) based on inputs for land use and transport networks. They can be used to estimate future traffic delay on strategic road networks, as well as the share of trips taking place by car, public transport, and sometimes other modes such as cycling.

These studies typically compare different scenarios for how a fixed amount of population growth will be distributed within a region. These scenarios can differ significantly in terms of the quantity of new development that occurs in 'greenfield' sites versus through redevelopment and infill in existing urban areas.

Figure 22 shows the four scenarios that were modelled in a 2011 Auckland Council evaluation of alternative future growth scenarios. They range from a scenario in which most population growth occurs in greenfield areas (Scenario D) to a scenario where most growth occurs in high-density urban centres (Scenario A).

Alternative scenarios for population growth were matched with different distributions of employment growth and different levels of transport infrastructure provision. This is an 'ad hoc' way of capturing feedback loops that moderate growth in congestion resulting from changes to urban form.

Figure 22: Alternative urban growth scenarios modelled for Auckland (Auckland Council, 2011)

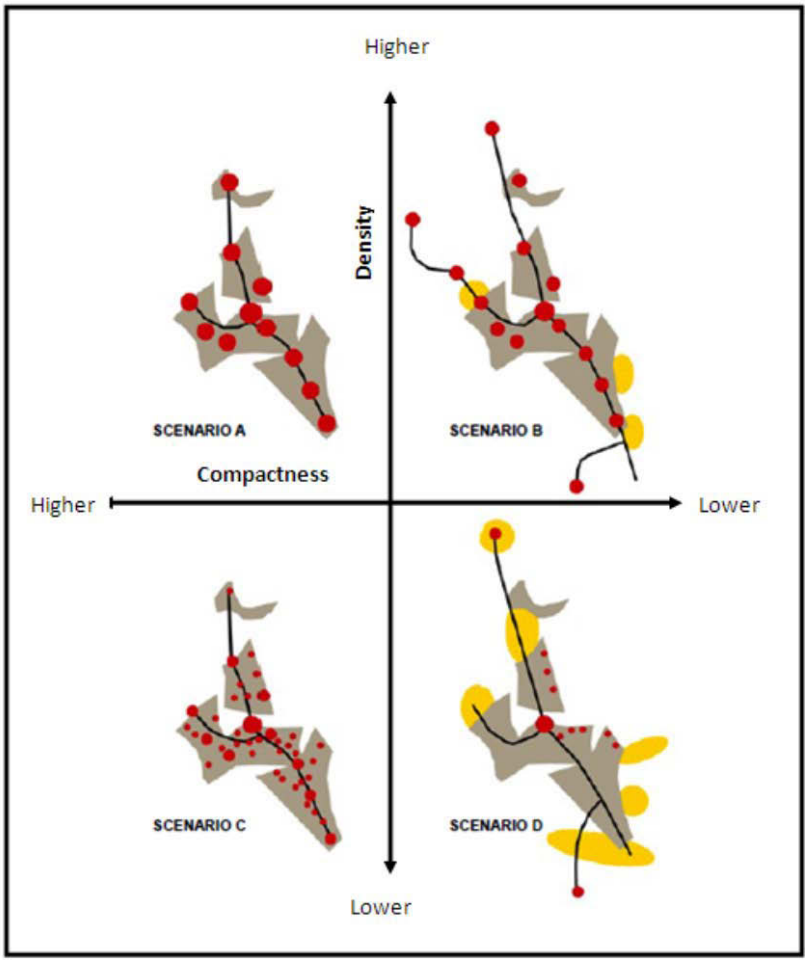
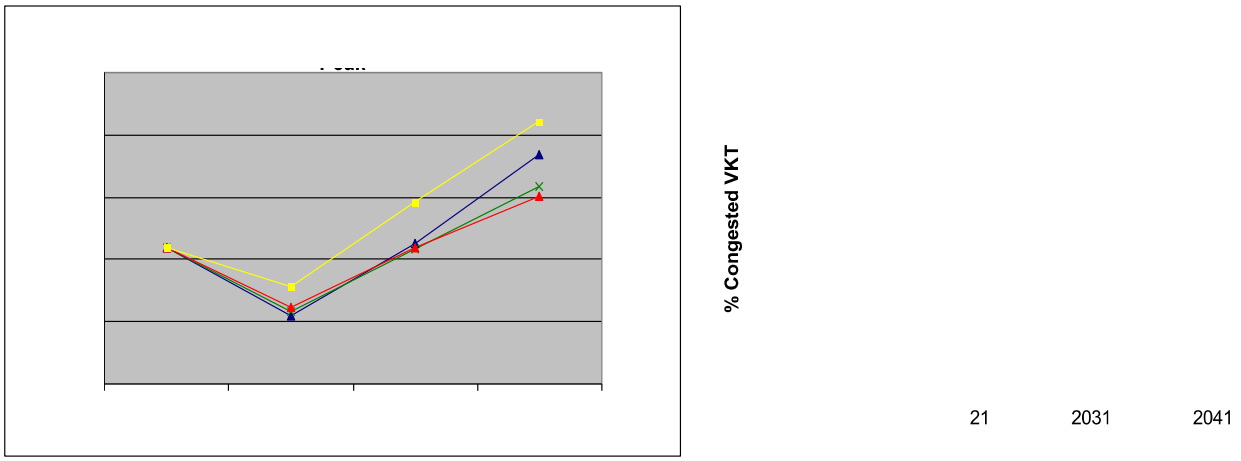


Figure 23 compares outcomes for traffic congestion under each scenario, measured by share of vehicle kilometres that would be travelled in congested conditions under alternative land use scenarios. This modelling shows that Scenario D would result in the highest congestion impacts and longest travel times, followed by Scenario A.

Figure 23: Modelled congestion impacts of alternative future land use scenarios (Auckland Council, 2011)



The report also estimates impacts on transport mode share. As shown in Figure 24, Scenario D would cause public transport mode share to decline, presumably leading to rising PT operating subsidies (or service cuts) while Scenario A would have the largest positive impact on PT mode share.

Figure 24: Modelled transport mode share impacts of alternative future land use scenarios (Auckland Council, 2011)

While this study models transport impacts of urban growth, it does not value changes in traffic congestion and transport mode share.

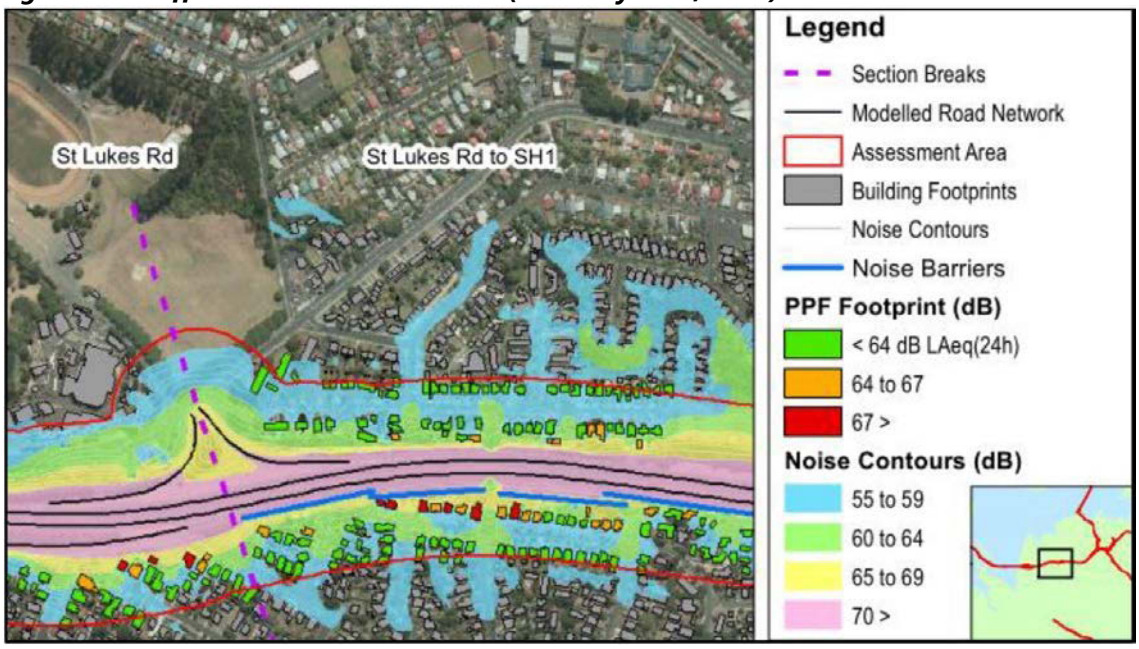
13.4 Evidence on road traffic and noise externalities

High noise levels can affect people's health and wellbeing, and influence the quality and liveability of urban places. World Health Organisation guidelines for community noise recommend that average levels of no more than 30-35 decibels are required in bedrooms to protect sleep disturbance and average levels of no more than 35-40 decibels are required in other habitable spaces to protect indoor amenity (Berglund et al, 1999). The joint Australian and New Zealand Standard AS/NZS 2107:2000: Acoustics – 'Recommended design sound levels and

reverberations times for building interiors' recommends maximum average levels of 30 dB (satisfactory) to 40 dB (maximum) in sleeping areas and 35-45dB in living areas near major roads to protect indoor amenity.

Traffic noise around major roads often exceeds this level. Figure 25 illustrates traffic noise levels near the St Lukes Road interchange on SH16. Noise levels can be significantly higher than WHO and AS/NZS standards in the vicinity of the motorway. Similar issues are likely to arise around urban arterials.

Figure 25: Traffic noise levels near SH16 (Hannaby et al, 2014)



Growth in traffic can increase noise levels for surrounding properties and public spaces, reducing amenity for residents. As a benchmark, the NZ Transport Agency (2018) suggests that "to increase the noise level by 3 dB requires a doubling of traffic volume" but they do not indicate whether this applies equally for low or high traffic volumes, or how widely the effects are felt.[61]

Salomons and Pont (2012) develop a model of traffic noise in cities that relates local population density to local vehicle kilometres driven and hence to noise levels. They apply this model to Amsterdam and Rotterdam, finding evidence of a negative relationship between local population density and sound levels – ie noise levels are *lower* in more populated areas, reflecting low car mode share and street design that prioritises walking and cycling in these areas. However, if overall traffic increases as a result of urban growth, many main roads may experience higher noise levels.

Analysis of property prices is commonly used to value the negative amenity impacts of increased noise levels. Nelson (2004) undertakes a meta-analysis of twenty studies on the impact of airport noise exposure on residential property values in Canada and the United States. He finds that a one decibel increase in noise levels is associated with a 0.8-0.9% reduction in property values in Canada, and a 0.5-0.6% reduction in property values in the United States, at least for noise levels up to 75 dB.

The NZ Transport Agency (2018) recommends using a higher value for valuing the negative noise impacts of road traffic in the context of transport appraisal. They suggest that a one decibel increase in all-day noise levels is associated with a 1.2% reduction in residential property values. This higher value reflects the fact that some

[61] Higher noise levels can have non-linear effects. Decibels are measured on a log scale – meaning that perception of noise doubles in loudness for every 10 dB increase. Background noise levels in urban areas are commonly in the range of 50-60 dB during the day, and around 40 dB at night (Nelson, 2004).

negative effects of high noise may not be fully capitalised into residential property prices. This implies that a doubling of traffic volumes would impose a cost of up to 3.6% of the value of nearby properties.

13.5 How these effects can be measured and valued

The above discussion identifies some important challenges to modelling the impacts of urban development in different locations on transport networks. Feedback between population growth, employment growth, and transport infrastructure provision can moderate congestion impacts, but existing transport models do not model this feedback.

As a result, we outline 'first-best' and 'second-best' approaches to measuring and then valuing the external costs of urban growth that arise principally in transport networks.

Measurement

- The first-best approach would be to develop a transport model that endogenised infrastructure provision and also business location. Parker (2013) suggests that a transport model could be developed that incorporated pre-planned 'shadow' networks that were built or not built depending upon modelled changes in demand. A similar approach is used to model electricity generation expansion.
- The first-best approach is unlikely to be feasible in the short run, as model development is a costly exercise.
- The second-best approach would be to use existing strategic transport models to estimate the impact of alternative land use and infrastructure provision scenarios on key outcome measures such as average travel distances, time spent travelling in congested conditions, mode share for public transport (and walking and cycling if possible), and traffic volumes on main roads.
    - Relevant models include Auckland's Macro Strategic Model (MSM), Wellington's Strategic Transport Model (WSTM), and the Christchurch Transport Model (CTM)
- Strategic transport models treat population and employment location and transport provision as fixed inputs and do not model feedback between these outcomes. To ensure a valid outcome, it is therefore important that:
    - Shifts in employment location should be aligned with population location, based on evidence about how these variables have evolved together
    - Different scenarios for the distribution of growth should be supported by different transport networks, potentially involving a different level of spending.
- In addition, we suggest validating outcomes from these models against empirical evidence on the relationship between urban form and travel behaviours. The modelled elasticity of vehicle kilometres travelled relative to distance to city centre is a key summary statistic: Ewing and Cervero (2010) suggest that this elasticity should be around -0.2.

Valuation

- To value congestion externalities: Use parameters for the value of travel time and the value of time spent travelling in congested conditions from the NZ Transport Agency's (2018) *Economic Evaluation Manual* to value differences in time spent travelling in congested conditions between scenarios.
- To value noise impacts of traffic: Calculate percentage changes in traffic volumes on main roads and use NZTA (2018) parameters (or more sophisticated estimates if available) to estimate the resulting change in noise levels. Use GIS analysis to estimate the number of properties that would be directly affected (eg due to the fact that they front onto the street) and estimate costs for them using NZTA parameters.

14 Appendix 7: Impacts on neighbours

14.1 How these effects arise

Anas, Arnott, and Small (1998) observe that "cities are awash in very localised externalities, from the smells from a fish shop to the blockage of ocean views by neighbors' houses." This section explores the impacts of urban development on neighbours and neighbourhoods. When urban development occurs in existing neighbourhoods, it typically entails renovating or changing the use of existing buildings, demolishing existing buildings and redeveloping sites, or 'infilling' sites with new buildings. Depending upon its design and form, new development can affect neighbouring buildings and alter the aesthetic characteristics of neighbourhoods.

We identify the following main external costs or benefits that reflect the impact of urban development on neighbours:

- Overshadowing of existing dwellings by tall buildings
- Blockage of existing views by new or expanded buildings
- Changes to neighbourhood aesthetics and crowding due to redevelopment of buildings and/or changes to neighbourhood density
- Nuisances from nearby incompatible activities

This section focuses on highly localised impacts that affect immediately adjacent properties or arise over small distances of no more than several hundred metres. External costs that arise over larger geographic scales, such as traffic congestion, are examined in other sections of this report. In some cases, effects like traffic congestion may be perceived at the neighbourhood level.

Underpinning most discussions of these effects is the implicit assumption that existing property owners have a right to continue to enjoy amenities like sunlight access or views that might be obstructed by new development. By contrast, new entrants must accept the conditions that were there when they arrived – for instance, shadows cast by existing buildings. This assumption is often codified in district plan rules, which Fischel (2015) describes as a 'community property right' over the status quo.

However, as Coase (1960) points out, there is no clear 'efficiency' case for this allocation of rights. In theory, a similar outcome could be obtained by either allocating the right to build tall buildings (and hence block sunlight) to property owners or allocating the right to ongoing sunlight access (and hence the right to block tall buildings) to neighbours, provided that neighbours were able to bargain with each other.

14.2 Evidence on overshadowing from tall buildings

Development of tall buildings in existing urbanised areas can reduce neighbouring properties' access to sunlight. There are several channels through which external costs of overshadowing from tall buildings can be detected and measured:

- Reduced access to daylight could reduce health and wellbeing for neighbours;
- Reduced access to daylight could increase heating costs in neighbouring buildings, as darker buildings tend to be colder. Increased expenditures on heating would tend to offset some negative health effects by preventing buildings from becoming too cold or damp; and

- Reduced access to daylight could reduce the value of neighbouring properties by making them less desirable for residents. Reduced property values would reflect both negative health and amenity effects as well as higher expected heating bills.

Survey evidence shows that New Zealanders are highly aware of sunlight when choosing homes. A 2015 survey of Auckland residents' housing preferences under financial constraints reports that natural light is one of the most highly rated features influencing housing choices. 77% of respondents rated it as 'very important' and only 2% rated it as 'not important' in determining housing choice (Yeoman & Akehurst, 2015).

Impact of daylight on health and wellbeing

New buildings that block sunlight could have adverse effects on neighbours' health and wellbeing. However, Aries et al. (2015) identified 47 studies on the impact of sunshine on a range of human health outcomes and conclude that there is only limited evidence linking the two. Limited data and heterogeneity of studies make it difficult to estimate the cost of overshadowing on health outcomes.

Impact of daylight on a building's energy costs

The research linking overshadowing and a building's energy costs is limited and studies in different contexts find different effects.

A limited number of studies have addressed the relationship between overshadowing and power bills. Strømann-Andersen and Sattrup (2011) find that narrow 'urban canyons' in a northern European climate significantly raise modelled residential energy consumption relative to dwellings with open horizons. They suggest that areas where average building heights are 2-3 times average street widths will experience a 7-19% increase in household energy costs relative to a low-rise built environment. On a typical two-lane Auckland street (~10 metres wide, including footpaths), this would equate to 5-8 storey buildings.

Other studies have found mitigating impacts of density on heating and cooling costs. Kolokotroni, Giannitsaris, and Watkins (2006) observe a 'heat island' effect in intensely developed areas such as central London, which raises summer cooling costs while lowering winter heating costs. Conversely, Donovan and Butry (2009) found that shading from street trees in Sacramento, California tended to lower summer cooling costs.

Impact of sunlight on house prices

We would expect access to sunlight should increase house prices, as people are likely to value a sunny home more than a dark one. Hedonic analysis of property sales can therefore be used to measure the amenity benefits that people derive from access to sunlight, and, conversely, the cost that they would bear from losing access.

Although there are few hedonic analyses that address sunlight, the evidence that does exist supports this relationship.

According to Rappaport (2009), US cities that have better climates and more annual sunshine tend to have higher property values and faster population growth rates. Grimes et al (2016) also find evidence that sunnier cities have grown faster in New Zealand. This reflects the observed relationship between quality of life and sunshine exhibited. Kämpfer and Mutz (2013), for example, found respondents had higher reported life satisfaction on sunnier survey days.

Several studies have found a price premium for higher storeys in high-rise apartment buildings, which typically have better access to natural light (Glaeser, Gyourko and Saks, 2005; Wong et al, 2011). Nunns and Denne (2016)

found that each additional storey is associated with a 5.1% increase in price in a sample of several 6-7 storey apartment buildings in Auckland, and that a northern aspect (ie facing the sun) was associated with a 17.3% higher price.

Fleming et al (2018) provide the first rigorous estimate of sunshine's impact on property values. They found that each extra daily hour of sunlight exposure is associated with a 2.6% increase in house sale prices.

The role of building design and district plan rules

While new development can in principle reduce access to sunlight for neighbouring properties, it is unclear how common this is likely to be in practice. There are a number of design factors that affect overshadowing, including:

- The height and form of new buildings: High-rise buildings are more likely to generate overshadowing than mid-rise or low-rise buildings
- Their placement on the site, vis a vis buildings on neighbouring sites: Buildings may cast shade on gardens but not other buildings
- The relationship of the site to the street, and the width of the street: Buildings that are on the north side of the street will not typically block access to sun for buildings on the south side of the street

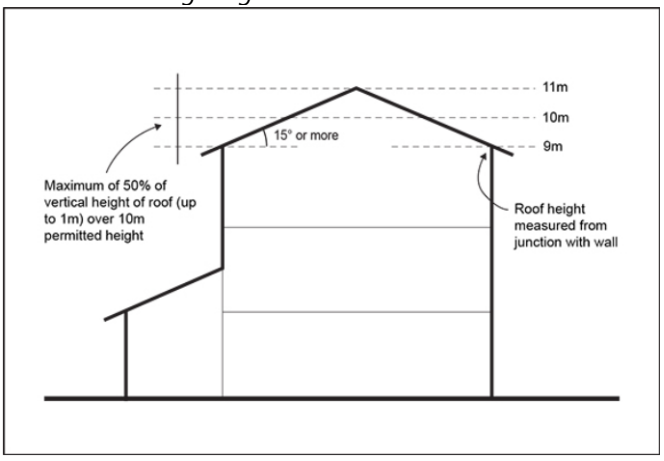
Often, existing district plans include rules that are intended to limit the potential for overshadowing. Commonly applied rules include building height limits, building coverage rules, boundary setbacks, and height in relation to boundary (HIRB) rules. These are generally more stringent in residential zones and relaxed in town centre zones that envisage mid-rise or high-rise buildings.

Figure 26 shows a representative example from the Auckland Unitary Plan's Mixed Housing Urban zone. While this zone allows three-storey buildings (left panel), it requires the upper storeys to be set back an increasing distance from the boundary (right panel) to ensure access to daylight on neighbouring sites.

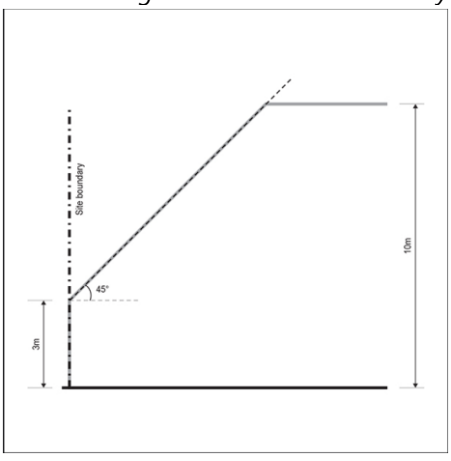
Developers can apply for resource consent to infringe these rules. When doing so, they may be required to produce three-dimensional modelling that shows the extent of any overshadowing arising from the proposal.

Figure 26: Height limit and height in relation to boundary rules in Auckland's Mixed Housing Urban zone (Auckland Unitary Plan)

Panel A: Building height limit



Panel B: Height in relation to boundary rule



14.3 Case study: The value of access to sunlight in Wellington

In a study of Wellington, Fleming et al (2018) found that each extra daily hour of sunlight exposure is associated with a 2.6% house sale price increase. This equates to an average of NZ$16,400 per extra daily hour of exposure for an average Wellington home. The study also provides an example methodology for measuring and valuing sunshine exposures for individual dwellings across a city.

Fleming et al used 5584 observations of house sales in Wellington from January 2008 to December 2014, including data such as the property's sale price, location, number of bedrooms, size, and age. To estimate access to sunlight for each site, they developed a three-dimensional topographic model that incorporated building shapes and natural topography throughout the city to compute the visible horizon from each building, including obstructions from tall buildings or hillsides. This model was then used to identify the daily exposure to sunlight at different times of the year, based on the sun's position at those times.

Wellington's hilly topography leads to wide variation in direct sunlight hours per house, meaning that some homes had plentiful sunlight while others had little. Comparing between these homes and controlling for the influence of other building characteristics and location characteristics on property values, the study found that an additional hour of sunlight exposure per day was associated with a 2.6% impact on sale price. This association is robust to the inclusion of control variables.

The impact did not vary significantly when accounting for season, indicating that sunlight was valued similarly in the summer and winter.

14.4 Evidence on blocked views

Development of new buildings can block neighbours' views and in turn reduce their ability to enjoy their environment. As with overshadowing, these effects are likely to be captured in property values, as people are willing to pay more for a home with a significant view than for a similar home without a view.

New development can in some cases increase the total amount of people that can enjoy a view. For instance, a new apartment building in a coastal area may block views from two existing houses, while creating a dozen new dwellings that enjoy access to the same view.

There is a large empirical literature that suggest that people value certain types of views and that these values are reflected in property values. Bourassa, Hoesli and Sun (2004) summarise a wide range of international studies that use hedonic analysis to quantify the value of views.

Several recent papers investigate the impact of views on property values in Auckland. These studies indicate that a high value is placed on water views, eg in coastal areas, while views of land are less valued and may have no significant value in some contexts.[62]

Bourassa, Hoesli and Sun (2004) find that a view of land was associated with a 4-6% higher price for houses sold in 1996 in Auckland. Wide views were more valued than narrow views. Views of water had a higher value – views of water at the coast were associated with a 33-59% increase in sale price, depending upon whether the view was medium or wide in scope. The value of water views drops off sharply with distance – at 2000 metres from the coast, water views raised prices by 11-14%, depending upon scope of view.

[62] We have obtained similar results in unpublished analyses of property sales in other New Zealand regions. For instance, in an analysis of five Wellington councils we found that water views consistently raised property values, but that views of land typically had a small, statistically insignificant, and occasionally negative impact.

Rohani (2012) find that, on Auckland's North Shore, a view of land was associated with a 6% higher property valuation in 2011. A view of the Hauraki Gulf, which is likely to include Rangitoto, was associated with a 15-50% higher property valuation, with wider views worth more.

Nunns, Hitchins, and Balderston (2015) find that, for residential properties sold in Auckland between 2011-2014, views of water had a strong positive association with sale prices (+8.3%), while views of land had a slight negative association with sale prices (-1.7%). They also found that controlling for spatial correlations between nearby property sales reduced the estimated value of views, which may indicate that water views are correlated with other localised amenities that also raise property values.

Nunns, Hitchins, and Balderston also report data on the share of property sales with water views. They found that 13.2% of residential house sales had views of water, and that these sales were highly concentrated in coastal areas.

This evidence suggests that the external costs of blocked views are likely to be concentrated in coastal areas or lakefront areas. Once again, it is likely that existing district plan rules manage these costs to some extent.

14.5 Evidence on changes to neighbourhood aesthetics and crowding

Existing residents often oppose nearby development, particularly when it increases neighbourhood density, for fear of negative local externalities including visual pollution, increased traffic noise, disruption to local traffic patterns, or loss of a neighbourhood's character (Ooi and Le, 2013). We therefore consider other types of impacts on neighbours, which include:

- Changes to neighbourhood aesthetics, which could be positive or negative, depending upon whether new buildings are 'eyesores' or whether they are more attractive and better maintained than what they replaced
- Crowding of local community facilities or on-street parking, which is unlikely when development occurs in low-density environments but which may become a problem in higher-density areas.

A separate effect, which we discuss in the appendix on agglomeration economies, is that additional urban development may encourage supply of new consumer amenities, such as cafes or grocery stores, and hence lead to benefits for existing residents.

Redevelopment and aesthetics

Redeveloping or renovating existing buildings can lead to either external benefits or costs, depending upon the initial characteristics of the site and the design of new buildings.

When neglected sites or dilapidated buildings are redeveloped, it is likely to have a positive effect on neighbours, reflecting the fact that a local 'nuisance' has been removed.

Conversely, if existing buildings with attractive aesthetics are demolished and replaced with new buildings that are perceived to be 'eyesores', then redevelopment may have a negative effect on neighbours. This is a common rationale for controls on the demolition or alteration of 'heritage' buildings, which we discuss further in the appendix on social and cultural impacts.

In principle, either effect can occur, and hence it is likely that the external impacts of new development on neighbourhood aesthetics will be highly context-specific.

Crowding of community facilities and parking

Existing residents often cite concerns that new development will lead to crowding of local parks and – in particular – on-street parking.

On anecdotal observation, most community facilities in New Zealand suburbs are not notably over-crowded at present. Public parks and local recreation centres are not intensively used, meaning that additional local residents are unlikely to inconvenience existing users. However, popular public open spaces in some city centre environments, such as the Wellington waterfront, can be intensively used and may be subject to crowding.

However, on-street parking is a different matter. In inner suburbs, many homes may lack on-site parking and hence people park their cars on the street. Often, people with garages will choose to park their cars on the street and use garage space for storage. As a result, people are often highly sensitive to the prospect that the residents of new development will also use on-street parking.

In practice, there are a variety of existing and commonly-applied techniques to manage crowding of on-street parking. Auckland Transport's (2015) *Parking Strategy* identifies a graduated range of responses that can be applied to mitigate excessive use of on-street parking, ranging from residential parking permits to time limits to priced parking. Following this strategy, Auckland Transport subsequently introduced priced parking in four new locations (Kingsland, Eden Terrace, Ponsonby, Albany) experiencing demand pressure, increased prices in four locations (city centre, Eden Terrace, Newmarket, Takapuna), and introduced residential parking permit zones in six inner-city suburbs.

Parking management methods have been shown to reduce crowding and congestion issues with on-street parking (Pierce and Shoup, 2013).

As a result, we would argue that if crowding of on-street parking occurs, then it reflects the impact of poor parking management by councils or transport agencies, rather than the impact of new development.

The impact of new development on neighbourhood property values

It is difficult to directly measure the impact of new development on neighbourhood aesthetics and crowding. As a result, we focus on empirical evidence on what happens to the value of properties when new development occurs nearby, as property values are likely to change in response to any positive or negative impacts.

Evidence on the impact of new development on neighbouring property values is mixed, but many studies find a positive impact. This suggests that new development can, on balance, improve neighbourhood aesthetics or generate some external benefits for nearby residents. These effects typically dissipate rapidly with distance: impacts can be observed up to 100-600 metres from a new development, and are small beyond this distance.

Because these effects are observed over small distances, they are unlikely to be complicated by supply effects. In principle, a large amount of new development could reduce the scarcity of housing and hence reduce house prices in that area. However, these effects are likely to arise at the level of entire suburbs or cities, rather than at the neighbourhood level, as people are typically happy to substitute one neighbourhood for another.

Evidence from Auckland suggests that attractive landscaping and buildings can positively affect nearby property values (Bourassa, Hoesli, & Sun, 2004). Being in a neighbourhood of entirely 'superior structures' was associated with a 37% price premium, while houses in neighbourhoods with 50% poor-quality structures experienced a 14% price discount. Sale prices were, on average, 51% less valuable in 'very poorly landscaped' neighbourhoods, while prices were similar in neighbourhoods with 'superior landscaping' or 'average landscaping'.

A separate study by Nunns, Hitchins, and Balderston (2015) find a small negative association between neighbourhood (meshblock) population density and residential house sale prices in Auckland. They found that doubling population density was associated with a 1.1% reduction in average prices.

Overseas studies have also examined how neighbourhood prices change when new development occurs. These studies provide more robust evidence of the causal impact of new development:

- Ding, Simons and Baku (2000) measured impacts following housing investments by non-profit community development centres in Cleveland, Ohio, most of which were heavily subsidised by city government. It found every dollar invested in new construction raised nearby housing prices $0.06 within a roughly 50-metre radius. The study found housing rehabilitation had a smaller but meaningful impact on nearby prices, while small-scale investment had no impact on nearby values. It found that the externalities were felt up to roughly 100 to 150 meters.
- Schwartz, Gould Ellen, Voicu and Schill (2006) examined the impact of New York City's subsidised housing investment from 1987 to 2000. Investment targeted upgrading properties that were generating negative local externalities. Before investment, average property prices in the immediate vicinity of the dwellings chosen for upgrade were 28% lower than their surrounding neighbourhood. After project construction, this gap fell to 13%. Five years later it fell further to 11%. Smaller positive externalities were felt by buildings up to about 600 meters away. The study found stronger effects in poor neighbourhoods.
- Yau, Chau, Ho and Wong (2008) found a 6.6% price premium for properties facing newly refurbished buildings in Hong Kong.
- Rossi-Hansberg, Sarte and Owens (2010) study the impact of government-funded housing investment in Richmond, Virginia from 1999-2004. The 'Neighbourhood-in-Bloom' program targeted specific homes in four selected low-income neighbourhoods. Homes were typically upgraded through demolition and reconstruction. Price effects were compared to houses in nearby and demographically similar neighbourhoods that did not receive program funding. The study found a 2-5% increase in land prices near upgraded houses relative to the control group. The study estimated that the externality decreased by half approximately every 300 metres from an upgraded house.
- A 2011 study of Paris found a 1.2% increase in home prices within a 50-metre radius of social housing, but a 5.5% price decrease for private properties within 350 and 500 metres (Goujard, 2011).
- A 2013 study of 275 new infill developments in Singapore found that nearby house prices rose up to 2.1% during the land acquisition/preparation stage. Price impacts eventually slowed after physical completion of the new development, which the authors explain was the result of the additional competition from the new development (Ooi and Le, 2013)
- Zahirovich-Herbert and Gibler (2014) found that construction of new houses of average size relative to surrounding houses have little effect on neighbouring house prices, though construction of larger-than-average size houses creates a small positive effect on nearby house prices. They find this externality dissipates after about 0.4 km.
- Development of senior housing, which can also be opposed by nearby residents for fear of negative externalities, has been linked to an increase in nearby housing prices (Kurvinen and Tyvimaa, 2016).
- Ahvenniemi, Pennanen, Knuuti, Arvola and Viitanen (2018) examined prices from 6000 housing transactions in Finnish urban areas and found no significant effect of infill development on nearby home prices.

- Davidoff, Pavolv and Somerville (2018) found a small negative spillover from increased density in Vancouver, Canada that is larger for properties with large lots.

There are several reasons why new development may result in positive, rather than negative, external effects for neighbours. One is that new buildings tend to be more attractive or in better condition than the buildings that they replace. To maximise profits, developers may choose to buy up the 'worst house on the best street' for redevelopment, rather than tearing down a higher-priced dwelling.

Another is that successful redevelopment may signal to neighbours that they too have development opportunities. There is some evidence for this effect. In a historical study, Hornbeck and Keniston (2017) find that the 1872 Great Fire of Boston, Massachusetts led to a virtuous cycle of upgrading. New buildings constructed in burned lots were of higher quality than the existing structure before the fire, and this encouraged further upgrades in surrounding areas, resulting in an overall increase in land values and building values in the decade after the fire.

While this research does not imply that all new development will have a positive impact on neighbours, it indicates that localised negative impacts may occur much less frequently than people expect before development occurs.

The impact of blight and neglect

Neighbourhood decline or population loss can be associated with vacancies that create negative externalities to nearby properties.

In extreme cases, citywide population loss can lead to neighbourhood blight in which many buildings are abandoned or in severe disrepair. One study of Cuyohoga County, Ohio – an area in the US 'rust belt' that has experienced significant, long-term population loss – found that each additional blighted house within about 150 metres of a non-blighted house reduced the selling price of the non-blighted house by 1 to 2%. In blighted neighbourhoods, this price discount also results from factors other than aesthetic neighbourhood change. For example, blighted neighbourhoods have been linked to higher crime and disease rates, increased juvenile delinquency, more frequent fires, and decreased social cohesion (Pough and Wan, 2017).

More broadly, several studies have found that foreclosures in a range of neighbourhoods decrease the value of nearby, non-distressed properties. Though estimates of the externality size vary significantly, several studies have found that an additional foreclosure creates a negative price spillover to nearby houses of about 1%. Gerardi, Rosenblatt, Willen and Yao (2015) conclude that these price spillovers result from a lack of property maintenance of foreclosed dwellings.

14.6 Evidence on nuisances from incompatible activities

Close proximity between incompatible land uses may generate nuisance costs for neighbours. These include, but are not necessarily limited to, effects such as:

- Noise from loud industrial or transport activities (eg busy roads or airplane flight paths). Above certain thresholds, noise exposure may lead to annoyance, sleep disturbance, and potential health effects for residents (Salomons and Pont, 2012). We would expect these negative externalities to be capitalised into residential property values. The costs of increases in nearby traffic noise are explored in more detail in the appendix on transport network effects.

- Poor air quality, odours, or dust from industrial, transport, or rural activities (eg farms). This may result in discomfort or, if exposure is prolonged, potential health effects for residents. The health impacts of poor air quality (fine particulates) can be estimated directly, as discussed in a later appendix on air and water quality.
- Reverse sensitivity effects, which refer to the disruption that an established activity may experience when new sensitive land uses move in (NZ Transport Agency, 2010). For example, new residents may complain about the noise or dust associated with existing industrial or rural activities.

People appear to place a value on land use regulations that act as an 'insurance policy' against the future potential for negative externalities associated with incompatible land uses. For example, McMillen and McDonald (2002) find evidence that the introduction of Chicago's first zoning code in 1923 resulted in faster increases in property values in areas newly zoned for residential use only. As the zoning code did not remove existing commercial and industrial activities from residential areas, McDonald and McMillen interpreted this effect as the value of an "insurance policy against the invasion of commercial or industrial activity that would create strongly negative effects."

Cost of incompatible activities (negative externalities of industry on residential properties)

Incompatible land uses, such as heavy industry and residential housing, or certain agricultural activities and housing, may result in negative externalities for the more 'sensitive' land use. This may reflect noise, smells, poor air quality, or visual disamenities.

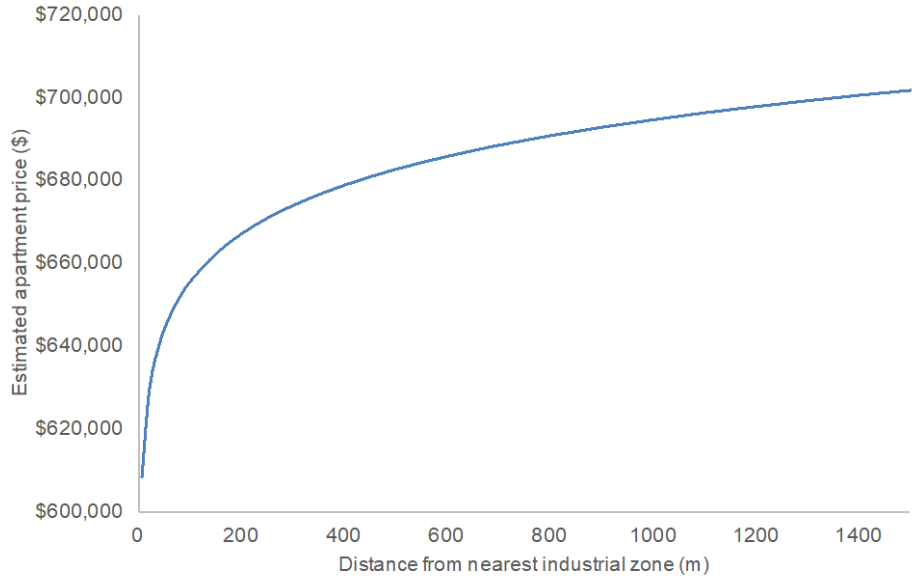
Some residential activities may be seen as incompatible. For example, some people may object to apartment developments in suburban areas dominated by standalone houses on the grounds that they are incompatible with the existing character of the area. We address this point elsewhere in this appendix, when considering the impact of new development on existing buildings.

Empirical studies suggest that the presence of industrial (and potentially commercial) land uses are associated with lower residential property values in adjacent areas (Irwin, 2002; Song and Knaap, 2004; Rouwendal and van der Straaten, 2008; de Vor and de Groot, 2010; Nunns, Allpress and Balderston, 2016). These effects are relatively localised. For instance, Rouwendal and van der Straaten find that they only apply within a 750-metre radius, while de Vor and de Groot find that they apply within a 500 metre radius.

Nunns, Allpress, and Balderston (2016) analyse the impact of proximity to industrial zones on residential property values in Auckland. The following diagram illustrates one of their key results, which is that the value of standalone homes declines with increasing proximity to industrial zones.[63] As with international studies, the majority of these impacts appear to dissipate after half a kilometre.

[63] This curve is extrapolated based on their estimate of the elasticity of house price with respect to distance to the nearest industrial zone (0.025).

Figure 27: Impact of proximity to industrial zones on the value of an average standalone house in Auckland (Nunns, Allpress and Balderston, 2016)



These results indicate that there is the potential for nuisance costs to arise as a result of the close proximity of residential housing and industrial activities. If urban development brings these activities together, it may generate external costs. However, district plan rules generally seek to manage these externalities by separating industrial and non-industrial uses into different zones.

Cost of reverse sensitivities (negative externalities of residential properties on industry)

Reverse sensitivity may arise in situations where a sensitive land use is proposed to be sited next to an existing land use that generates some negative external effects, such as noise, dust, or smells. In these situations, the new entrants may complain about the adverse effects of existing land uses, which may result in costs for those land uses, or restrictions on their operations, to reduce nuisances. Davidson (2003) provides an overview of case law and RMA law on this issue.

This may apply to, for example, established industrial activities or agricultural activities in areas that are undergoing residential development. While these effects have been posited and are often raised by heavy industrial business and quarries in district plan reviews, we are not aware of any quantitative evidence on reverse sensitivities.

14.7 How these effects can be measured and valued

Based on the above evidence and case studies, the following approaches could be explored to measure and value the external costs of urban growth that are caused principally by new or existing neighbours on nearby residents:

Measurement

- Overshadowing from added buildings can be estimated using 3-D GIS modelling of building envelopes and topology. Effects must be estimated at a site-by-site (micro) level. Impacts will vary depending upon height and design of new buildings; topography; etc.
- Availability of existing views can be identified using property sales records / rating valuation rolls, which contain information on property attributes. This data can be used to identify which locations have concentrations of homes with water views.
- Incompatible activities and their range of effects must be assessed on a case-by-case basis, as they will depend upon the type of activity 'intruding' into a new area and the density of existing activities around it.
- Further research is needed to be able to measure (and hence value) the impact of changes to aesthetics and neighbourhood crowding as a result of new development. The overseas literature does not clearly demonstrate that there is a negative impact here, although it does suggest that impacts tend to be spatially concentrated. Ideally, New Zealand-specific research would be undertaken to understand whether these effects arise in practice and what attributes of new developments influence whether effects are positive, negative, or neutral.

Valuation

- To value overshadowing externalities: Calculate the impact of reduced sunlight access on property values using hedonic analysis or willingness to pay studies.
- To value blocked views: Calculate the impact of reduced views using outputs from hedonic analysis or willingness to pay studies of specific notable views.
- To value incompatible activities: Use hedonic analysis of property prices near incompatible activities.
- Further research is needed to value changes in neighbourhood aesthetics and crowding as a result of new development. Following overseas literature, hedonic analysis of changes in property prices near redeveloped sites can be used to estimate the value of any localised costs or benefits.

15 Appendix 8: Consumption of open space

15.1 How these effects arise

Urban development in previously undeveloped 'greenfield' sites requires undeveloped or open space to be converted to urban use. The uses and values previously associated with this land may be foregone as a result.

Consumption of undeveloped land or open space is usually irreversible, as it is costly to restore land and ecosystems to their undeveloped state. Falling demand for urban uses in some places, eg in declining 'rust belt' cities, has caused some large industrial sites or even entire residential neighbourhoods to be vacated. However, the costs to demolish buildings and remove contaminated soil can be high.

If undeveloped land has an economic use, such as pastoral farming or horticulture, then urban development will result in the loss of these productive uses. The value of existing production is likely to be captured in land values, and hence will be internalised by developers and future residents.

However, the availability of open space in cities or on the edge of cities also provides a range of external benefits that are not reflected in the price for individual sites. Following Brander and Koetse (2011) and Meurk, Blaschke, and Simcock (2013), these may include:

- Environmental services provided by open space, such as local climate regulation (mitigating the urban 'heat island' effect), stormwater retention, and natural hazard management
- Aesthetic, recreational, and cultural benefits provided by open space, which reflect the amenity offered to people who can access or enjoy those places
- Option value, which reflects the fact that undeveloped land may allow a more versatile range of future uses relative to developed land
- Existence value and bequest value of ecosystems and biodiversity, which reflect the fact that people may value the services provided by the land, both for themselves and for future generations, even if they do not visit it.

Urban development that occurs on previously undeveloped land can therefore result in external costs due to the loss of these public benefits. These costs are likely to vary depending upon the type of open space that is being developed. For instance, public parks and conservation land are likely to provide a broader range of external benefits than private farmland, as they serve recreational uses and provide biodiversity benefits in addition to aesthetic benefits and option value.[64]

Costs are also likely to vary depending upon the urban context. The external costs of developing open space may be higher in dense urban area as opposed to low-density environments, as people may value open space more in denser areas.

15.2 Internalised costs from foregone agricultural uses

In an econometric study of the link between agricultural production and farmland prices, Allan and Kerr (2014) find that the monetary value of agricultural production is reflected in land prices.[65] This means that people

[64] In addition, some agricultural uses are likely to result in negative externalities, eg due to the impact of agricultural runoff on water quality or local nuisances such as dust or smells from farming operations.
[65] https://motu.nz/our-work/environment-and-resources/lurnz/examining-the-drivers-of-rural-land-values-in-new-zealand/

seeking to develop farmland for urban uses must internalise the cost of foregone agricultural production and pass it on to residents or other users of new urban places.

To illustrate this point, Table 23 summarises recent REINZ data on rural property sales. It shows that sites that support higher-value agricultural activities, such as horticulture, can be up to twenty times as valuable as lower-value activities such as dry stock grazing. This means that purchasing highly productive land is likely to be costlier for developers than purchasing grazing land or scrubland.

Table 23: Median price per hectare for rural properties, 3 months ending November 2018 (REINZ)

Farm type	Median price per hectare	Number of sales
Dairy farms	$51,000	46
Finishing farms	$32,600	82
Grazing farms	$11,800	99
Horticulture farms	$196,100	44

Source: https://www.reinz.co.nz/rural-lifestyle-property-data

However, this does not necessarily mean that all of the potential future economic costs of urbanising productive agricultural land are reflected in present-day decision-making. For instance, retaining farmland in an undeveloped state may enable more flexibility in the face of future changes in demand for agricultural products. There may be some 'option value' from retaining farmland that is not fully captured in market prices. However, we note that there is no clear empirical evidence of this effect.

15.3 Evidence on ecosystem services provided by open space

Open space in or near cities can provide a range of ecosystem services such as natural hazard mitigation, improved air quality, climate regulation, and stormwater management. If land is urbanised, then city residents may experience lower quality of life, or incur costs to replace ecosystem services with built infrastructure or mitigation. For instance, if wetlands that provide runoff and stormwater management services are drained and developed, it may be necessary to construct new stormwater systems to handle runoff and avoid flooding.

Meurk, Blaschke, and Simcock (2013) review the evidence on ecosystem services in New Zealand cities. While they do not quantify the value of services provided by open space, they identify evidence for the following effects, which generally reflect external benefits from the ongoing availability of open space:

- Climate regulation
- Runoff and stormwater management
- Water purification, wastewater, and solid waste treatment
- Human disease regulation (eg due to impacts of sanitation and crowding on health)
- Pest regulation and pollination
- Air quality enhancement
- Natural hazard and erosion management

We cover several important categories of ecosystem services in the appendix on air and water quality.

An important point is that the design of urban developments can have a significant impact on the ongoing provision of ecosystem services. For instance, ecosystem services can be incorporated into the design of new developments, eg through 'green' stormwater infrastructure.

15.4 Evidence on other external benefits of open space

Many New Zealanders express a preference for preservation of open space, rural land, and conservation land. This reflects the benefits that people derive from the existence and availability of these places, as well as New Zealanders' cultural values around land.

Non-market valuation techniques can be used to quantify the value that people place on the availability of open space, including both indirect use value, and existence, bequest, and option values. Commonly used techniques include contingent valuation, which entails surveying people about their 'willingness to pay' to preserve open space, and hedonic analysis, which entails estimating people's willingness to pay to live closer to open space by analysing residential property prices.

Both methods have been widely used internationally and have been applied to some specific cases in New Zealand. However, the New Zealand literature does not provide a definitive estimate of the external benefits of open space.

An alternative, which has the advantage of directly revealing people's preferences is to look at cases where communities or groups have bought land for the purpose of preservation. For instance, a certain amount of private land is covered by conservation easements or covenants, which may provide an indication of the value that people place on conservation even without a regulatory mechanism.

Contingent valuation studies

Brander and Koetse (2011) undertake a systematic 'meta-analysis' of 20 studies that used contingent valuation methods to estimate the benefits that people derive from access to open space in and around cities. These studies used 'willingness to pay' surveys to estimate the external benefits of open space that accrue to people throughout a region.

The mean value of open space was equal to $13,210 per hectare per annum (in 2003 USD), while the median value was only $1,124. (In 2017 NZD, these equate to $27,800/ha/year and $2,400/ha/year.) Brander and Koetse found that the external benefits of open space varied significantly depending upon the following factors:

- Land use: Parks and green spaces were more highly valued than agricultural and undeveloped land, which was in turn more highly valued than forests.
- Services provided by open space: Open spaces that provide recreational use were more highly valued than open spaces that provided aesthetic value or preservation value. Open spaces that provided agricultural use were valued least.
- Size of open spaces: Larger open spaces tend to provide 'diminishing returns' – the per-hectare value of open space tends to fall as size increases.
- Urban context: Open spaces were valued more in denser areas (measured at the city / region level). Higher incomes may also increase the value placed on open space.

Brander and Koetse's results can be used to estimate the external costs of developing open space in different cities (via a 'value transfer' method). However, value transfer is subject to a number of caveats. Even after

controlling for the above factors, there is evidence that values from one country may not always apply to another. Value transfer is not necessarily a reliable substitute for a well-designed local survey or participatory process.

Noting that caveat, we use Brander and Koetse's analysis to provide indicative estimates of the external cost of developing different types of open space near selected New Zealand cities. We use SNZ *Subnational Population Estimates* and *Regional GDP* data to estimate regional average population density and GDP per capita in 2017, and World Bank data to convert 2003 USD to 2017 NZD (using GDP deflators and purchasing power parity exchange rates).[66]

We then assess the 'cost' of developing 5000 hectares of various types of open space, which is sufficient to accommodate around 65,000 households at typical suburban densities of 13 dwellings per gross hectare, including roads and reserves.

The resulting estimates are summarised in the following table. Forest land that mainly provides agricultural services is least 'costly' to develop in all cities, while parks and green spaces that provide recreational or preservation services are most 'costly'. Agricultural land has an intermediate value.

These results are qualitatively sensible, but quantitatively confusing. For instance, estimated willingness to pay for agricultural land near Christchurch is around $8100 per hectare per annum. At a 6% discount rate, this equates to a present value of around $130,000 per hectare. This implies that the 'social' value of agricultural land may be a large multiple of land prices, which are in the range of $51,000 per hectare for dairy farms (see Table 23).

Table 24: Estimated willingness to pay to preserve open space near NZ cities (NZD per hectare per annum)

Existing land use	Type of services provided	Auckland	Wellington	Christchurch
Forest	Environmental / agricultural	$2,800	$2,600	$2,400
Forest	Preservation	$5,500	$5,300	$5,100
Parks and green space	Recreation	$14,900	$14,600	$14,500
Parks and green space	Preservation	$12,900	$12,600	$12,400
Agricultural and undeveloped land	Environmental / agricultural	$8,500	$8,300	$8,100

A review of Lincoln University's *Non-Market Valuation Database*, which covers studies undertaken between the 1970s and the early 2010s, and further studies reviewed by NZIER (2018), suggests that there is little New Zealand-specific evidence on willingness to pay to preserve open space or agricultural land.[67]

The topics covered by available studies include the value of outdoor recreation opportunities (such as tramping or fishing) and the value of specific environmental protection measures or water quality improvements. Some studies address the preservation of improvement of specific open spaces, such as the Waikato's Pekapeka Swamp (Ndebele and Forgie, 2017), or specific environmental services provided by farmland (Baskaran, Cullen

[66] Regional data underestimates the density of the Wellington and Christchurch urban areas as Wellington and Canterbury regions include large rural areas. We therefore assume that these urban areas are 80% as dense as the Auckland region, based on our previous analysis of urban population densities in New Zealand.
[67] Available online at http://selfservice.lincoln.ac.nz/nonmarketvaluation/

and Takatsuka, 2009). Some studies have used a mix of methods to value specific categories of services from open space, including value transfer (Sandhu et al, 2008; Rohani and Kuschel, 2017).

In general, this evidence supports the idea that New Zealanders place a value on the services offered by open space, but does not provide a basis for making a specific estimate of that value. Moreover, as NZIER (2018) note, there is some evidence that Māori may place a higher value on environmental protection than non-Māori, eg in areas that have cultural or practical significance.

Hedonic studies of the value of proximity to open space

Brander and Koetse (2011) also review twelve studies that use hedonic analysis of residential property sales to estimate the price that people are willing to pay in order to live closer to parks or open spaces. This is a 'revealed preference' method that entails comparing the price that people pay for similar houses that are different distances from the nearest park. If house prices are higher in areas near open spaces, it implies that there are positive external benefits from the availability of those spaces.

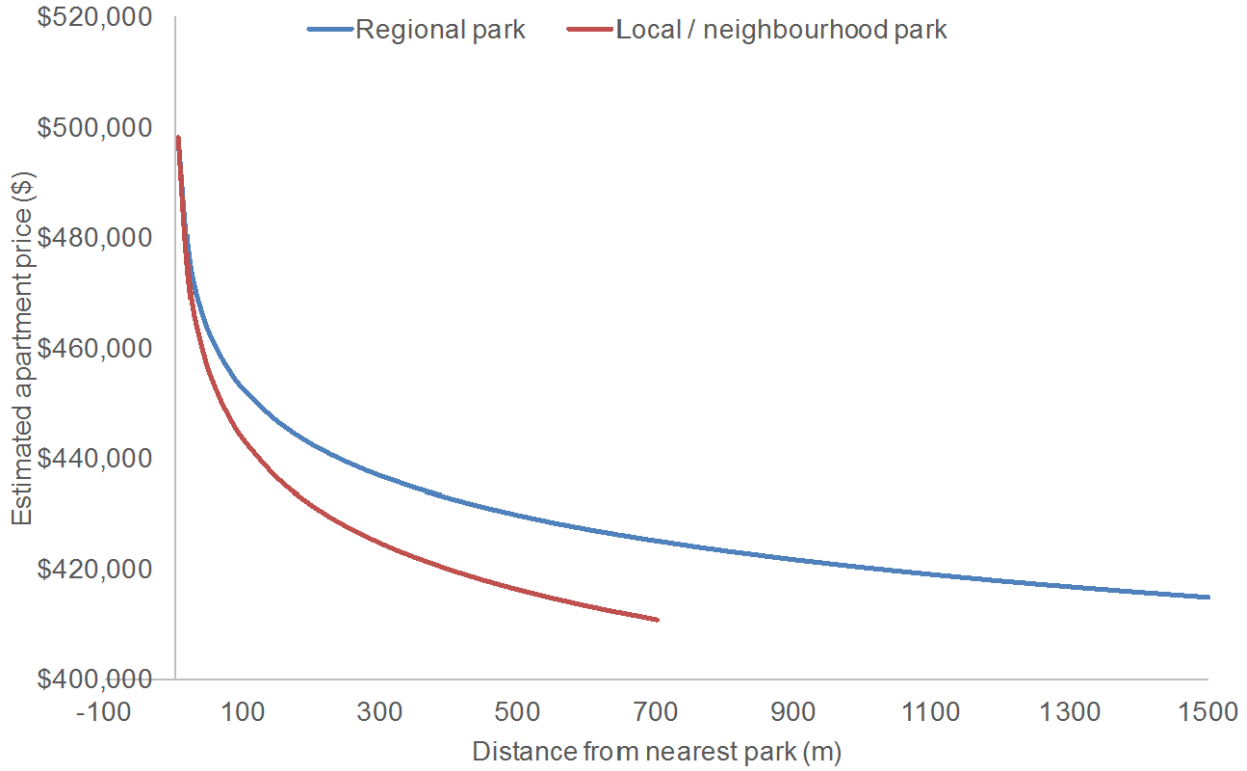
The international literature generally finds that house prices are higher in areas near parks and open space. This suggests that there are often positive external benefits from the availability of open space at a local level. This can include the availability of open space at the edge of the city, if it provides environmental amenities to nearby households (McCann, 2001).

However, several hedonic analyses have found that proximity to open space has either no effect or a mixed effect on residential sale prices in Auckland.

Nunns, Allpress, and Balderston (2016) investigated the impact of proximity to regional and local parks on property values in Auckland. They found that proximity to parks does not have a statistically significant impact on prices for standalone homes, but that it does positively impact prices for multi-storey apartments.[68] The following figure illustrates their estimated price gradient for apartments, which suggests that "an average apartment immediately adjacent to the nearest regional or local / neighbourhood is expected to sell for roughly $500,000. By contrast, an average apartment 500 metres away from the nearest regional park is expected to be 13.7 per cent less valuable, while an average apartment 500 metres away from the nearest local / neighbourhood park is expected to be 16.4 per cent less valuable."

[68] This result is robust to inclusion of controls for house characteristics, including lot size, and neighbourhood characteristics, including local density and the number of burglaries in the neighbourhood.

Figure 28: Estimated apartment sale prices as a function of distance from the nearest regional or local / neighbourhood park (Nunns, Allpress and Balderston, 2016)



Nunns, Allpress and Balderston note that this does not mean that Aucklanders do not value the availability of parks. Rather, the result for houses may simply reflect a limitation of the hedonic method:

> *[…] almost all residential property sales in Auckland are close to parks. Over 95 per cent of property sales are within 500 metres of at least one local or neighbourhood park, and there are only 306 property sales that were further than one kilometre from the nearest park. Similarly, approximately 75 per cent of properties were within one kilometre of the nearest regional park. This reflects the widespread availability of parks throughout the urbanised area.*
>
> *Consequently, our results for houses and flats may simply reflect the relative equality of proximity to parks throughout Auckland. Compared to other cities, Auckland may have few places that aren't close to parks. In this context, we may be unable to observe enough variation in access to parks to obtain meaningful estimates of the degree to which park proximity affects property values. This does not necessarily mean that parks are not valued in Auckland, but that their value accrues broadly to most Auckland houses and flats, regardless of whether they are immediately next to a park.*

A re-analysis by Auckland Council (2017) obtained qualitatively similar results, finding that a larger amount of land devoted to green space within a Census area unit was associated with lower residential property prices. However, close proximity to the nearest green areas may be associated with higher property values, after the overall quantity of green space in the suburb is accounted for.

Analysis of land values near rural-urban zoning boundaries in New Zealand cities undertaken by MBIE (2017) also suggests that proximity to agricultural open spaces at the edge of the city does not provide strong localised amenities. If agricultural land provides local amenities, then we would expect house prices to be higher

immediately inside the edge of the city, relative to suburbs further away from the boundary. MBIE (2017) found that the opposite was true in most New Zealand cities.[69]

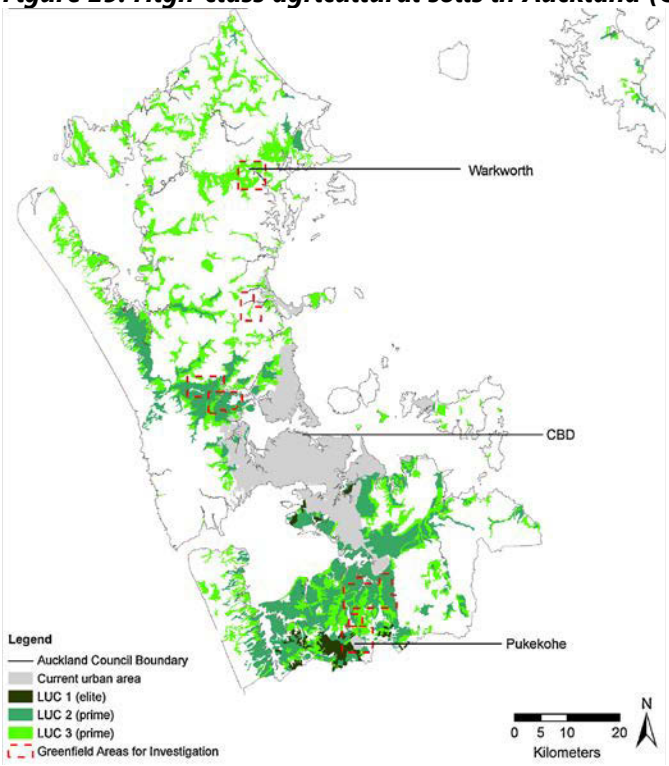
These results suggest that it may be difficult to measure the full value of open space using hedonic analysis. Hedonic analysis can capture local benefits of open space that arise over a relatively short distance, eg less than one kilometre. There is evidence that open space provides local benefits for higher-density dwellings such as multi-storey apartments in New Zealand cities. However, most of the benefits of open space availability are likely to arise at a regional level. These impacts are better captured using other research methods.

15.5 Case study: Urban development on high-class soils in Auckland

It is possible to identify the characteristics of open space and undeveloped land in and around cities using GIS analysis of databases on land cover, soil quality, and conservation areas. The impact of urban development on the stock of open space and farmland can also be assessed using historical data on urban footprints.

Curran-Cournane et al (2014) measure the impact of urban development on high-class agricultural soils in Auckland, identified using the land use capability (LUC) framework. LUC 1 to 3 indicate land that is suitable for horticulture, pastoral grazing, and forestry, while LUC 8 indicates land that is unsuitable for agriculture and hence only fit for conservation uses. The following map shows the distribution of high-class soils in Auckland, excluding areas that were urbanised before the 1980s.

Figure 29: High-class agricultural soils in Auckland (Curran-Cournane et al, 2014)



Curran-Cournane et al estimate that 10,080 ha (or 8.1%) of Auckland's high class land was been converted to urban uses between 1975 and 2012. The rate of urban expansion onto high class land has accelerated since

[69] See the appendix to the technical report. MBIE (2017) estimated the difference between the value of rural- and urban-zoned land within a small 'band' around the edge of the zoning boundary. They undertook sensitivity testing of alternative band widths ranging from 50 metres to 2000 metres. If proximity to agricultural land on the city fringe provided local amenity benefits, then we would expect the differential to rise as smaller distance bands are used. In all of the cities that were assessed, the differential actually fell as smaller bands were used.

1996. Identified future greenfield developments may result in the development of an additional 6010 ha (or 4.8%) of current high class land.

While this paper does not attempt to value the external costs of developing high class soils, it illustrates how GIS data can be used to identify the characteristics of undeveloped land and identify how much has been developed, or will be developed in the future.

15.6 How these effects can be measured and valued

Based on the above evidence and case studies, the following approach could be used to measure and value the external costs of urban growth that arise as a result of consumption of open space.

Measurement

- These effects principally relate to greenfield development, including development of large undeveloped sites within cities.
- International evidence suggests that they may vary in magnitude depending upon the type of open space that is used for development.
- It is conceptually straightforward to estimate the amount of open space that would be consumed as a result of urban development. This entails three key steps.
- First, develop benchmarks for the quantity of land consumed per dwelling or per employee in different cities. For instance, a new suburb with 500m^2 sections and around one-third of the area devoted to roads, parks, and other infrastructure would have a gross density of around 13 dwellings per hectare.
- Second, identify the characteristics of open space in different peri-urban locations using GIS datasets of existing soil type, land cover and land uses. This may be a complicated exercise due to the need to merge multiple datasets, eg conservation estate GIS shapefiles, regional park shapefiles, soil datasets, etc. (See Fiona C-C's research on this.) Ideally, these categories should be simplified to a small number of categories that are meaningful for social, cultural, or environmental reasons.
- Third, combine the above data to estimate the quantity of each type of open space that would be consumed as a result of a given amount of development that occurred in different locations.

Valuation

- After measuring the quantity of land that would be consumed as a result of urban development in different locations, it would be necessary to value those impacts.
- Our literature review suggests that hedonic analysis is unlikely to capture the full benefits of open space provision in or near cities, as it focuses on benefits that arise over relatively short distances. Contingent valuation methods may be more appropriate, subject to caveats about the validity of those methods.
- The simplest approach to valuing these impacts would be to use value transfer methods to apply Brander and Koetse's (2011) estimates of willingness to pay for open space to New Zealand cities. Above, we illustrate how this could be done.
- This simple approach has some important limitations. Value transfer can be subject to significant uncertainty, and, as we illustrate above, it may produce counterintuitive results.
- Hence it may be useful to undertake a local CV study to estimate willingness to pay to preserve different types of open space.
- Due to the fact that some environmental impacts, eg on biodiversity and long-run sustainability of ecosystems, are unlikely to be perceived by humans, a natural capital accounting approach should also be considered for some types of open space.

16 Appendix 9: Air and water quality

16.1 How these effects arise

We identify the following main external costs that arise as a result of the impact of urban development on air and water quality:

- Health impacts of reduced local air quality, which arise due to emissions from transport, home heating and industry. These impacts arise within local airsheds and downwind from emission sources.
- Greenhouse gas emissions from transport, domestic fires for heating and industry, which contribute to climate change. These impacts are global in nature.
- Reduced freshwater and costal water quality from increased contaminated run off due to increasing amounts of paved surfaces and buildings and reduced areas of natural filtration.

Poor local air quality can damage human health. Fine particulate matter with a diameter of less than 10 microns, (PM_{10}) or less than 2.5 microns ($PM_{2.5}$) are the main contributor to health costs, while other sources such as sulphur dioxide (SO_2) can have a localised impact in industrial areas or around ports. PM10 exposure can increase mortality and morbidity from acute respiratory illnesses, heart attacks and strokes. This in turn increases healthcare costs and leads to costs from reduced productivity and sickness leave.

At present, traffic and solid fuel burners for domestic heating are the main anthropogenic causes of air pollution in New Zealand cities, followed by industrial emissions.[70] Transport emissions are caused mostly by the total quantity of vehicle kilometres travelled (VKT) by petrol- or diesel-fuelled vehicles, and secondly by traffic behaviour, especially speed and congestion (Rohani and Kuschel, 2017). Exposure to these emissions, and hence health damages, is influenced by the location of stationary emissions sources and the location of major roads relative to human populations, as well as prevailing winds and natural barriers that affect how emissions spread.

In the long run, changes to technology, policy, and preferences, including the uptake of electric vehicles and changes to provision of public transport options, will also affect how transport demands translate into health impacts.

Urban areas contribute a significant proportion of New Zealand's total greenhouse gas emissions, primarily via carbon dioxide (CO_2) emissions from motor vehicles but also from emissions from heating buildings and industrial production in cities. Around half of NZ's total gross GHG emissions are from agriculture, and 40% are from energy, which is split roughly evenly between transport and electricity generation.[71]

Greenhouse gas emissions from transport are also influenced by the total quantity of VKT by petrol- or diesel-fuelled vehicles, and secondly by traffic behaviour. In the long run, electric vehicle uptake is likely to reduce greenhouse gas emissions from transport, especially if electricity is generated from renewable sources.

Urban development can also affect freshwater and coastal water quality through several mechanisms. Increasing the total amount of paved surfaces (eg for roads and parking lots) reduces natural water filtration and stormwater retention, leading to increased runoff of contaminants (eg heavy metals and motor oil) into streams and harbours.

[70] Sea spray and wind-blown dust also contributes to particulate concentrations, especially in coastal areas.
[71] http://www.mfe.govt.nz/climate-change/state-of-our-atmosphere-and-climate/new-zealands-greenhouse-gas-inventory

In areas with combined sewers and stormwater systems, increased runoff from paved / developed areas can raise the likelihood that untreated wastewater will be discharged into water bodies during heavy rainfalls.[72] Central suburbs in many New Zealand cities are prone to this issue, contributing to poor water quality in some inner-city beaches. Wastewater discharges can be reduced or avoided by upgrading and separating sewers and stormwater systems, albeit at a cost.

Increased runoff and discharges of contaminants can damage the quality of freshwater and coastal ecosystems and undermine these ecosystems' aesthetic and recreational value. For instance, the possibility of sewage outflows can make it unsafe to swim at many inner city beaches after heavy rainfalls.

16.2 Evidence on health impacts of air quality

How urban development can affect air quality

Air quality varies within cities, and hence people living in different places are likely to incur different health impacts. For instance, the HAPINZ model suggests that the population-weighted average PM_{10} concentration in Auckland was 15.4µg/m^3. The 10th percentile of PM_{10} concentration was 12.9µg/m^3, or approximately 16% less polluted than average, while the 90th percentile of PM_{10} concentration was 17.0µg/m^3, or approximately 11% more polluted than average. Because health impacts scale with pollutant levels, people's choice about where to live may affect their health.

As long as people are aware of air quality issues, they are likely to consider these effects when choosing where to live. For instance, Smith and Huang (1995) find evidence that poor air quality is reflected in lower property values. This suggests that the impact of existing poor air quality is largely internalised for residents, excluding any impacts on the public health system.

However, urban development that causes *changes* in air quality can result in external costs. In urban areas, the primary anthropogenic sources of PM_{10} are domestic fires and motor vehicles. As a result, urban development that results in an increase in use of domestic fires and woodburners due to the design of heating and insulation in new buildings, or an increase in total vehicle kilometres travelled by petrol and diesel vehicles may increase health costs of poor air quality.

Health impacts of air pollution

There is a large epidemiological literature that links air pollution to increased mortality and morbidity. According to the World Health Organisation, the four pollutants with strongest evidence for health impacts are:[73]

- Particulate matter (PM) accounts for the majority of health impacts. Chronic exposure to fine particles contributes to the risk of developing cardiovascular and respiratory diseases, as well as of lung cancer. According to the WHO, there may be no safe threshold for exposure as health damage has been observed even at low concentrations.
- Ozone (O_3) can cause breathing problems, trigger asthma, reduce lung function and cause lung diseases at high concentrations. It contributes to smog at ground level.
- Nitrogen dioxide (NO_2) can cause inflammation of the airways at high concentrations, and at low concentrations can contribute to the formation of fine particulates and ozone.
- Sulphur dioxide (SO_2) can can affect the respiratory system and the functions of the lungs, and causes irritation of the eyes. There is evidence that it contributes to cardiac disease and respiratory diseases.

[72] Combined sewers and stormwater systems typically pass through water treatment plants before being dicharged to the sea. During heavy rainfalls, treatment plants can overflow, leading to discharges of untreated sewage.
[73] https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

A number of meta-analyses systematically review the evidence on the health impacts of air pollution (Schwartz, 1994; Seaton et al, 1995; Stieb, Judek and Burnett, 2002; Shah et al, 2013; Atkinson et al, 2014; Lu et al, 2015). These confirm that there is a consistent relationship between poor air quality, particularly for PM and SO_2, and increased mortality and morbidity. Several meta-analyses highlight that this relationship is likely to be causal, as it is stable across different contexts and robust to the inclusion of controls for other confounding variables.

There is a smaller pool of epidemiological evidence on the health impacts of poor air quality in New Zealand, but the available studies are consistent with international evidence. Two studies in the early 2000s found 'strong and consistent' associations between increased daily levels of fine particulates, NO_2, and SO_2 and childhood hospital admissions, and 'significant associations' between daily levels of PM, NO_2, and carbon monoxide and adult cardiovascular hospital admissions, especially in the elderly (Barnett et al, 2005; Barnett et al, 2006).

While a number of pollutants can damage human health, attempts to model health impacts in New Zealand usually focus on PM_{10}, both because it has the strongest negative impacts on health and because it often coincides with other pollutants (Covec, 2015).

Trends in urban air quality

Regional councils monitor air quality at a number of urban sites to comply with the National Environmental Standards on Air Quality (NESAQ).[74] Monitoring data shows that urban air quality generally, although not always, complies with the NESAQ standard of an annual average PM10 concentration of no more than 20 µg/m^3. Moreover, most long-established sites show an improvement in air quality.

Table 25 summarises monitoring data at sites in Auckland, Wellington, and Canterbury. Air quality is improving (shown by an upward green arrow) at most sites, although PM_{10} levels remain considerably higher in Canterbury due to local weather patterns and high use of woodburners for winter heating.

[74] Available online at https://www.lawa.org.nz/explore-data/air-quality/

Table 25: PM_{10} trends and levels at selected urban air quality monitoring sites

Location	2016 annual average (µg/m^3)	10-year trend
Auckland		
Glen Eden	13	Static
Henderson	13	Improving
Pakuranga	15	Improving
Penrose	16	Improving
Pukekohe	12	Static
Takapuna	14	Improving
Wellington		
Central Lower Hutt	11	Improving
Central Upper Hutt	11	Improving
Masterton	14	Improving
Wainuiomata	11	Improving
Wellington inner city	11	No trend data
Canterbury		
Ashburton	18	Improving
Christchurch	19	Improving
Geraldine	17	Improving
Kaiapaoi	18	Improving
Rangiora	17	Improving
Timaru	21	Improving
Waimate	16	Improving

Source: https://www.lawa.org.nz/explore-data/canterbury-region/air-quality/

Air quality improvements in turn reflect economic and technological changes, such as the decline of 'smokestack' industries and improvements to vehicle emission performance, as well as regional and national policies to reduce emissions.

Studies of health and air quality in New Zealand

Several studies have attempted to estimate air pollution levels in New Zealand and estimate the resulting health impacts. The Health and Air Pollution in New Zealand (HAPINZ) study was initially undertaken in 2007 (Fisher et al, 2007) and subsequently updated to take account of new data and understanding of health effects (Kuschel et al, 2012).

HAPINZ provides data on:

- Estimated annual average levels of PM_{10} and $PM_{2.5}$ concentrations within each Census area unit in New Zealand, which provide an indication of long-term exposure to PM for people living in that area;
- Estimated sources of PM10 emissions in that area, broken down into natural sources (eg sea spray), domestic heating, motor vehicle use, industry, and outdoor burning;
- Estimated contribution of poor air quality to premature deaths and hospital emissions, based on epidemiological studies on the health impacts of long-term exposure to PM combined with Census data on area unit population (ie the number of people who are exposed); and
- The estimated social cost of increased mortality and morbidity, which is valued using value of statistical life (VOSL) parameters published by the Ministry of Transport.[75]

HAPINZ can be used to estimate changes in health costs resulting from changes in pollutant levels, eg due to an increase in transport emissions or industrial emissions, or changes to population levels in areas with poor air quality. It has been used as inputs to a national cost benefit analysis of air quality standards (eg NZIER, 2009; Covec, 2015).

Table 26 presents some sample outputs from the HAPINZ model, showing the estimated impact of current PM10 concentrations in the Auckland region. In total, HAPINZ estimates that PM10 exposure led to 614 premature deaths, 135 cardiac hospital admissions, and 268 respiratory hospital admissions, roughly half of which were among children under 15. It also led to over one million restricted activity days, eg sick days due to respiratory issues.

Based on assumptions about the social cost of premature deaths (VOSL), hospital admissions, and restricted activity days, HAPINZ estimated a total annual social cost of $2.25 billion from poor air quality.[76] However, half of these impacts were due to naturally-occurring PM_{10}, eg sea spray, rather than human-created sources. Anthropogenic sources were estimated to have a total annual cost of $1.07 billion, which is broken down as follows:

- Domestic fires: 38% of total health costs;
- Motor vehicles: 44%
- Industry: 7%
- Open burning: 11%.

Table 26: Estimated annual impacts of PM_{10} exposure in Auckland (Kuschel et al, 2012)

Health Effects	Health effects (cases)						Social cost ($million/annum)
	Domestic fires	Motor vehicles	Industry	Open burning	Natural	Total	
Mortality Adults 30+ yrs	112	126	22	31	321	611	2,176.8
Mortality Adults Maori 30+ yrs	18	20	3	5	51	97	346.6
Mortality Babies 0-1 yrs	0.6	0.6	0.1	0.2	1.6	3.0	10.6
Cardiac Hospital Admissions: All ages	25.7	28.2	3.8	7.2	70.0	134.9	0.9
Respiratory Hospital Admissions: All ages	50.4	57.0	7.6	14.9	138.2	268.1	1.2
Respiratory Hospital Admissions: Children 1-4 yrs	18.0	20.4	2.8	5.5	49.7	96.4	0.4
Respiratory Hospital Admissions: Children 5-14 yrs	10.4	11.4	1.5	3.1	28.6	55.0	0.2
Restricted Activity Days	191,587	214,982	30,814	55,322	534,339	1,027,045	63.7
TOTAL POPULATION 1,303,029	$ 411.8	$ 465.7	$ 79.0	$ 115.0	$ 1,181.6	$ 2,253.1	2,253.1

HAPINZ data can also be combined with emissions inventory data, which is available for some regions, to estimate the average social cost of additional emissions in each region.

Challenges in valuing health impacts of changes to air quality

[75] http://www.transport.govt.nz/assets/Import/Documents/UTCC20-Value-of-statistical-life.pdf
[76] Note that value of statistical life parameters have been updated since the HAPINZ study was completed.

Because long-term exposure to poor air quality has chronic effects on health, changes in exposure may have lagged effects. Even if all pollution is eliminated, it might take many years without pollution for the full benefits to be realised. For instance, if widespread uptake of electric vehicles in (say) a decade were to significantly reduce transport emissions, the health costs of present-day emissions would continue to be experienced.

As a result, most international studies now include a lagged benefit of reducing air pollution (or a lagged cost of increasing emissions). For instance, the US EPA advocates distributing benefits (or costs) over a 20 year window (US EPA, 2011).

There are also some conceptual challenges for valuing changes in premature deaths arising from pollution. As noted above, the HAPINZ study assigns a social cost to premature deaths using a standard value of statistical life parameter. However, this may be somewhat misleading when examining the impacts of policy that will incrementally change emission levels and concentrations (or exposure to poor air quality).

Where emissions are reduced, people may still die prematurely, and the same people may die prematurely, but not as prematurely; premature mortality is not so much reduced as is the prematurity of the mortality. These impacts may be better measured as a change in the number of life years, or a change in disability-adjusted life years. International studies have therefore used a value of life year (VOLY) approach rather than a VOSL approach (COMEAP, 2010; Defra et al, 2007; US EPA, 2011).

Covec (2015) compared these alternative approaches, finding that VOSL led to an estimate of emission reduction benefits that was six to 21 times higher than the VOLY approach.

16.3 Case study: Auckland's urban form and emissions from transport and home heating

Rohani and Kuschel (2017) estimate changes in the total social costs of poor air quality resulting from three alternative urban growth scenarios for Auckland out to 2046. They assess the impacts of these scenarios on the total quantity of emissions from motor vehicles and domestic fires, considering fine particulate matter, nitrous oxides, and carbon dioxide. Their estimates therefore focus on the external costs arising from different development patterns.

They used several models, including Auckland's strategic transport model, a vehicle emissions model, and a domestic fire emissions model, to estimate how each scenario would affect the volume of emissions. (Although it is unclear from the report how future uptake of electric vehicles has been taken into account.) For instance, Table 27 summarises estimated impacts on the total volume of vehicle travel in Auckland. Consistent with international evidence (summarised in a previous appendix), a more 'intensive' growth profile reduces vehicle kilometres travelled. As shown in Table 28, this also reduces the quantity of vehicle emissions.

Table 27: Impact of alternative growth scenarios on total annual vehicle kilometres travelled in 2046 (Rohani and Kuschel, 2017)

Scenario	Annual VKT (million)
I9 (Baseline)	10,087
Intensive growth	9,616
Expansive growth	10,940

Source: Auckland Transport model (ART3)

Table 28: Estimated transport emissions in 2046 for alternative growth scenarios (Rohani and Kuschel, 2017)

Pollutant	Vehicle type	Tonnes emitted in 2046 for each scenario		
		I9 (Baseline)	Intensive	Expansive
NOx	Total	3,381	3,282	3,548
	Car	1,410	1,349	1,517
	HCV	1,971	1,933	2,030
PM_{10}	Total	245	237	261
	Car	170	163	183
	HCV	75	74	77
CO_2	Total	1,806,703	1,746,171	1,923,615
	Car	1,300,513	1,249,699	1,402,418
	HCV	506,190	496,472	521,196

However, Rohani and Kuschel also find that an 'intensive' growth scenario would lead to higher overall health costs as more people are exposed to pollution in more densely populated areas. This is shown in Table 29. Conversely, the overall environmental impacts of greenhouse gas emissions would be lower in an 'intensive' scenario, as those effects are not localised.

Table 29: Total health cost ($ million, NZD 2017) from Auckland's transport emissions in 2046 (Rohani and Kuschel, 2017)

Pollutant	I9 (Baseline) scenario	Intensive scenario	Expansive scenario
PM_{10}	$56.68	$60.45	$52.16
NOx	$3.33	$3.66	$2.89
Total cost	$60.01	$64.11	$55.05

Rohani and Kuschel also analyse the impact of changes in domestic fires, taking into account development of new homes with woodburners and redevelopment of existing dwellings that will tend to remove old, emission-intensive woodburners and replace them with cleaner heat sources. They find that an 'intensive' scenario would result in lower health impacts due to faster removal of old woodburners in existing urban areas.

16.4 Evidence on greenhouse gas emission impacts

In addition to their localised impacts on air quality, petrol- or diesel-powered vehicles, domestic woodburners, and industrial activity also emit carbon dioxide (CO_2) and other greenhouse gases. Greenhouse gas emissions in turn contribute to climate change, which, if unabated, will cause widespread environmental, economic, and social damage.

The causes and consequences of climate change are well covered in reports from the International Panel on Climate Change (IPCC). In New Zealand, Ministry for the Environment data indicates that around half of New Zealand's gross greenhouse gas emissions are from agriculture, which is not directly affected by urban

development.[77] However, 40% of gross emissions are from energy, which is split roughly evenly between transport and electricity generation. If urban development affects transport behaviours or other categories of energy use, it may therefore increase or decrease transport emissions.

Some greenhouse gas emissions, including CO_2 emissions from petrol and diesel use, are included in New Zealand's Emissions Trading Scheme. This sets a price on emissions that is intended to internalise the damage they are expected to cause. However, the price currently falls below credible estimates of the damage of CO_2, meaning that there is an external cost that is not being attributed to the people who cause it.

Estimates of the social cost of carbon emissions vary. The NZ Transport Agency's *Economic Evaluation Manual* recommends valuing changes in carbon emissions at $70 per tonne of CO_2-equivalent (in 2018 NZD). Other research indicates that the cost of carbon emissions may be much higher. For instance, the Productivity Commission (2018) states that:

> *New Zealand's emissions price will need to rise to levels of the order of $75 a tonne of carbon dioxide equivalent (CO_2e) and possibly over $200 a tonne over the next few decades to achieve the domestic emissions reductions needed to meet New Zealand's international commitments.*

As a result, urban development that increases (or reduces) greenhouse gas emissions may result in some external costs (or benefits) for the global and national environment.

16.5 Evidence on reduced freshwater and coastal water quality

Urban development can also affect freshwater and coastal water quality by:

- Increasing the total amount of paved surfaces (eg roads and parking lots), which reduces natural water filtration and stormwater retention and increases runoff of contaminants (eg heavy metals and motor oil) into streams and harbours
- Increasing outflows of untreated stormwater into water bodies during heavy rainfalls in areas with combined sewers and stormwater systems
- Reducing the amount of water flowing back into natural water bodies and inhibiting their function as ecosystems.

Increased runoff and discharges of contaminants can damage the quality of freshwater and coastal ecosystems and undermine these ecosystems' aesthetic and recreational value. For instance, the possibility of sewage outflows can make it unsafe to swim at many inner city beaches after heavy rainfalls.

Urban development that increases runoff can also increase flooding risk for downstream areas.[78]

Well-designed infrastructure can mitigate many of these impacts. Our concern is therefore whether there are external effects on water quality that are not covered by the engineering costs of water infrastructure.

Impacts of urban runoff

[77] http://www.mfe.govt.nz/climate-change/state-of-our-atmosphere-and-climate/new-zealands-greenhouse-gas-inventory
[78] Tonkin + Taylor (2014) has developed a flood damage assessment methodology for Auckland Council with the aim of producing results that can be incorporated into a cost benefit analysis. The RiskScape model produced by NIWA and GNS Science has also been developed to estimate damage costs and is being used by a number of councils. The most common approach used to express flood risk is Average Annual Damage (AAD), which is the annual risk of flooding multiplied by the expected cost of damage to people, property and the environment.

Urban runoff can affect the health and condition of water bodies and the marine environment. In addition, measures to manage runoff through construction of stormwater infrastructure can also cause environmental damage.

In urbanised areas, surface runoff is usually captured by the stormwater system, which has the objective of moving the water rapidly away from houses and built areas. This can involve systems of pipes or the use of natural systems, including streams, rivers and ponds. Increasingly, developers and councils are attempting to incorporate 'green' infrastructure that can detain and retain stormwater within developments to reduce the amount of 'grey' infrastructure that must be built. This can include swales, detention ponds, and permeable paving as an alternative to hard concrete paving.

While urban runoff can be mitigated through design, urban development typically generates some level of damage to water quality, as discussed in the case study of the Lucas Creek catchment.

Table 30: Ecological impacts of stormwater runoff (Kelly, 2010)

Issue	Effect
Concrete-lined channels	Disconnected from the groundwater system, provide virtually no habitat function, and potentially impede fish migration
In-stream structures, e.g. culverts and weirs	Impair ecological function, impede the upstream migration of freshwater fish
More impervious surfaces	More frequent, larger and flashier floods that increase streambank erosion and reduce natural character
Higher stream temperatures	Results from lack of shade and hot impervious surfaces. It is harmful to temperature sensitive invertebrates and fish
Sediment runoff	Reduces water clarity, light levels, food quality, and the feeding efficiency of animals. Harmful to some fish species and can smother food supply. In the marine environment sediment can kill benthic macrofauna or lead to reduced species diversity and abundance; it can lead to increased mangroves and reduced extent of other habitats
Solid waste/plastics	Plastics kill marine species through ingestion and entanglement, and act as a vector for the transport of invasive organisms. Toxic additives which are used in the manufacture of some plastics, and organic contaminants which become concentrated on plastics, may also affect organisms that are intimately exposed to plastics
Heavy metals	Metal and organic contaminants accumulate in the tissues of shellfish, fish, birds and other invertebrates. They can compound the effects of other environmental stressors and differentially affect rare species and large species
Nutrient runoff	Mainly a concern from rural catchments and dairy farms.

Valuing impacts on freshwater quality

Kerr and Sharp (2003a, 2003b, 2008) have examined the value that Auckland households place on freshwater quality. They survey households about their 'willingness to accept' values for reductions in the ecological value

of Auckland streams. The resulting figures reflect the 'existence value' that Aucklanders assign to freshwater streams, and may not capture recreational values such as swimming and fishing.

Table 31 summarises their estimates of the external costs that Auckland households perceive from reductions in freshwater quality, as well as confidence intervals for these values. Summing up across all categories suggests that people perceive a cost of around $239 per annum as a result of a stream changing from high ecological value to degraded quality.

In principle, these results could be applied to value changes in freshwater quality. However, it is not clear how widely the external costs of poor freshwater quality are spread. For instance, do households ten kilometres away from a stream perceive changes in water quality in the same way as households living near the stream? Similarly, it is not clear how much variation there is value that different groups place on freshwater quality.

On that point, we note that the Ministry for the Environment has constructed a Cultural Health Index for water bodies. This index allows Maori to assess the cultural and biological health of a stream or catchment, and then communicate this information to water managers in a way that can be understood and integrated into resource management processes (Tipa and Teirney, 2006). Participatory tools like this may further illuminate differences in how different groups and individuals perceive water quality issues.

Table 31: Components of existence value for Auckland urban streams (Kerr and Sharp, 2008)

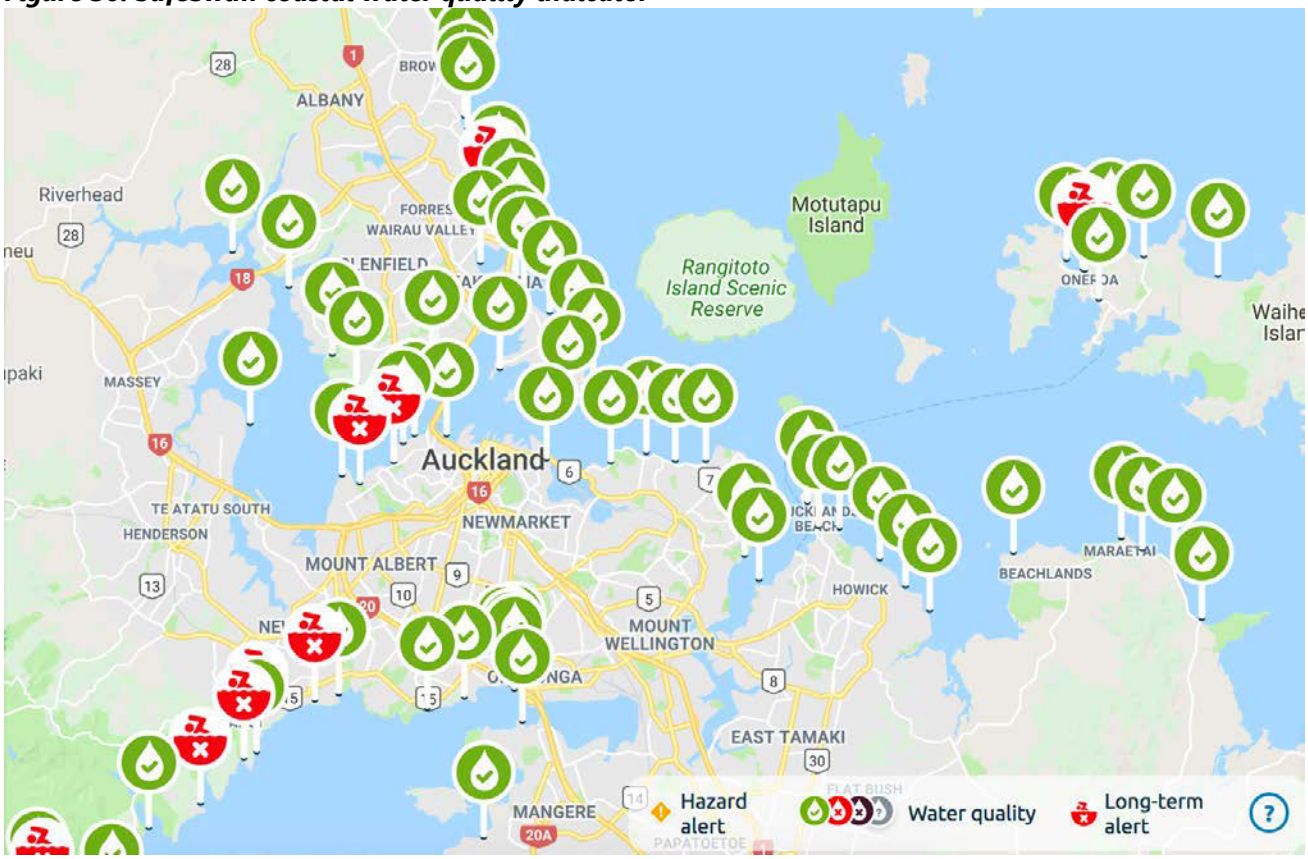
Attribute	**Change in attribute**	**Annual value per household (2003 NZD)**
Water clarity	Clear to muddy (or low visibility)	$79 ($53 - $148)
Native fish	One fewer species	$14 ($8 - $27)
Vegetation	Moderate to little or no vegetation High to moderate vegetation	$42 ($1 - $115) $35 ($13 - $81)
Stream channel	Stream channel from straight to natural form	$69 ($44 - $126)
Total (estimated)	Change from high ecological value to degraded	$239 ($119 - $497)

Valuing coastal water quality

The coastal and marine environment is affected by the quality of the water entering it, particularly the presence of heavy metals, sediment, faecal matter and gross pollutants. Batstone et al (2008) note that many studies show that urban stormwater is contaminating urban estuaries with heavy metals, as well as persistent organic pollutants such as hydrocarbons, dichloro-diphenyl-trichloroethane (DDTs) and polychlorinated biphenyls (PCBs). They also noted the potential for bio-accumulation in marine organisms and for accumulation in sediments, and that sediment itself was a contaminant.

This can lead to damage to marine ecosystems as well as diminishing the cultural, recreational and aesthetic opportunities that the coastal environment offers. Damage to recreational opportunities has been highlighted by coastal water quality data that regional councils are now publishing. For instance, in Auckland the SafeSwim website provides real-time information on whether urban beaches are safe for swimming (eg due to faecal contamination), raising awareness and concern about urban water quality.

Figure 30: SafeSwim coastal water quality indicator



Source: https://safeswim.org.nz/, accessed 25 January 2018

There are a range of international studies of willingness to pay for environmental services provided by coastal and marine environments. Liu and Stern (2008) undertake a meta-analysis of 39 contingent valuation studies. Locally, Batstone et al (2010) study willingness to pay for improvements to the coastal and marine environment in different parts of the Waitemata Harbour. Their results indicate Auckland residents' willingness to pay for improvements relative to low quality environments. They distinguish between upper harbour areas, middle harbour areas, and outer harbour areas, which include most of central Auckland's urban beaches, and examine three outcomes (ecological health, water quality, and underfoot conditions).

Table 32 summarises their results. For instance, average willingness to pay for water quality improvements from low quality to high quality was $275 per annum in outer harbour areas (in 2010 NZD), $87 in middle harbour areas, and $99 in upper harbour areas. Willingness to pay is lower, although still substantial, for improvements in ecological health and underfoot conditions.

Batstone et al also investigate heterogeneity in willingness to pay between respondents, including between different locations. For instance, they find that people in north Auckland tended to have higher willingness to pay for coastal water quality, but that this difference was not statistically significant.

These results highlight the value that Aucklanders place on having better coastal water quality, as well as potential heterogeneity between outcomes in different places or values perceived by different people.

Table 32: Aucklanders' willingness to pay for improvements to coastal and marine environments (Batstone et al, 2010)

Model	Estimated Coefficient	WTP Estimate[1]	Z (WTP)
Constant	-0.1726	NA	
OTEM = Outer Ecological Health (Med)	0.5225	$ 135.64	8.69
OTEH = Outer Ecological Health (High)	0.6989	$ 181.45	9.15
OTWM = Outer Water Quality (Med)	0.7297	$ 189.45	9.55
OTWH = Outer Water Quality (High)	1.0591	$ 274.96	8.08
OTUM = Outer Underfoot Conditions (Med)	0.4470	$ 116.05	8.62
OTUH = Outer Underfoot Conditions (High)	0.6507	$ 168.94	6.72
MEM = Middle Ecological Health (Med)	0.3268	$ 84.83	7.42
MEH = Middle Ecological Health (High)	0.4254	$ 110.45	4.49
MWM= Middle Water Quality (Med)	0.1817	$ 47.18	6.74
MWH= Middle Water Quality (High)	0.3347	$ 86.90	5.06
MUM = Middle Underfoot Conditions (Med)	0.2166	$ 56.22	5.20
MUH = Middle Underfoot Conditions (High)	0.2234	$ 57.99	5.92
UPEM = Upper Ecological Health (Med)	0.2450	$ 63.60	6.95
UPEH = Upper Ecological Health (High)	0.3197	$ 83.00	4.15
UPWM= Upper Water Quality (Med)	0.1578	$ 40.98	7.48
UPWH= Upper Water Quality (High)	0.3819	$ 99.16	4.80
UPUM = Upper Underfoot Conditions (Med)	0.1962	$ 50.94	4.95
UPUH = Upper Underfoot Conditions (High)	0.2207	$ 57.31	8.30
Cost = Additional annual household cost	-0.0039		

Willingness to pay studies may not capture all of the values arising from the quality of coastal and marine environments. Van den Belt and Cole (2014) undertook a more comprehensive assessment of the value of ecosystem services provided by seven marine ecosystems that currently have different legal protection and management arrangements, including two near urban environments in Whangārei and Christchurch. They use benefit transfer methods to assess a wider range of ecosystem service values generated by these areas.

16.6 Case study: Urban water quality modelling

Lucas Creek Catchment Case Study

The Lucas Creek Catchment Case Study was commissioned by the Ministry for Primary Industries to understand how the National Policy Statement for Freshwater Management (NPS-FM) could maintain or improve freshwater in a catchment undergoing urban development. A particular focus of the study was to assess the costs effectiveness of different methods to meet the NPS-FM (Moores et al, 2016).

The case study modelled changes in contaminants and water quality for five future urban development scenarios in the Lucas Creek catchment in the upper Waitemata Harbour near Albany. The *Urban Planning that Sustains Waterbodies Decision Support System* (UPSW DSS), which produces economic, environmental and social/cultural indicators for urban water, was used as a modelling tool.

The Lucas Creek study found that under all development scenarios, the environmental quality of the estuary will decline as contaminates accumulate. It then examines costs to mitigate water quality degradation, finding that:

- The 50-year life cycle costs of contaminant mitigation are *lower* in sub-catchments that are already partially developed and mitigated, compared to the mitigation costs of greenfield development.
- Life cycle costs are lower in high density greenfield developments compared to low density greenfield developments.

This suggests that although urban development tends to damage water quality, further development in existing urban areas or greenfield development at higher densities can reduce this damage.

The Lucas Creek study found that the total lifecycle costs to deliver improvements in water quality and macroinvertebrate indicator scores in both sub-catchments vary between $45.2 million and $323.4 million, or between $3,900 and $19,700 per dwelling. These reflect lifecycle costs discounted over 50 years at an 8% discount rate. Partial brownfields redevelopment was at the lower end of these costs while full, low density, new greenfield development had the highest costs. Using existing infrastructure more intensively with higher density development could be a cost effective way to minimise water quality damage.

The Lucas Creek study did not assess the benefits of investment in mitigation, eg by comparing mitigation costs against households' willingness to pay for water quality improvements. Hence we emphasise that these expenditures will generate offsetting benefits.

Pauraque Inlet Case Study

The UPSW DSS tool was also used in an earlier 2013 case study to assess the impacts of future urban development within the Pahurehure Inlet near Papakura (Cameron et al, 2013). This was done to assess options for Auckland's Southern Rural Urban Boundary as part of the Auckland Unitary Plan. Seven urban development and water treatment scenarios were assessed for their impact on water ecology over a 50-year horizon.

The Pahurehure Inlet study found that water quality would deteriorate with or without new development, reflecting the ongoing impact of existing development and rural land uses. Although existing urban and rural development affects water quality, avoiding increasing future damage is still important.

In order for new development to occur without further reducing water quality, the best available stormwater and earthwork controls would be needed. Current rules would further compound existing environmental damage. Damage to estuaries can also be minimised by focusing development in a few catchments rather than spreading it across multiple catchments.

16.7 How these effects can be measured and valued

Based on the above evidence and case studies, the following approach could be used to measure and value the external costs of urban growth that arise principally with respect to air and water quality.

Measurement

- The HAPINZ model can be used to measure existing air quality. This model can be loosely coupled with land use, transport, and household energy modelling or scenarios to estimate the impact of new urban development on air quality and hence health effects.
- Strategic transport modelling plus assumptions about vehicle emissions can be used to estimate impact of urban development on transport emissions. Scenarios should be constructed to estimate impacts of changes to domestic fires.
- The Towards a Sustainable Urban Form (TOTUS) model developed by NIWA could also be used to assess the air quality impacts of broad changes to urban form.
- A similar approach could be adopted for greenhouse gas emissions, as many of the sources of greenhouse gas emissions (vehicles and home heating) are the same.

- The Urban Planning that Sustains Waterbodies Decision Support System (UPSW DSS) can be used to assess the impact of new urban development on water quality. Inputs to the model include land use change scenarios, stormwater management and mana whenua interests. The outputs include a range of economic, environment, social and cultural indicators for water quality based on different urban development scenarios. This model was used to predict the changes to the water bodies in Auckland's Lucas Creek and Southern Rural Boundary (Moore et al, 2016; Cameron et al, 2013).

Valuation

- HAPINZ model assumptions can be used to value health impacts of changes to air quality relative to baseline. Alternative assumptions about the social cost of health damages (VOSL versus VOLY) should also be considered.
- Assumptions about social cost of GHG emissions should be applied. NZTA EEM recommends a social cost of $70 per tonne (in 2018 NZD); other sources cite higher figures that should be tested.
- To value changes in freshwater and coastal water quality, willingness to pay values from existing Auckland-specific stated preference surveys could be applied (Kerr and Sharp, 2003a, 2003b, 2008; Batstone et al, 2010). However, the transferability and relevance of these studies is unclear and should be explored further.
- Due to the fact that some environmental impacts, eg on biodiversity and long-run sustainability of ecosystems, are unlikely to be perceived by humans, a natural capital accounting approach should also be considered for freshwater and coastal water quality.

17 Appendix 10: Social and cultural effects

17.1 How these effects arise

We identify the following categories of costs / benefits of urban development that arise principally with respect to social and cultural effects:

- Health impacts of changes to transport behaviour: Urban development in car-dependent locations can contribute to increased road crashes and reduced physical activity levels that in turn contribute to obesity and other 'diseases of inactivity'.
- Mental health impacts of the built environment: Researchers have posited that the design of buildings and neighbourhoods can affect mental health. Some research finds negative impacts from low-density areas where people have little incidental human contact, while other studies find negative impacts from high-density housing.
- Impacts on social capital, trust, and community cohesion: Some evidence suggests that the form of urban development can affect social capital and trust, as well as measurable outcomes such as crime. It may also affect cultural identify, eg by enhancing or detracting from people's ability to realise and express their identity.
- Impacts of modifying places with cultural significance: Urban development can affect people's cultural identity and connection to places by modifying or demolishing historic buildings, historic places, or sites and places with historical or cultural significance.

For the most part, these effects are hypothesised to arise due to the design of urban development, rather than its location. However, location may be important for conditioning some effects, eg if it influences people's transport behaviours or if specific locations have cultural or historical significance.

17.2 Evidence on health impacts of changes to transport behaviour

The location and form of urban development can affect residents' transport behaviours. In the appendix on transport network effects, we reviewed evidence on the impact of urban form on transport behaviours. In general, compact, transit-oriented development tends to increase use of public transport and walking, while dispersed, low-density development tends to increase car use. Ewing and Cervero (2010) note that these differences largely reflect 'place' effects rather than the sorting of people with different preferences into locations that match those preferences. However, transport behaviour is inelastic to individual urban form variables.

The external infrastructure costs and transport network effects of urban development have been addressed in previous appendices. This section explores the health impacts of differing urban development patterns, many of which also arise from changes to transport behaviours.

There are three primary ways in which transport behaviours can affect human health. First, walking or cycling more can improve people's health and lead to reductions in chronic diseases such as diabetes and obesity, and vice versa (Genter et al, 2008; Oja et al, 2011). Second, changes to vehicle kilometres travelled can increase the risk of road crashes, which often affect third parties, including pedestrians and cyclists. A third mechanism, the health impacts of air pollution, has already been discussed in the appendix on air and water quality impacts.

Health impacts are partly internalised and partly external in nature. On one hand, people may accept that physical inactivity will damage their health, or accept a certain crash risk when choosing to drive.

On the other, individuals may not understand the long-run health impacts of transport behaviours when choosing a place to live. For example, Stutzer and Frey (2008) find that when people change their home or job location and end up commuting longer distances, it reduces their self-reported wellbeing. The costs of poor health or road crashes are also felt externally by friends and family and are borne across society in the form of public health costs.

Urban form, physical activity, and health

A number of studies find a negative relationship between dispersed development and residents' physical health. In part, this appears to reflect lower rates of walking in lower-density environments or less walkable environments (Ewing and Cervero, 2010).

Pucher et al (2010) find a consistent association between higher rates of walking and cycling and lower rates of obesity and diabetes at the country level and at the state and city level in the United States. A 2014 study of the US compared health outcomes with urban form for two different metrics for urban sprawl. Both measures were correlated to higher body mass index, obesity, heart disease, high blood pressure, and diabetes (Ewing, Meakins, Hamidi, and Nelson, 2014). Surveys of roughly 100,000 US women in 2000 and 2001 found residents of less dense and compact environments (measured by a county sprawl index) averaged a higher body mass index and lower levels of physical activity (James et al, 2013). An American-Canadian study found people in more walkable environments are 2.4 times more likely to achieve minimum levels of moderate activity than residents of the most sprawling areas (Frank and Engelke, 2005).

A 2018 study of the US found that overall life expectancy was significantly lower in less compact areas. This likely results from a combination of factors related to sprawl – including worse physical health and reduced traffic safety (Hamidi, Ewing, Tatalovich, Grace, and Berrigan, 2018).

In New Zealand, Shaw et al (2018) quantify the health impacts of different cities' urban form and transport infrastructure provision. We discuss this case study further below.

The costs of physical inactivity in New Zealand

Auckland currently experiences a range of poor health outcomes as a result of diseases of inactivity. Market Economics (2013) estimated that physical inactivity caused the premature death of 246 New Zealanders in 2009. This reflects the fact that many New Zealanders that are not physically active on a regular basis. At a national level, the 2015/16 New Zealand Health Survey found that only 47.7% of adults were physically active (doing at least 30 minutes of exercise at least five days a week).[79] Only 45.8% of children usually use active transport (walk, bike, skate, or similar) to travel to school.

New Zealanders have high levels of physical inactivity compared to other countries. Lee et al (2012) find that New Zealand was the 27th least-active country out of a total of 122 countries studied. As a result, physical inactivity makes a larger-than-average contribution to health outcomes, accounting for an estimated 18.3% of overall mortality, compared with 14.2% of overall mortality in the median country and 13.4% in the median European country.

Health outcomes associated with physical inactivity vary within cities. This appears to reflect socioeconomic factors as well as different opportunities to walk or cycle for transport in different locations. While obesity rates are an imperfect proxy for physical inactivity, they provide a rough indication of variations between areas. Table 33 summarises estimated obesity rates for the three Auckland DHBs and compares them to national averages

[79] https://minhealthnz.shinyapps.io/nz-health-survey-2015-16-annual-update/

using data from the 2011-2014 New Zealand Health Survey.[80] Confidence intervals are reported in parentheses. This shows that although obesity rates are lower than the national average for both children and adults in the Waitemata and Auckland DHB areas (covering the North Shore, West Auckland, and the Auckland Isthmus), they are substantially higher than the national average in the Counties Manukau DHB area.

Table 33: Obesity rates in Auckland (New Zealand Health Survey, 2011-2014)

DHB	Obesity rate for adults	Obesity rate for children
Waitemata	24.3 (21.9-26.8)	7.1 (5.3-9.6)
Auckland	21.8 (19.7-24.0)	8.8 (6.6-11.8)
Counties Manukau	37.7 (34.6-40.9)	17.7 (14.3-21.7)
New Zealand total	29.7 (29.0-30.4)	10.4 (9.5-11.3)

The NZ Transport Agency's *Economic Evaluation Manual* recognises the health impacts of changes to walking and cycling activity as a result of new transport facilities. It suggests health benefit values of $1.52 per additional kilometre cycled and $3.04 per additional kilometre walked (in 2017 NZD). These values reflect the internalised and external benefits of improved health outcomes that arise from additional physical activity.

Urban form and road crash risk

The location and form of urban development can also affect the total volume of vehicle kilometres travelled (Ewing and Cervero, 2010). There is also some evidence, in US cities, that traffic speeds are higher in lower-density environments (Couture, Duranton and Turner, 2016). Both factors can in turn influence the number of road crashes.

Following this theory, several studies find urban sprawl is associated with higher levels of traffic fatalities (Yeo, Park, & Jang, 2014; Ewing, Pendall, and Chen, 2002). One study found urban sprawl itself is a better predictor of traffic fatalities than vehicle kilometres travelled (VKT), suggesting other traffic features enabled by sprawl – such as increased traffic speed – are more influential to traffic safety than VKT (Yeo, Park, & Jang, 2014). A 2003 study of 448 US counties in the largest 101 metropolitan areas found that less compact development was associated with higher pedestrian fatalities (Ewing, Schieber, and Zegeer, 2003).

The costs of road safety in New Zealand

New Zealand has poor road safety outcomes relative to comparator countries. Figure 31 summarises overall road fatality rates in developed countries. In 2013, New Zealand had 6.3 road fatalities per billion vehicle-kilometres, compared with 3.9 in Denmark, 3.5 in the United Kingdom, and 3.4 in Sweden. Notably, countries that had better overall road safety outcomes also tended to have better safety outcomes for vulnerable users, such as cyclists (Cycle Safety Panel, 2014).

[80] http://www.health.govt.nz/publication/regional-results-2011-2014-new-zealand-health-survey

Figure 31: Road fatalities per billion vehicle-kilometres, 2013

Note: Provisional data for Australia, Canada, Ireland, Lithuania and the United States. 2012 data for the Czech Republic.

Source: International Transport Forum, https://www.itf-oecd.org/sites/default/files/docs/15irtad_summary.pdf

According to Ministry of Transport data, the number of road deaths and serious injuries has risen significantly since 2013. In the year ended December 2018, 379 people died on the roads, and over 14,000 were injured.[81] In 2017, when there were a similar number of fatal crashes, the Ministry of Transport estimated that the total social cost of road crashes was $4.17 billion, including monetary impacts like healthcare costs and disability payments and non-monetary impacts on quality of life.[82]

In a recent econometric analysis, Best and Burke (2018) find that lower fuel prices lead to increases in road crashes, and vice versa. They suggest that around half of the recent increase in road crashes can be explained by falling fuel prices, which can increase distances travelled and speed of travel. However, fuel prices had a stronger impact on rural crashes than urban crashes, which suggests that 'open road' speeds play an important role.

Finally, we note that although the distance travelled by car influences road crash outcomes, road design and speed management can moderate or even reverse this relationship.

17.3 Case study: Health impacts of transport patterns in NZ cities

A recent study from the New Zealand Medical Association Journal attempts to quantify opportunities to improve health outcomes and greenhouse gas emissions in NZ's largest cities (Shaw et al, 2018). It benchmarks cities against Wellington City, which currently has the highest rate of travel by walking, cycling and public transport, with 35% of trips taken on these modes.

The study adapted the Integrated Transport and Health Impacts Model (ITHIM) developed at Cambridge University for New Zealand, and used it to assess the connections between health costs and transport patterns. Using the World Health Organization's comparative risk assessment methodology, the model uses known relationships between physical activity, air pollution ($PM_{2.5}$) and road injury and various diseases. Different levels of private motor vehicle use, public transport and active transport and used to assess the change in disease burden on different age groups and gender. Changes in carbon dioxide emissions are also estimated based on changes in vehicle kilometres travelled.

[81] http://www.transport.govt.nz/assets/Uploads/0585ae9f7f/2018-12-December.pdf
[82] http://www.transport.govt.nz/mot-resources/road-safety-resources/roadcrashstatistics/social-cost-of-road-crashes-and-injuries/

Shaw et al focuses on a limited set of health and environmental indicators rather than attempting to comprehensively value the benefits and costs that people obtain from transport options. The health impacts associated with physical activity, air pollution and road injury are combined to estimate changes in premature deaths, years of life lost (YLL), years of life lived with disability (YLD), and disability adjusted life years (DALY). Changes in greenhouse gas emissions from transport were also reported.

A limitation of this model is that it uses aggregate data on city transport outcomes and health and environmental outcomes, rather than modelling specific features of urban development that contribute to transport outcomes.

Baseline information

Table 34 shows the baseline information and existing differences for each of the cities assessed. Wellington is the reference city, with the highest share of trips taken by walking (27.5%) and public transport (6.2%).

Table 34: Baseline information and existing differences for each city (Source, Shaw et al, 2018)

	Population[a]	House-holds with two or more vehicles (%)[a]	Trips walking (annual %)[b]	Trips cycling (annual %)[b]	Trips by public transport (annual %)[b]	$PM_{2.5}$ (annual mean mcg/m³)[c]	Light vehicle CO_2 emissions (tonnes/ year)[d]	Transport-related injury (annual deaths (DALYs))[e]
Auckland City	1,493,210	55	16.1	0.5	3.3	4.8	2,150,000	146 (8,407)
Tauranga City	119,830	51	14.1	2.1	1.3	5.1	190,000	12 (611)
Hamilton City	150,180	49	13.8	1.2	1.9	6.3	253,000	15 (878)
Wellington City	197,460	36	27.5	1.3	6.2	3.5	227,000	20 (1,184)
Christchurch City	356,750	53	18.9	3.1	3.3	11.3	447,000	37 (2,028)
Dunedin City	123,540	46	23.5	1.3	1.4	7.5	153,000	13 (737)

Sources: [a]Statistics New Zealand, Census of Population and Dwellings 2013, [b]Ministry of Transport, New Zealand Household Travel Survey 2008–2014, [c]NIWA, [d]Ministry of Transport, The New Zealand 2015 Vehicle Fleet: Data Spreadsheet, [e]adapted from Institute of Health Metrics and Evaluation, Global Burden of Disease study, 2013.

Key findings

As shown in Table 2 below, all cities would be healthier if they had the same transport mode share pattern as Wellington. Auckland and Hamilton would experience a reduction of 57 and 52 premature deaths per annum, respectively. A total of 203 premature deaths could be avoided across all five cities, and 4,268 years of healthy life could be preserved (DALY) each year.

In most cities, fewer diseases due to increased physical exercise were responsible for most of the health gains. For Auckland especially, avoided injury also contributed to improved health due to the large reduction in vehicle travel.

Existing levels of active transport and population determine how much each city can benefit from shifting towards a Wellington transport mode. For example, Dunedin's small population and high current levels of walking avoids 13 deaths each year compared to 57 avoided deaths in Auckland where car trips dominate.

Table 2: Improvements in annual health and $C0_2$ transport emissions if each city had the same transport patterns as Wellington (Source, Shaw et al, 2018)

		Physical activity	Injury	Air pollution	Total
Auckland	Premature deaths	-41.2	-15.1	-1.0	-57.3
	YLL	-534.8	-764.0	-12.8	-1,311.6
	YLD	-169.1	-102.0	0.0	-271.2
	DALYs	-703.9	-866.0	-12.9	-1,582.8
	Light vehicle CO_2 emission change tonnes/year (% reduction from baseline)	-	-	-	-433,778 (-20)
Tauranga	Premature deaths	-46.5	-1.8	-1.3	-49.7
	YLL	-599.6	-81.7	-17.5	-698.8
	YLD	-183.8	-16.8	-0.1	-200.6
	DALYs	-783.4	-98.5	-17.5	-899.4
	Light vehicle CO_2 emission change tonnes/year (% reduction from baseline)	-	-	-	-52,210 (-27)
Hamilton	Premature deaths	-47.2	-2.9	-1.5	-51.7
	YLL	-620.9	-148.1	-20.1	-789.1
	YLD	-195.8	-21.5	-0.1	-217.4
	DALYs	-816.7	-169.6	-20.2	-1,006.5
	Light vehicle CO_2 emission change tonnes/year (% reduction from baseline)	-	-	-	-79,960 (-32)
Wellington	Reference	-	-	-	-
Christchurch	Premature deaths	-29.1	-1.5	-0.4	-31.0
	YLL	-298.8	-79.3	-5.3	-383.4
	YLD	-95.1	-16.4	0.0	-111.5
	DALYs	-393.9	-95.8	-5.3	-495.0
	Light vehicle CO_2 emission change tonnes/year (% reduction from baseline)	-	-	-	-36,789 (-8)
Dunedin	Premature deaths	-12.3	-0.4	-0.3	-13.1
	YLL	-193.3	-20.9	-4.4	-218.6
	YLD	-63.4	-2.2	0.0	-65.6
	DALYs	-256.7	-23.1	-4.4	-284.2
	Light vehicle CO_2 emission change tonnes/year (% reduction from baseline)	-	-	-	-10,395 (-7)

17.4 Evidence on mental health impacts of urban form

The location and form of urban development has also been posited to affect people's mental health, eg risk of depression.

The relationship between sprawling development and mental health is complex and there is no consensus on which factors matter the most. Some studies find that high-density housing, which increases contact and proximity, harms mental health, while others find that dispersed low-density development, which makes incidental human contact harder, harms mental health.

A 2004 study of the US found that sprawl significantly predicts chronic medical conditions but not mental health disorders (Sturm and Cohen, 2004). A 2018 study of 44,388 residents of the Seville metropolitan area found inhabitants of areas with lower sprawl had *greatest* risk of mental health problems, followed by residents of high-sprawl areas and finally by medium-sprawl areas. The authors suggest that this may be due to the presence of confounding factors that also affect mental health, such as job status (Garrido-Cumbrera, Marco, Braçe, and Lara, 2018). Overall, research has found people living in urban environments have been found to have a higher risk of developing mental disorders than people living in rural locations (Peen, Schoevers, Beekman, and Dekker, 2009).

Other studies have found that lifestyle features related to life in a sprawling environment can be detrimental to mental health. A study for Hewlett-Packard found peak-hour drivers suffered worse stress than fighter pilots or riot police facing mobs of angry protestors (p.185). An American study found that the longer people's commute, the more likely they were to report chronic pain, high cholesterol and general unhappiness. By contrast, people who walk and cycle feel more freedom, ease, joy and connection to the world when they commute. In the Netherlands, cyclists are the happiest people on the road (Montgomery 2013).

In line with these findings, Stutzer and Frey (2008) find that when people switch to longer commutes, eg due to a change in job or work location, they appear to experience lower wellbeing as a result. These effects are robust to self-selection issues and suggest that people may underestimate the subjective costs of travel time.

A study from northern Italy found a dense urban structure and accessibility to public transport could contribute to reduced risk of depression by increasing opportunities for an active social life, especially for women and the elderly (Garrido-Cumbrera, Marco, Braçe, and Lara, 2018).

Overall, this evidence suggests that the form and location of urban development may affect mental health, but it is inconclusive about which factors play the most significant role.

17.5 Impacts on social capital, trust, and community cohesion

The location and form of urban development has also been hypothesised to affect social capital formation, levels of trust, and community cohesion. This can in turn lead to further positive or negative effects, such as increased (or reduced) crime, or political instability due to disengagement from democratic politics.

The Treasury's Living Standards Framework identified several indicators of social capital including pro-social behaviour, pro-social norms, feelings of unity, and institutional trust. Higher levels of social capital and connectedness can improve outcomes for families, friends, and communities (Montgomery, 2013).

Analysis of data from the New Zealand General Social Survey suggests that people place a high value on social capital and cultural identity. The Treasury's CBAx tool uses this data to estimate the equivalent monetary value for a variety of outcomes, including the ones summarised in Table 35. For instance, being gaining a friend is estimated to lead to a similar increase in wellbeing as an $592 increase in annual income, while joining a club is similar to a $2,536 increase in annual income.

Table 35: CBAx proxy values for various social and cultural outcomes

Outcome	Value (2019 NZD)	Unit
Physical health for every 1 point change (improvement) (0-100 scale)	$1,158	Per year
Having access to general help for every 1 point change (0-4 scale)	$5,805	Per year
Being able to express cultural identity for every 1 point change (0-4 scale)	$9,563	Per year
Feeling lonely for every 1 point change (increase) (0-4 scale)	-$17,633	Per year
Gaining a friend (for every friend gained)	$592	Per year
Having contact with neighbours for every 1 point change (0-4 scale)	$8,572	Per year
Being a member of a club (per membership)	$2,536	Per year

Source: *https://treasury.govt.nz/information-and-services/state-sector-leadership/investment-management/plan-investment-choices/cost-benefit-analysis-including-public-sector-discount-rates/treasurys-cbax-tool*

However, there can also be a dark side to social capital. For instance, Satyanath, Voigtländer and Voth (2017) find that denser social networks in politically unstable German states were associated with higher rates of entry to the Nazi Party in the 1920s and 1930s. They suggest that clubs and societies – ranging from veteran associations to animal breeders, chess clubs and choirs – provided a vector for spreading and normalising Nazism.

Urban form and social capital

Researchers and planners have sometimes linked low-density, dispersed development with lower levels of social capital and increased isolation. Sociologist Robert Putnam's well-known 2001 book *Bowling Alone* documents increasing social isolation in the US alongside increasing suburbanisation. He found the average American in 1995 had three people they in whom they could confide. In 2004, it was two (Montgomery, 2013). About 50% of the American population say they have no one or just one person, including family, to whom they can confide.

Different studies have obtained contrasting results. A study of social interaction potential across 42 US metropolitan areas found social interaction is hampered by decentralization, fragmentation, and longer commutes in the largest metropolitan regions in the country (Farber et al, 2013). By contrast, a study that used US data from 2003 to 2013 found no meaningful difference in suburbanites' and city dwellers' time spent socializing (Morris and Pfeiffer, 2017).

Like low-density suburbs, high-density neighbourhoods can also create conditions for social isolation. Ivory et al (2012) created the New Zealand Index of Neighbourhood Social Fragmentation and found that inner-city areas of Wellington and other cities were more likely to be ranked as the most fragmented. Canadian research found that people living in Vancouver's central tower blocks to be less trusting, less connected and less happy than those living in other parts of the city, especially those who live on the ground. Montgomery (2013) states that part of the problem is the short tenure of residents (eg foreign students) in the tower blocks, which limits enduring social connections. High-density areas may also attract significant foot and car traffic from other areas, decreasing the time individuals spend in their front yard and potentially reducing interaction with neighbours (Wood et al., 2010).

Mazumdar et al's (2017) review of research on the built environment and social capital highlights their complex, sometimes ambiguous relationship. It surveyed 23 studies with a combined total of 90,002 participants from seven countries. The following table summarises the relationships found between various measures of

neighbourhood cohesion (collective efficacy, neighbourhood attachment, social capital, and social cohesion) and elements of urban form.

Table 36: Relationships between social capital and built environment variables (Mazumdar et al, 2017)

	Density	Design	Destination	Diversity	Overall relationship
Collective efficacy			↑	↑	↑
Neighborhood attachment	↓	↑	↑	↑	↑
Social capital	↓	↑	↑	↑	↑
Social cohesion	↓	↑	▲	↑	▲
Overall relationship	↓	▲	▲	↑	▲

Note. SC-BE = social capital-built environment.
↓ = negative nonsignificant relationship.
↑ = positive nonsignificant relationship.
▲ = positive significant relationship.

The study found conflicting results in some areas. It found that density was negatively correlated with measures of neighbourhood cohesion, though the relationship was not significant or consistent.

Neighbourhood design – which can consist of many features – is positively and significantly correlated to measures of neighbourhood cohesion. Montgomery (2013) argues that the best social environments are those were people are free to edge closer or move apart as desired. Too much crowding pushes people together physically but apart socially as people withdrawal as a coping strategy from over stimulation. If enough people withdrawal, a reclusive social norm is established. There may be a 'sweet spot' that balances the human need for privacy, conviviality, convenience and nature.

Other research has linked some specific urban design features to social isolation. Noisy, dangerous, high-traffic streets cause people to engage less with each other, end conservations sooner, and generally become less patient, helpful and social (Montgomery 2013). Parking in garages also reduces people's social interactions by keeping people from the street. People move directly from their home to their destination without interacting with others or businesses. This "garage effect" dampens street life for residents and businesses. Montgomery observes that "the further away the parking, the livelier the street".

Lastly, some research has found a clear relationship between mixed-use, walkable neighbourhoods and higher social capital, neighbourhood political participation, and neighbourhood trust (Leyden, 2003; Rogers et al, 2012; Rogers, 2011). While it is often associated with density, walkability is a distinct feature that is also influenced by street network design.

Home ownership and social capital

A number of studies have shown a positive effect of home ownership on a rich variety of social capital and citizenship variables (DiPasquale & Glaeser, 1999; Glaeser, 2001). Using New Zealand data and controlling for factors such as income and educational attainment, Roskruge, Grimes, McCann, and Poot (2013) found that homeowners report significantly higher levels of trust in others, participate more in local activities and have a more positive sense of their local community. Residential instability, which is more common for people who are renting, is argued to disrupt community social networks (Frieling, 2018).

This suggests that urban development that contributes to the affordability of home ownership may in turn increase social capital.

Crime prevention through environmental design

The form of urban development can affect crime rates. Going back to Jane Jacobs (1961), development that creates 'eyes on the street' has been assumed to reduce neighbourhood crime. Increased trust and community cohesion has also been assumed to reduce crime.

As a result, crime prevention through environmental design (CPTED) techniques are increasingly popular for reducing crime. CPTED aims at creating 'defensible space', defined as:

> *A residential environment whose physical characteristics—building layout and site plan—function to allow inhabitants themselves to become key agents in ensuring their security. (Newman, 1973)*

Specific CPTED interventions range from lighting and CCTV in public places to mixed-use developments that ensure that 'eyes on the street' are present around the clock.

Cozens, Saville, and Hillier (2005) review the evidence on CPTED techniques. They find that the available empirical evidence tends to be incomplete, reflecting difficulties measuring design features and confounding factors such as local socioeconomic status. Nonetheless, they conclude that CPTED methods are likely to contribute to crime prevention.

17.6 Impacts of modifying places with cultural significance

Urban development can modify (or destroy) places or matters of cultural significance. For instance, redeveloping a central city site may result in the alteration of an existing building with historic significance. Similarly, greenfield development may disrupt an archaeological site or a place with cultural significance. These changes may reduce people's cultural capital.

However, urban development does not always have a negative impact on cultural values. Development that preserves or adapts existing assets may result in benefits relative to an alternative scenario in which those places become dilapidated or neglected from a lack of investment and use. For instance, urban development in a historic town centre could contribute to the preservation of existing buildings that may otherwise be at risk of being torn down.

Challenges to value cultural impacts

It is challenging to identify and value the full range of places and matters of cultural significance. In any city or society, different cultural groups may value different things, and even within groups individuals will value different things. Moreover, cultural values often have ephemeral, shifting, incoherent and even irrational properties, which makes valuation more difficult, especially using economic methods which assume individuals behave rationally (Throsby, 2003).

People often question the appropriateness of attempting to assign a value to cultural impacts. Chan et al (2012) discuss the difficulty of asking people to place a monetary value on cultural values through which the ontological importance of all things is understood. There may be intrinsic challenges to measuring values that do not fit will in an economic framework using an economic framework.

A further point is that specific changes to the environment can be positively or negatively *perceived* depending on one's viewpoint/preferences and culture, distributional effects of the impacts of the changes (ie whose wellbeing do the changes support?), and the scale over which the impacts are measured.

Previous attempts to value cultural impacts

However, some research has attempted value existing cultural or heritage resources, often focusing on specific culturally significant sites or heritage buildings. Dümcke and Gnedovsky (2013) review the literature on the social and economic value of cultural heritage. These studies generally relied upon proxies for economic impacts, often related to activity in the local tourism sector. For instance, some studies measured the number of visitors to heritage sites, total tourist expenditures, or net impacts on economic output (GDP or gross value added).

To demonstrate the social impact of heritage, the majority of studies reviewed by Dümcke and Gnedovsky (2013) offer descriptive case studies or data based on questionnaires and expert interviews. Few studies contain attempts at developing a general methodology of quantitative assessment of the social value of heritage based on a consistent system of measurable indicators. Despite this they found that positive social impacts are often achieved via preservation of cultural heritage.

In a similar vein, a review by Rypkema, Cheong, and Mason (2011) finds that most studies on the economic impact of historic preservation include an effort to measure impacts in four areas: the creation of jobs and household income from the rehabilitation process; the impact of heritage tourism; the impact on property values stemming from the protections of a local historic district; and economic development indicators from preservation-based downtown revitalization programs. Some studies also attempted to measure the following: environmental impacts of historic preservation; the effectiveness of state tax credit and grant programs; the role of historic preservation in providing affordable housing; and environmental/social measurements such as walkability.

Both contingent valuation techniques and hedonic pricing models have been used to value access to cultural resources, often notable heritage buildings. Throsby (2003) reviews the application of contingent valuation methods to cultural resources, noting the difficulty of applying rational economic method based on benefits to individuals to capture the collective and esoteric values associated with cultural assets. Noonan (2003) undertook a meta-analysis of 65 studies that applied willingness to pay methods to value cultural heritage. He found that many studies revealed a willingness to pay for cultural resources and assets, but described the use of this method to such an intangible good as cultural resources a "regrettable necessity".

Other studies have recommended 'choice modelling' to value cultural heritage because of its ability to distinguish between use and non-use values, and to reveal attributes which are valued by respondents. Choice modelling is similar to contingent valuation but instead of asking respondents about their willingness to pay, it asks them to make a sequence of choices between sets of resource use alternatives, which demonstrates the respondents' willingness to trade-off between the various attributes of the choices (Bennett, 2000).

A number of studies use hedonic pricing to investigate the impact of heritage designation on property values. Nijkamp (2012) reviews the variety of tools available to value cultural heritage and concludes that despite some important limitations, the use of hedonic pricing is a promising method. It is most often used to identify the price premium that people are willing to pay to purchase heritage-listed dwellings, as shown in Table 37. Lazrak et al (2009) note that it is difficult to separate the confounding impact that heritage listing will often restrict redevelopment opportunities in such studies. They suggest that hedonic pricing is most applicable for investigating whether the costs of heritage designation exceed the benefits for property owners.

However, a small number of studies have investigated whether there are positive 'spillovers' from build heritage. Lazrak, et al. (2014) apply hedonic analysis to property sales in Zaanstad, the Netherlands. They find that each additional heritage-scheduled property within a 50-metre radius is associated with a 0.24-0.28% price increase.

In Auckland, Nunns, Hitchins and Balderston (2014) find that an additional pre-1940 building is associated with a 0.3% price increase for other buildings in the same neighbourhood.

Both studies focus on benefits of built heritage that are highly localised, eg to individual city blocks, and hence do not capture wider benefits that may accrue regionally or nationally.

Table 37: Overview of hedonic pricing studies of cultural heritage (Lazrak et al, 2009)

Study	Study	Study area	Key findings
Narwold et al. (2008)	The effect of historically designated houses on sale price	San Diego, USA	Historic designation of single-family residences creates a 16 percent increase in housing value which is higher than the capitalization of the property tax savings due to designation.
Noonan (2007)	The effect of landmarks and districts on sale price	Chicago, USA	Designated property has a positive effect on both itself and neighbouring properties.
Ruijgrok (2006)	The effect of 'authenticity', 'ensemble' and landmark designation on house prices	Tiel, Netherlands	Authenticity and façade elements accounts for 15 percent of sale prices in the Hanseatic city of Tiel.
Coulson and Lahr (2005)	The effect of district designation on appreciation rate	Memphis, Tennessee, USA	Appreciation rate were 14-23% higher when properties were in neighbourhoods which were zoned historical. Local designation is more important than national designation.
Deodhar (2004)	The effect of heritage listing on sale prices	Sydney, Australia	On average heritage listed houses commanded a 12 percent premium over non heritage listed houses. This premium is a combined value of heritage character, their architectural style elements, and their statutory listing status.
Coulson and Leichenko (2001)	The effect of designation on tax-appraisal value	Abilane, Texas, USA	Local historic designation raises value 17.6 percent of designated property.
Leichenko et al. (2001)	The effect of historic designation on house prices	nine different Texas cities, USA	Historical designated properties in Texas enjoy 5-20% higher appraised prices than other property.
Asabere and Huffman (1994a)	The effect of federal historic district on sales prices	Philadelphia, USA	Owner-occupied property located in national historic districts in Philadelphia sell at a premium of 26 percent.
Asabere and Huffman (1994b)	The effect of historic façade easements on sale prices	Philadelphia, USA	Condominiums with historic easements sell for about 30 percent less than comparable properties.
Asabere et al. (1994)	The sales effects of local preservation	Philadelphia, USA	Small historic apartment buildings experience a 24 percent reduction in price compared to nonlocally certified properties.
Moorhouse and Smith (1994)	The effect of architecture on original purchase price	Boston, USA	Architecture design was valued with a premium.
Schaefffer and Millerick (1991)	The impact of historic district on sale prices	Chicago, USA	Properties with national historic designation have a premium and local historic designation have a discount over non designated properties. Properties near a historic district may enjoy positive externalities.
Asabere et al. (1989)	The effect of architecture and historic district on home value	Newburyport, Massachusetts, USA	Historical architectural styles have positive premiums. The historic district of Newburyport does not have positive external effects.
Ford (1989)	The price effects of local historic districts	Baltimore, Maryland, USA	Historic districts do have higher prices than non-historical districts.
Vandell and Lane (1989)	The effect of design quality on rent and vacancy behaviour on the office market	Boston and Cambridge, USA	Design quality has a positive premium of 22 percent on rents but there is a weak relationship between vacancy behaviour and design quality.
Hough and Kratz (1983)	The effect of architectural quality on office rents	Chicago, USA	Tenants are willing to pay a premium to be in new architecturally significant office building, but apparently see no benefits associated with old office buildings that express recognized aesthetics excellence.

Throsby (2012) states that it is possible to view cultural assets (both tangible and intangible ones) as part of the stock of cultural capital and assign an asset value. This is similar to the ways in which natural capital is generally viewed, eg, it is handed down from the past, will degrade if it is not maintained, and therefore imposes a duty of care on current generations. He states that use value can be interpolated from rent paid for the asset (or access fees spent by tourists to access a heritage site). Non-use values include the existence value, option value (to use the asset at some future time), and bequest value (to bequeath it to future generations) and are harder to calculate. Methodologies used for estimating non-use values of the natural environment have been applied to cultural capital, but it is very difficult to represent a cultural asset's aesthetic, symbolic, spiritual, or historic value in monetary terms.

Valuing cultural assets in New Zealand

Measures of cultural identity are increasingly used in policy frameworks in New Zealand. The Treasury's Living Standards Framework includes the following indicators of cultural identity:

- Ability to express identity - percentage of adults who said it was easy or very easy to express their identity in New Zealand;
- Te Reo Maori speakers - percentage of people who can converse about a lot of everyday things in Te Reo Maori)

It also includes the following measure of social connections that have a link to cultural identity:

- Maori connection to marae - percentage of Maori adults who feel strongly connected with their ancestral marae).
- Sense of belonging - average adult score for sense of belonging to New Zealand, on a scale from 0 (no sense of belonging) to 10 (very strong sense of belonging).

The Ministry for the Environment has constructed a Cultural Health Index for water bodies. This index allows Maori to assess the cultural and biological health of a stream or catchment, and then communicate this information to water managers in a way that can be understood and integrated into resource management processes (Tipa and Teirney, 2006). A recent NIWA project further developed this into an assessment tool for use in urban areas, identified preventative and mitigation measures available for deal with the cultural perceptions of urban water problems.

In urban development, cultural values assessments (CVAs) or cultural impact assessments (CIA) are often prepared to demonstrate and document the cultural impacts of urban development proposals. These assessments are often prepared by mana whenua to assist local authorities with planning and resource management decisions, frequently as part of the Assessment of Environment Effects (AEE) for resource consent applications, and show evidence of cultural impacts. Under the RMA, the relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga is considered a matter of national importance (Gooder, 2018).

17.7 How these effects can be measured and valued

The evidence on social and cultural effects of urban development is suggestive at best. While it is stronger in some areas than others, eg on the cultural costs of demolishing notable 'heritage' buildings or the health impacts of transport patterns arising from different urban form, it is hard to be certain about how large many of these effects are, or how specific urban development outcomes affect them.

The above evidence and case studies suggest that further research is needed to understand the impact of urban development on mental health impacts, social capital, trust, and community cohesion, and cultural identity and values. Each area is subject to significant measurement and valuation challenges, eg due to the fact that it is hard to identify what aspects of the built environment enhance or detract from cultural identity.

However, we do note that the Treasury's CBAx tool provides some proxy values that could be used to value some changes in social and cultural outcomes, such as gaining or losing friends or community associations.

However, the health impacts of transport behaviours are feasible to measure and value based on existing data and methodologies.

Measurement

- The primary measurable health impacts will arise from changes to transport behaviours, such as an increase or decrease in walking and cycling participation in different types of neighbourhoods. The impact of location and built form on walking and cycling can be estimated using transport models (if they cover active modes) or extrapolations from empirical data, such as the data summarised by Ewing and Cervero (2010)
- An alternative that could be used to assess broad changes to urban form would be to use the Integrated Transport and Health Impacts Model (ITHIM) used by Shaw et al (2018) to model how differences in transport patterns between New Zealand cities impact population health. Changes in physical activity, road traffic injury risk and exposure to air pollution ($PM_{2.5}$) are used to assess the health effects of different transport scenarios.

Valuation

- The health impacts of changes in walking and cycling participation can be valued using parameters from the NZTA's *Economic Evaluation Manual*, which are noted above. Impacts on changes in road crashes could also be valued using EEM parameters, if they are assessed.

18 Appendix 11: Distributional impacts on housing prices and rents

18.1.1 How these effects arise

When increased demand for housing collides with a limited supply of housing, then house prices and rents tend to rise to 'ration' the existing stock of housing. Conversely, if increases in housing demand are met by a sufficient increase in new home construction, then prices and rents tend to rise less, if at all.

Housing demand may increase due to a rising population, rising incomes, or changing preferences for different types of homes than are currently available (see Cheshire, Nathan, and Overman, 2014). Efficiently planned and delivered urban development that increases housing supply in desirable locations can moderate the impact of increased demand on prices, while insufficient or inappropriate located development may have the opposite effect.

There is evidence that large increases in housing supply can reduce prices and rents in some contexts. For example, average inflation-adjusted rents in Greater Christchurch peaked at around $430 per week in early 2015 due to the housing shortage caused by the 2010/2011 Canterbury Earthquakes. However, increased home building caused them to fall to $370 per week by late 2018, even as the city's population increased.[83]

Increases or decreases in housing prices have important distributional impacts, but their *net* impacts on overall social wellbeing are likely to be minor. An increase in house prices would impose costs for New Zealanders who do not already own homes. This includes existing renters (who pay for housing on a weekly basis) and first home buyers, such as young New Zealanders. Conversely, increased prices would benefit New Zealanders who own homes and rental properties, due to increased asset value and rental income. The opposite would be true for a reduction in house prices.

On balance, this would:

- Redistribute income and wealth away from lower-income people, as renters and first home buyers tend to have lower incomes than landlords and homeowners
- Transfer income and wealth from younger generations, who are more likely to be renting or seeking to buy a home, to older people. In the long run, this may lead to inherited inequalities in wealth, as people with home-owning parents inherit significant assets and people with renting parents do not.

However, costs and benefits for different people are likely to balance out in a financial sense.[84] For instance, if average house prices rose by $50,000, a first home buyer would have to pay $50,000 more to purchase a typical home, without necessarily deriving more benefits from owning and occupying that home. The added costs they face would be fully offset by increased revenue for the seller. However, this transfer of income may lead to a reduction in social wellbeing if first home buyers' marginal utility of income is higher than existing homeowners, eg if first home buyers value money more due to the fact that they have less of it.

We see these distributional impacts as important to consider as they may be large in magnitude. For instance, Census data suggests that 154,000 households rented dwellings in Auckland in 2013, paying median weekly rent of $350. This suggests that renting Aucklanders paid at least $2.8 billion for accommodation in 2013. A 5%

[83] Based on data published at https://mbienz.shinyapps.io/urban-development-capacity/
[84] They will not exactly balance out due to the fact that some homes are owned or puchased by non-New Zealanders. If the value of a home owned by a non-New Zealander falls, and they subsequently sell it to a New Zealander, then it will provide net economic benefits for New Zealand.

increase in rents would therefore result in a $140 million transfer in income from renters to landlords. (For reference, nominal average rents in Auckland have risen by around 25% since 2013, which suggests that there has been a large transfer of wealth from renters to landlords over this period.)

The resulting redistribution of income and wealth may in turn undermine New Zealanders' perception in the fairness of the housing market. Because capital gains on property are largely untaxed, it may also undermine their perception of the fairness of the tax system. We note the Tax Working Group's (2018) comments on the importance of perceived fairness:

> *A sense of fairness is central to maintaining public trust and confidence in the tax system. This is because a system that distributes the costs of taxation in a way that is perceived to be unfair will generate resentment and undermine social capital. Perceptions of unfairness will erode public acceptance of the prevailing levels of taxation, as well as the spirit of voluntary compliance that underpins efficient tax collection.*

18.1.2 Evidence on growth and regional house prices

There is a significant empirical literature that demonstrates that population growth, eg due to migration inflows, can push up house prices and rents, either at a regional or a local level. Some studies suggest that these effects are mediated by local housing supply dynamics (Glaeser and Gyourko, 2018). Regions with constraints to building new homes, such as a shortage of development capacity caused by restrictive zoning and insufficient infrastructure capacity, may experience higher price increases in response to a similarly-sized demand shock.

Migration inflows and house prices

A number of empirical studies have examined the impact of population growth, often from inflows of migrants, on local house prices and rents.

In the US, Saiz (2003) uses the 1980 Mariel Boatlift, which resulted in a large inflow of Cuban refugees to Miami, as a natural experiment to estimate the impact of migration shocks on local rents. He estimates that the Boatlift increased Miami's population by 4% in one year, and caused rents to increase 8% more in Miami relative to comparator cities. Saiz (2007) undertakes a broader analysis of the impacts of exogenous migration inflows on rents and house prices on 306 US cities over the 1983-1997 period. He estimates that an immigration inflow equal to one percent of a city's population leads to a 1-2% increase in average rents and house prices.

Several papers have investigated the impact of migration or other population shocks on New Zealand house prices at a national and regional level. Coleman and Landon-Lane (2007) analyse the relationship between migration flows, new home building, and house prices over the 1962-2006 period. They find that a net immigration inflow equal to one percent of the population is associated with an 8-12% increase in real house prices after a year. McDonald (2013) updates this analysis using data for the 1990-2012 period, finding that a net inflow of migrants equal to one percent of the population is followed by a 7% increase in real house prices, and an additional 1 home consented for every six migrants.

Stillman and Maré (2008) use data from the 1986-2006 Censuses to examine how population changes from international and internal migration affect regional rents and house prices. They conclude that a one percent increase in an area's population is likely to lead to a 0.2 to 0.5 percent increase in local housing prices and a smaller impact on rents. They found no evidence that inflows of foreign-born immigrants to an area are positively related to local house prices. In a related paper, they find little evidence that migrant inflows displace either the New Zealand born or earlier migrants with similar skills in the areas in which migrants are settling (Maré and Stillman, 2009).

Similarly, Maré, Grimes, and Morten (2009) find that regional employment shocks result in strong in-migration but not movements in relative house prices. Surprisingly, this differs from their estimates from national-level data, which suggest that a one percent employment shock raises house prices by around 6%.

Differing estimates from national-level and regional data are not necessarily inconsistent. They may arise from spatial sorting processes and migration between towns. For instance, a sudden influx of migrants to Wellington may be housed in Miramar, as new homes are being built in this area, but if prices rise in Miramar they are also likely to rise in Karori as well even if the net population increase in Karori is zero. Prices in all suburbs can be expected to increase, but relative prices in Miramar and Karori might not change very much. This means that estimates of the aggregate (mean) effect and the disaggregated (around the mean) effect can be very different while still related to the same phenomena. This highlights the difficulty in making inferences from microeconomic data in the absence of macroeconomic models and empirical estimates (and vice versa) as spatial adjustment mechanisms tend to be complex.

Nunns (2018a) re-analyses the impact of migration shocks on regional housing markets in New Zealand using data for the 2001-2016 period and a similar econometric approach to Saiz (2007). Depending upon model specification, he finds that, on average a migration shock equal to one percent of regional population leads to:[85]

- A 1.6% to 2.7% increase in local house prices. These estimates are statistically significant at the 5% and 10% level, respectively.
- A 1.5% to 2.1% increase in local rents. The lower estimate is statistically significant at the 1% level.

Moreover, Nunns finds tentative but not conclusive evidence that regions that had smaller house price distortions in the early 1990s (suggesting that housing was not in scarce supply) subsequently experienced *smaller* housing price increases in response to migration shocks. This is consistent with the hypothesis that areas with fewer constraints to housing supply can accommodate demand increases without price increases.

Point estimates suggest that a 1% migration shock in the Auckland region, which had higher house price distortions in the early 1990s, will cause a 3.3% increase in house prices and a 2.3% increase in rents. By contrast, Palmerston North, with lower price distortions, is predicted to only experience a 1.4% increase in house prices and no increase in rents as a result of a similarly-sized shock. However, these effects are not precisely estimated and are not generally statistically significant.

2013 Census data indicates that Auckland had 154,000 renting households, and a median weekly rent of $350. A 1% increase in population (equal to roughly 5,000 added households) that resulted in a 2.3% increase in rents would therefore lead to an aggregate increase in rents equal to around $65 million. This equates to an annual impact of around $13,000 per added household.

These estimates should be viewed with caution as the underlying model coefficients are not precisely measured. However, they highlight the potentially significant magnitude of these effects.

The role of housing supply constraints

A number of papers have investigated the determinants and impacts of housing supply responsiveness in various countries, including New Zealand (eg Caldera and Johansson, 2013; Mayer and Somerville, 2000a;

[85] Strictly speaking, not all of this effect is due to migrant arrivals. At the national level, increased migrant arrivals tend to coincide with reduced departures of New Zealanders, which will also affect local housing demand. Hence these estimates may capture the effect of both outcomes.

McLaughlin, 2011; Grimes and Aitken, 2010). These papers suggest that increases in housing demand are generally met by increased home building, which can moderate the impact of demand shocks on house prices (Grimes and Aitken, 2010).

Moreover, there is evidence that various measurable factors, such as geographic constraints on developable land, zoning restrictions, and delays in obtaining building permits, can slow down supply responses (Mayo and Sheppard, 1996; Mayer and Somerville, 2000b; Saiz, 2010; Paciorek, 2013; Jackson, 2016; Nunns, 2018b).

This suggests that urban development policy, including district plan rules and infrastructure supply, can be used to mitigate adverse distributional impacts.

18.1.3 How these effects can be measured and valued

Based on the above literature review, the following approach could be used to measure and value distributional impacts that arise from changes to house prices and rents.

Measurement

- First, identify how many people may be positively or negatively affected as a result of increased house prices.
    - A simple way to do this would be to use Census data to identify the number of people who are living in rental accommodation or owner-occupied properties in each urban area. Renters would face higher housing costs as a result of price increases, while owner-occupiers would not.
    - A more sophisticated approach would be to use property title data or ratings databases to identify people who own one or more rental property. This would allow an assessment
- Second, further research is needed to more accurately quantify (a) how much house prices and rents may increase in response to population growth in different urban areas and (b) what measurable factors influence this relationship.
    - The research cited above demonstrates that these effects exist, but studies using different methodologies and data from different time periods come to different conclusions about the magnitude of impacts.

Valuation

- Based on the above findings, it would be possible to estimate the impact of a given population or employment shock (say, another 1000 people moving to a city) on house prices and rents and then quantify the resulting financial impacts on (a) renters, (b) existing homeowners, and (c) owners of rental properties.
- As noted above, financial impacts would be negative for renters (and first home buyers), and positive for existing homeowners (at the point that they sold property) and owners of rental properties.