The costs and benefits of urban development: A theoretical and empirical synthesis

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Prepared by:
Peter Nunns (MRCagney)
Tim Denne (Covec)

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MRCagney

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Abstract

Cities are complex. In the words of Edward Glaeser, cities are the absence of physical space between people and companies. Consequently, the actions of individuals and organisations in cities have (positive and negative) repercussions for people around them. Urban complexity therefore creates the potential for various market failures and regulatory failures.

A perennial question for urban planning is where and when there is a case to limit development to manage the potential for market failure. Regulations may reduce the competitiveness of land and development markets by limiting capacity for development and creating barriers to entry such as regulatory uncertainty for developers. This results in a less responsive urban development market that delivers less housing (or business floorspace) at a higher cost.

It may be desirable to bear these costs in order to manage market failures in the built environment. However, there have been relatively few attempts to comprehensively quantify the costs and benefits of urban planning rules in New Zealand. This paper attempts to fill this gap by synthesising evidence on the costs of specific urban planning rules and the various positive and negative externalities associated with urban development.

In doing so, it identifies the degree to which existing practices are inefficient, and the degree to which it would be possible to raise wellbeing by enabling more competitive, responsive urban development markets. To close, it asks whether alternative policy mechanisms are needed to efficiently address market failure in the built environment.

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1 Introduction and context

Cities are complex. In the words of Edward Glaeser (2011), cities are the absence of physical space between people and companies. Consequently, the actions of individuals and organisations in cities have (positive and negative) repercussions for people around them. This in turn creates the potential for various market failures and regulatory failures.

A perennial question for urban planning is where, when, and how there is a case to limit development to manage the potential for market failure. This paper aims to inform this discussion in three ways:

- First, in Section 2 we review theory and empirical evidence on the impact of urban planning policies on land and development markets in cities. To synthesise: excessively restrictive policies can limit the competitiveness of these markets, and in turn reduce their responsiveness to growth in demand.
- Second, in Section 3 we review the previous evidence on the costs of specific urban planning rules in Auckland and extend this to examine whether two specific policies – Auckland's Metropolitan Urban Limit and building height limits – are efficient.
- Third, in Section 4 we consider how urban planning policies can influence the *dynamics* of cities' growth and development, as this is an area that has received less attention to date. We propose several simple models that capture, at least to some degree, the costs and benefits that arise under more or less enabling policies.

To finish, we briefly discuss some implications for researchers interested in the effects of urban planning policies and some questions for policymakers, who must ask how best to address challenges and opportunities associated with urban development.

1.1 The what and why of urban planning

Urban planning involves regulating the use and development of land in and around cities. A range of plans, policies, and rules developed by local governments and legislation developed by central government seek to manage *where* residential and commercial activities can be located, or *how* development may occur. These include a range of rules that manage, among other things:

- The location of urban activities (e.g. residential, business, and rural zoning)
- The intensity of development and density of dwellings (e.g. building height limits, minimum lot sizes)
- The design of buildings, sites, and subdivisions (e.g. minimum parking requirements, minimum dwelling sizes)
- Connections to public infrastructure networks, and development and financial contributions to pay for public infrastructure
- Environmental quality, including discharges into air or water.

In general, the purpose of urban planning policy is to manage the good and bad sides of urban growth. It does this by separating incompatible activities (like heavy industry and residential dwellings), integrating public good land uses such as parks and transport facilities, and attempting to manage specific negative externalities from developments (Chung, 1994).

Although urban planning helps shape land use outcomes, housing and business space is ultimately developed by other agents – landowners, developers, financiers, and government departments – in response to demands from households and businesses. Consequently, when regulating it is important to be attentive to observed outcomes in land and development markets.

1.2 Local decisions, national implications

Planning decisions are usually made at the local level and are heavily influenced by local input. Fischel (2015) argues that urban planning developed in response to *demands* from politically-empowered homeowners, or "homevoters". Analysis of submissions on, and outcomes from, major urban planning processes often confirms this view – as well as highlighting some of the inequities that arise in planning processes. For example, Morrow (2013) finds that changes to urban planning in Los Angeles between 1965 and 1992 were strongly influenced by input from affluent, predominantly white homeowners associations, while residents of low-income and minority communities had less input.

To give a local example, there were significant variations in submission rates on the Auckland Unitary Plan from different local boards. Some local boards had as few as 0.4-0.8 submissions per 1,000 residents (Otara-Papatoetoe, Mangere-Otahuhu), while others had as many as 12.3-12.5 submissions per 1,000 residents (Orakei, Rodney). A statistical analysis showed that local boards with higher median personal income and a greater share of residents over 65 were more likely to submit at higher rates. It is likely that varying submission rates have influenced planning decisions, with consequences for the future shape of the city.

Although planning decisions are local, they have broader societal ramifications for urban labour markets, housing markets and housing affordability, and transport behaviours. In the words of the Productivity Commission (2015):

> *Cities are national assets. When cities function well, they provide greater choices of employment and more opportunities for specialisation, and they have higher incomes and productivity than other areas. This is because firms located in close proximity to each other can take advantage of having access to a wider pool of skilled labour, better links to markets for both inputs and outputs, and the ability to share knowledge. However, the concentration of people and businesses in cities also creates costs, such as pressure on infrastructure and on the availability of housing. This puts a premium on good city organisation and on the ability to plan for growth.*

In other words, overly restrictive urban planning policies can have macroeconomic ramifications. Glaeser et al (2005) observe that "the social costs of binding development restrictions lie in the misallocation of consumers, and having them live in less productive, less attractive places." When this happens, it can reduce overall economic productivity and limit opportunities for social mobility.

Increasingly, economic evidence points to significant national-level effects from local regulations. In the United States, two recent papers have investigated the role of planning regulations in discouraging migration to high-productivity cities. Policies that raise the cost to supply new housing can dissuade low-income workers from moving to productive cities, as the gains from increased wages are consumed by higher costs of living.

Ganong and Shoag (2013) find that the convergence of per-capita incomes between US states slowed dramatically after 1980, as did migration of workers from low-wage to high-wage locations. These trends are driven by higher house prices in productive coastal areas like California and New York, which now pose a higher barrier to migration for low-skilled workers than high-skilled workers:

> *Historically, both janitors and lawyers earned considerably more in the tri-state New York area (NY, NJ, CT) than their colleagues in the Deep South (AL, AR, GA, MS, SC). This was true in both nominal terms and after adjusting for differences in housing prices. Migration responded to these differences, and this labor reallocation reduced income gaps over time.*
>
> *Today, though nominal premiums to being in the NY area are large and similar for these two occupations, the high costs of housing in the New York area has changed this calculus. Though lawyers still earn much more in the New York area in both nominal terms and net of housing costs, janitors now earn less*

in the NY area after housing costs than they do in the Deep South. This sharp difference arises because for lawyers in the NY area, housing costs are equal to 21% of their income, while housing costs are equal to 52% of income for NY area janitors. While it may still be "worth it" for skilled workers to move to productive places like New York, for unskilled workers, New York's high housing prices offset the nominal wage gains.

Ganong and Shoag also demonstrate, using an innovative measure of changing restrictiveness of planning regulations, that divergences in house prices are driven by increasing regulatory constraints on supply in some cities.

In the aggregate, the misallocation of workers across space results in large economic costs. Hsieh and Moretti (2015) find evidence that high housing costs have dissuaded increased employment in high-productivity cities – in particular New York, San Francisco, and San Jose, which are home to growing human-capital intensive industries like high tech and finance. The potential gains from relaxing urban planning regulations to enable workers to migrate to these cities are large, as are the potential costs of increasing regulations in less restricted cities:

We estimate that holding constant land but lowering land use regulations in New York, San Francisco and San Jose to the level of the median city would increase U.S. output by 9.7%. In essence, more housing supply would allow more American workers to access the high productivity of these high TFP cities. We also estimate that increasing regulations in the South would be costly for aggregate output. In particular, we estimate that increasing land use regulations in the South to the level of New York, San Francisco and San Jose would lower U.S. output by 3%.

To date, there is no clear empirical evidence of a similar "misallocation of consumers" in New Zealand. There *is* evidence of a large productivity premium in Auckland (Maré, 2008), as well as relatively high housing prices (Productivity Commission, 2015). In principle, unaffordable housing could dissuade some people from moving to Auckland – or encourage them to move to Australian cities instead.

Historically, this does not seem to have been the case. Grimes et al (2014) examine the determinants of long-run population growth in 56 New Zealand cities and towns over the period 1926 to 2006. They find that:

five dominant factors have impacted positively on urban growth, especially since 1966: local land use capability, sunshine hours, human capital, population size and proximity to the country's dominant city, Auckland.

Sinning and Stillman (2012) provide more recent evidence on population trends. They use Australian and New Zealand Census data to study trans-Tasman migration flows from 1996 to 2006. Across both countries, higher median real incomes tend to be associated with higher population growth. In New Zealand, higher local employment rates also have a positive effect on population growth. However:

house prices have little impact on location choice decisions in either Australia or New Zealand. This is consistent with spatial sorting theory that shows that differences in house prices (and other amenities) need to be compensated for by other factors, such as higher wages, in equilibrium.

Notwithstanding these findings, the US experience should serve as a cautionary tale about the national implications of local decisions about urban planning.

2 A theoretical and empirical synthesis

In this section, we briefly review and attempt to synthesise theory and evidence on the impact of urban planning on land and development markets in cities. In doing so, we highlight three important considerations that are important when assessing outcomes from urban planning policies:

- First, excessively restrictive urban planning policies can limit the competitiveness of land and development markets
- Second, observed distortions in prices that can be linked to planning policies, such as discontinuities in land prices arising at zoning boundaries, provide evidence of reduced competitiveness
- Third, reducing the competitiveness of land and development markets results in less responsive housing development and (over time) higher housing prices than would have otherwise been the case.

We also briefly review some evidence on each of these points, including the available New Zealand-specific evidence.

These considerations pose a challenge for economists assessing the costs and benefits of urban planning policies, either individually or in the aggregate. As we will see in the next section, it is common to assess the costs of regulations using static models, such as the general equilibrium Alonso-Mills-Muth model (NZIER, 2014, 2015a) or partial equilibrium approaches employing comparative statics (Donovan and Nunns, 2015). These approaches may underestimate the long-term costs of some planning policies by failing to consider the effects of urban planning on market dynamics.

2.1 Restrictive planning policies can limit the competitiveness of land and development markets

Microeconomic theory (see e.g. Sorrell et al, 2000) describes a competitive market as one in which:

- There are numerous buyers and sellers in the market or placed to enter the market
- There are no barriers to entry or exit from the market
- There are no transaction costs that would prevent market participants from contracting with each other
- Markets are complete, meaning that there are no unpriced externalities that are borne by non-participants
- All participants have access to complete information about prices and products.

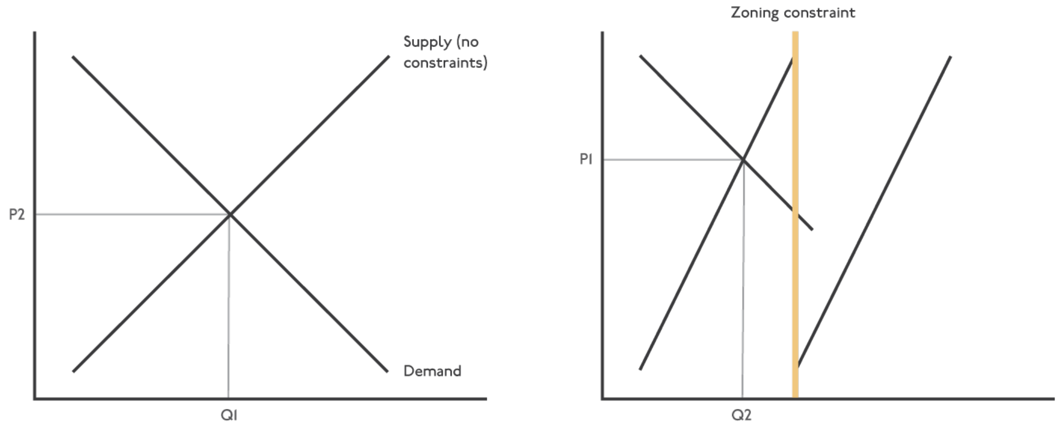
These assumptions are not always, or even usually, met in practice. However, they provide a useful theoretical benchmark against which to assess market operation. In the case of urban planning policies, there are two principal ways in which they can potentially affect the competitiveness of land and development markets by imposing barriers to entry or increasing transaction costs.

First, restrictions on the supply of appropriately zoned land limit the competitive pressure that landowners face from other landowners, and give them greater market power over developers / land users. For example, in the context of a shortage of sites for high-rise development, zoning a single lot for high-rise use while keeping all surrounding lots in low-density zoning will enable that landowner to demand a higher price from developers due to the fact that they face no threat of competition from neighbouring sites (Kulish et al, 2011).

Evans (2004) observes that the impact of regulations that constrain the supply of developable land (or land that can be developed to a greater intensity) will reduce the number of landowners who will be willing to sell land for development at any given price point. This is illustrated in the following diagram. The left panel shows an "unconstrained" scenario in which all land in the area is available for development (or more intensive redevelopment). The right panel shows a scenario in which planning regulations prevent the (re)development of some of this land. Even if these rules enable a technically sufficient quantity of land to be available for development, they can still have an effect on the functioning of the market by dividing the supply curve in two. (In the right panel, we draw a shortened demand curve as it is not possible to meet demand for urban uses in land that isn't zoned appropriately.)

The outcome is that less land will be (re)developed – the quantity of development falls from Q_1 to Q_2. Furthermore, the development market will be less responsive to future growth in demand – as shown by the steeper slope of the supply curve in the right hand panel. This means that it will be costlier to grow in the future.

Figure 1: Supply outcomes with and without a constraint on the supply of developable land (Source: Evans, 2004)



Such effects can arise both at the rural/urban boundary and within the urban area. In terms of the latter, Auckland's Unitary Plan identifies zones (e.g. the Metropolitan Centre, Town Centre, and Terrace Housing and Apartment Block zones) for more intensive residential development (4+ storeys). However, these zones are often concentrated in relatively small areas, meaning that landowners in these areas may face little competition to develop their land (or can demand a high price for the development of this land due to the shortage of supply alternatives).

To illustrate this point, the following table shows the amount of land within walkable catchments (1 kilometre walk on street networks) around selected rapid transit stations (i.e. rail and busway) which is zoned Metropolitan Centre, Town Centre, or Terrace Housing and Apartment Block.

Table 1: Land zoned for intensive development around selected rapid transit stations (Source: MRCagney, 2015b)[1]

RTN station	Total land area in catchment (m2)	Land zoned for medium- to high-density residential development (m2)	Share available for residential development (%)
Newmarket	1,127,579	263,173	23.3%
Mt Eden	1,580,552	39,671	2.5%
Mt Albert	1,601,977	105,169	6.6%
Avondale	1,271,984	413,157	32.5%
New Lynn	1,593,070	693,955	43.6%
Glen Eden	1,343,164	622,449	46.3%
Glen Innes	1,560,928	471,993	30.2%
Panmure	1,287,954	331,948	25.8%
Onehunga	1,403,306	330,489	23.6%
Otahuhu	854,240	24,400	2.9%
Manurewa	1,420,276	345,909	24.4%

With the exception of the city centre RTN stations, the majority of land in most RTN catchments is zoned for low-density residential use. In some catchments, such as Mt Albert, Mt Eden, and Otahuhu, the supply of land available for apartment development is restricted to less than 10% of the walkable catchment. Although it seems perfectly feasible to develop apartments or flats throughout the walkable catchments of these stations, the supply of land for these activities is apparently restricted to a small area that is immediately adjacent to stations.

A second potential cause of limited development capacity and constrained supply is that regulatory policies and processes can impose significant cost, delay, or uncertainty on developments (Grimes and Mitchell, 2015). This can create barriers to entry in the development market, as some people will choose not to bear this cost and uncertainty.

Uncertainty is likely to play an important role as a barrier to entry. If the outcomes of consenting processes, or the time required to obtain a resource consent, are uncertain, then developers' holding costs will also be uncertain, increasing the issues associated with financial planning. While this uncertainty can be managed through experience, relationships with regulators, or larger balance sheets, it is likely to pose a barrier to entry for smaller or less experienced developers.

Uncertainty associated with consenting requirements is likely to be larger for developers that are proposing to build new dwelling types in a market, as they may be subject to additional resource consent requirements. Uncertainty is also likely to be higher for developments on "brownfield" sites that are potentially subject to notification and public input than it is for greenfield sites, as there will be more neighbours around brownfield sites who may potentially object. The effect of this is that uncertainty and delay in the planning process may have a disproportionate impact on development in existing urban areas.

Economists have developed microeconomic models to investigate the impact of uncertainty and delay on the development process. Mayo and Sheppard (2001) find that increased delays in obtaining consent tend to reduce the quantity of developments that apply for resource consent (leading to increased deadweight losses). In addition, increased *uncertainty* about the outcomes of consent applications (which they model as an increase in

[1] Based on the notified version of the Auckland Unitary Plan. Data is available online at https://catchies.mrcagney.webfactional.com/. This analysis was undertaken on behalf of Auckland Transport, who were seeking to understand opportunities to improve walking and cycling provision around rapid transit stations.

the variance of delays) also tends to reduce the quantity of development. Mayer and Somerville (2000) and Grimes and Mitchell (2015) obtain similar results, showing that increases in the cost of consent applications, delays during the consent process, and perceived uncertainty about consenting outcomes are likely to reduce the value of developments (and hence the likelihood of development).

As above, uncertainty and delay in the development process may be translated into a less flexible, responsive development market. We explore the evidence on this in the following section.

Third, we note that regulations can also add cost to developments without necessarily affecting the competitive dynamics of the market. For example, many regulations require developers to provide specific attributes, ranging from carparking (which is surprisingly expensive even in moderately dense urban areas by virtue of its opportunity cost) to balconies, floor to ceiling heights, and window sizes (MRCagney, 2013; MRCagney, 2015). If these requirements do not limit the quantity of development that can occur on sites, and if they are relatively *predictable* for developers, then they may simply impose costs (and thereby reduce demand, supply, and wellbeing) without necessarily changing the relative dynamics of land and development markets.[2] However, if they raise uncertainty for developers, in either timing or outcome of consenting processes, they may result in fewer developers prepared to take on the development risks (as identified above).[3]

2.2 Distorted prices are evidence of constrained competition

Urban planning policies and practices do not invariably limit competition in land and development markets. If planning policies policies enable a sufficient amount of development capacity for residential and business activities within a city, including a buffer to enable efficient market operation, they can achieve objectives such as separating incompatible uses without distorting the market.

Consequently, it is important to have empirical evidence that existing planning policies are limiting competition. Distorted prices for land and floorspace – as opposed to the *level* of prices – can provide specific evidence of constraints on competition. In an influential paper on the costs of planning regulations, Glaeser, Gyourko and Saks (2005) note that prices equal to the marginal cost of supply is evidence of a competitive market:

> *One of the strongest implications of free markets is that in an open, competitive, unregulated market, the price of a commodity will not be greater than the marginal cost of producing that good... Free competition among these suppliers should ensure that prices are pushed down to marginal cost, so the presence of a large gap between market values and marginal production costs indicates the presence of supply-side restrictions. If we are confident that we are not missing any technological barriers to construction, then the gap between market value and the cost of supply must reflect the impact of government regulation.*[4]

Where there is a significant gap between prices and marginal costs, it suggests that regulations may be limiting the supply of land and/or development capacity, and thereby the competitiveness of land and development markets. This gap can be observed both in land markets and development markets:

- In land markets, discontinuities in prices across zone boundaries or at the urban fringe are an indication that the supply of land for one use has been artificially restricted and/or inflated by other regulations that limit development in other locations (Grimes and Liang, 2009; NZIER, 2015b). If the magnitude of these

[2] However, even relatively straightforward regulations can have complex effects. For example, MPRs are likely to impose larger costs on more intensive developments, as multi-storey buildings tend to require expensive basement parking garages. Consequently, they may deter multi-storey developments while having a smaller impact on lower-density developments.

[3] Conversely, clear regulatory requirements may reduce uncertainty relative to a scenario in which developments are assessed on a "case by case" basis. They may also play a role in mitigating information problems in the market, for both buyers and sellers.

[4] However, it is possible that there are technical constraints in land and development markets, such as economies of scale or natural monopolies.

discontinuities exceed the cost to convert land between uses (e.g. costs of infrastructure, earthworks, and subdivision consents for bare land), it indicates that regulations may be pushing up price of urban land above the marginal cost of supply; and

- In development markets, a persistent gap between marginal construction costs and sale prices of buildings is an indication that development capacity has been artificially restricted. This is easiest to observe in high-rise apartment development or high-rise office development, where land costs make up a smaller portion of development costs but where regulations on building heights create barriers to development (Glaeser et al, 2005; Cheshire and Hilber, 2008).

We explore these examples in greater detail below. Before doing so, we note that a competitive market does not necessarily imply *low* prices in all situations. Prices may rise in a competitive market if the marginal cost of supply is increasing. For example, research from the United States and France shows that larger cities tend to have higher land prices – a 10% increase in city size is associated with a 6-7% increase in land prices, all else being equal (Albouy and Ehrlich, 2013; Combes et al, 2014). This increase appears to reflect both increased congestion / crowding, which may push up demand for central land, as well as the fact that larger cities offer economies of scale in production and the supply of consumer amenities (de Groot et al, 2015).

Consequently, we would expect it to be costlier to supply housing in larger cities, even in the absence of regulatory constraints on land supply. However, higher land prices can be offset at a dwelling/unit level, by increasing the height of development. At a city level, they can also be offset by other economic advantages that arise as a consequence of increased urban scale and density (e.g. higher productivity or amenity levels). Easing regulatory constraints on more intensive development may therefore help to "decouple", or at least mitigate, the impacts of land prices on housing costs.

2.2.1 Land price discontinuities at zone boundaries

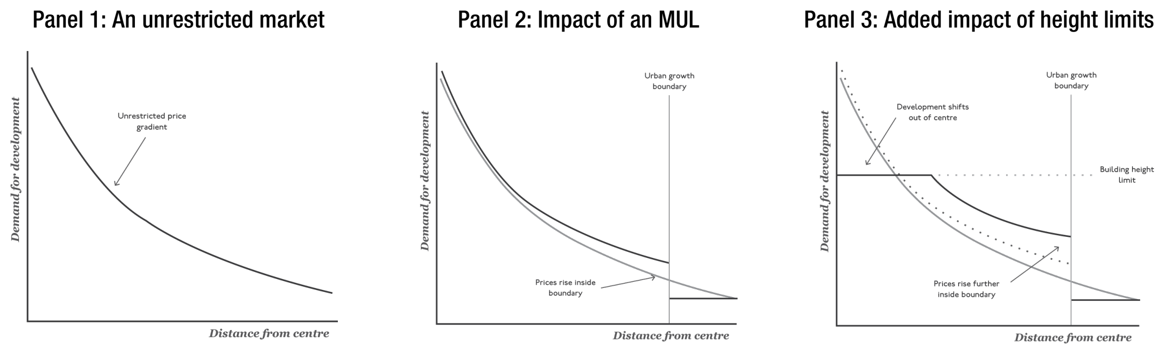
Inflexible zoning can create discontinuities in land prices at the fringe of the city or between adjacent zones within cities (NZIER, 2015b). In Auckland, most research attention has been focused on land prices around the city's Metropolitan Urban Limit (MUL), a planning instrument that defines the boundary between land that can be used for urban development and land that cannot.[5] The MUL has been identified as a constraint on land supply for urban growth (Productivity Commission, 2012). Land price discontinuities have also been hypothesised, but not empirically demonstrated, around older industrial zones in the Auckland isthmus and lower North Shore.

Land price discontinuities can reflect the impact of regulations like the MUL, which artificially limits the supply of urban land, and other regulations such as building height limits, which constrain development in the existing urban area and thus artificially inflate demand for fringe land.

This is illustrated in Figure 2. Relative to an unrestricted market (Panel 1), adding a binding MUL will tend to raise prices just inside the urban fringe, and lower them immediately outside (as shown in Panel 2). This reflects the fact that land just outside the MUL will not be able to be converted from agricultural use to higher-value urban use. However, restrictions on denser development within the city, such as building height limits, will *also* inflate the magnitude of the discontinuity, by shifting some development out of higher-value central areas and towards the fringe. (In this respect, urban development is a little like a waterbed or a game of whack-a-mole: if you push down growth in one area, it pops up in another.)

[5] However, we note that housing can still be developed in rural areas, albeit at a much lower density.

Figure 2: The causes of discontinuities in land prices at the MUL



A number of studies have examined discontinuities in land prices around the MUL boundary. Grimes and Liang (2009) found that land just inside the MUL is valued (per hectare) at approximately ten times land that is just outside the boundary. Similarly, the Productivity Commission (2012) found a differential of close to nine times in 2010. This boundary discontinuity reflects both the effect of the MUL as well as other regulations that distort the demand for land within the city.

More recently, Zheng (2013) assessed that the price differential for land either side of the MUL was 5-6 times, and that the impact is uneven, with a much larger impact on land at the lower end of the price distribution. Zheng notes that, in 2010, the price impact of the MUL was an approximate nine times multiplier for the lowest quartile of land prices and close to a two times multiplier for the upper quartile, as shown in the following table. In absolute terms, the median difference is close to $3.8 million/ha in 2015 prices.

Table 2: Land prices by distance to MUL (Source: Zheng, 2013; 2010 results in 2015$ values)

Location	Lower quartile	Median	Upper quartile
2km Inside MUL	$3,836,661	$4,615,441	$6,436,384
2km Outside MUL	$410,162	$845,056	$3,665,102
Difference	$3,426,499	$3,770,385	$2,771,283
Multiplier	9.4	5.5	1.8

Note: values converted from Q2 1995$ values to Q2 2010$ values using CPI (www.rbnz.govt.nz/monetary-policy/inflation-calculator) (Zheng had deflated using CPI); we then inflated to 2015 values using an index of Auckland house prices (Greenfield sites, including values for Albany, Manukau Rural, Papatoetoe, Rodney North and Franklin) using Real Estate Institute of New Zealand house sales data (June 2010 = 100; Dec 2015 = 161)

The land values within the MUL are based on land value data from QV. These are capital values less the value of improvements, which includes the costs of the buildings on the land but does not include the costs of infrastructure provision. The value of infrastructure is included in the land value. Thus to examine the pure land price effect, these values would also need to be accounted for. Our analysis of infrastructure costs in the Appendix suggests that they are not large enough to explain this discontinuity; however, we note that further work is needed to understand how land conversion costs vary between different locations, e.g. due to flood-prone land requiring expensive stormwater mitigation or steep hillsides requiring extensive earthworks.

Regulatory constraints on building heights

Building height limits (and other restrictions on more intensive development of land) have also been identified as constraints on urban development (Productivity Commission, 2015). To that end, a number of papers have analysed the impact of building height restrictions on the competitiveness of the development market.

Glaeser et al (2005) were the first to observe that the impact of regulations limiting building heights could be observed as large, persistent gaps between market prices for high-rise apartments (or offices) and marginal costs to build additional storeys. Cheshire and Hilber (2008) build upon their analysis, including providing a microeconomic analysis of prices with and without height limits. They observe that developing high-rise buildings entails a mix of both fixed costs (e.g. land costs and site preparation costs) and variable costs (e.g. the cost to construct additional storeys) that tend to rise as building height increases due to the need for more internal services (e.g. lifts) and strengthening.

Average costs per apartment therefore follow a "u-shaped" pattern. Up to a certain point, they fall as more storeys are added, due to the fact that fixed costs are spread over a larger number of units. Past that point, they rise again, because rising construction costs outweigh reductions in fixed costs per unit. This is illustrated in Figure 3. The X axis is building height (in storeys), while the Y axis is price per square metre. The three curves on the chart are:

- MCC = marginal construction cost for an additional storey
- AC = average cost per storey
- AVC = average variable cost (excluding fixed costs) per storey.

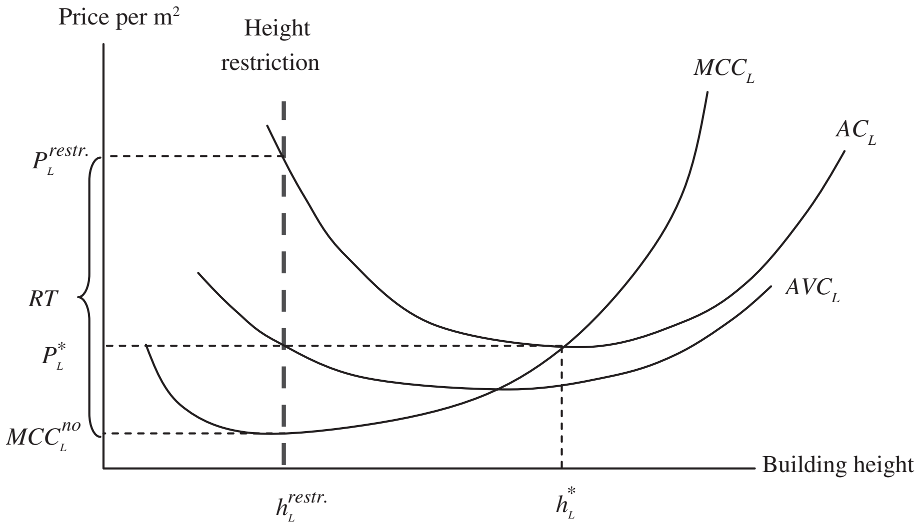
In the absence of building height limits, a profit-maximising developer would seek to minimise average costs per storey.[6] In order to do so, they would seek to build up to the point at which MCC=AC, indicated by h* on the X axis. Up to this point, marginal construction costs are lower than average development costs, indicating that it would be possible to reduce average costs by building up. Past this point, marginal construction costs are higher than average costs, indicating that costs will tend to rise.

Consequently, in an unconstrained market, prices for new apartments would tend to be roughly equivalent to marginal costs to construct additional storeys on high-rise buildings.

The impact of building height limits is also shown in this diagram. Limiting building heights to a lower level than is economically optimal for the developer – $h^{restr.}$ – can result in a situation in which average costs are substantially higher than marginal construction costs. In this case, developers would not develop apartments unless they could sell them for a price that covered average costs – i.e. $P^{restr.}$.

In other words, large, persistent deviations from marginal construction costs indicate that building height limits are constraining development and distorting prices.

Figure 3: Costs to construct high-rise buildings (Source: Cheshire and Hilber, 2008)

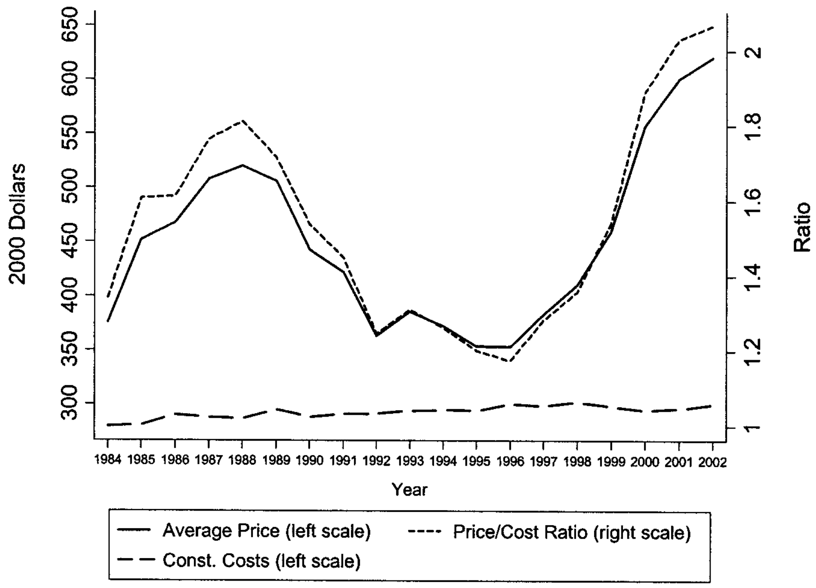


[6] This assumes that the developer is a price-taker – i.e. that they cannot directly influence the prices people are willing to pay for apartments.

Glaeser et al (2005) find evidence that Manhattan's planning regulations (including building height controls and heritage demolition controls) create a situation in which dwelling sale prices are not equal to the marginal cost to supply dwellings – indicating constrained competition. Using a database of 23,000 sales of Manhattan apartments over the period 1984 to 2002, plus data on construction costs for tall buildings, they estimate the difference between sale prices and marginal construction costs (which they describe as a "regulatory tax").

Even under conservative assumptions about construction costs and depreciation (no depreciation was calculated), the authors find evidence of a significant regulatory tax in Manhattan, rising to above 100% in 2001 and 2002, as shown in the following chart.

Figure 4: Apartment sale prices and marginal construction costs (US$/sq ft) in Manhattan (Source: Glaeser et al, 2005)



Cheshire and Hilber (2008) conduct a similar exercise for the office market in 14 UK cities and 8 European cities, finding evidence that UK cities experience an even higher regulatory tax, with office space valued several times higher than construction costs. This regulatory tax was highest in London's West End, where office floorspace was 809% more expensive than marginal construction costs over the 1999-2005 period, and lowest in Croydon (94% more expensive).

Other analytical approaches also produce evidence of constraints on competition in development markets. Brueckner et al (2015) investigate the impact of floor area ratio (FAR) restrictions on land prices in Chinese cities.[7] They use data on land transactions in 200 Chinese cities over the period 2002 to 2011 to estimate the relationship between FAR restrictions and land prices. After controlling for observed and unobserved characteristics of land parcels, they find evidence of a positive, statistically significant relationship. This relationship is stronger in some cities, and in some parts of cities, than others. For example, FAR restrictions have a stronger impact on land prices near the centre of Beijing, where the demand for tall buildings is higher. The findings of Brueckner et al provide evidence of localised "discontinuities" in land values between similar parcels with different FAR restrictions. This is prima facie evidence that this regulation limits the competitiveness of the land / development market.

[7] FAR restrictions can be calculated as a combination of maximum building height and maximum site coverage – i.e. a zone that allowed property owners to build a 2-storey building on 40% of the site would have a maximum FAR of 0.8.

The empirical literature has less to say on the impact of height limits on the competitiveness of development markets in New Zealand. Luen (2014) applies Glaeser et al's approach to investigate the relationship between sale prices and marginal construction costs for taller (3+ storey) buildings in Auckland, and draws the following tentative conclusion:

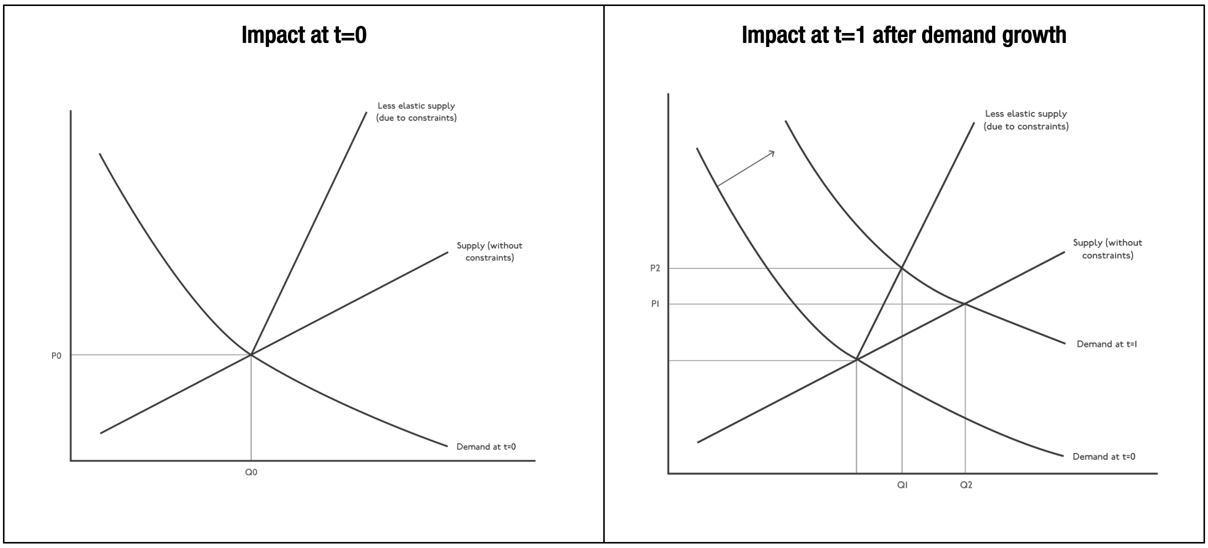
> *We find that the price to construction cost ratio was 2.64 for small dwellings, 2.47 for medium dwellings and 2.59 for large dwellings at the end of 2013 in Auckland. These ratios are large… [However] It is acknowledged that this gap is not wholly attributable to regulation, nor is it directly attributable to height restrictions.*

2.3 Housing supply tends to lag behind in uncompetitive markets

As Evans (2004) suggests, restrictions on competition in land and development market can in turn reduce the responsiveness of housing supply or business floorspace supply to rising demand. In a growing city, this means that fewer homes will be constructed and that prices (including both rents and sale prices) will rise more rapidly.

This is illustrated in the following diagram. The city begins in an "unregulated" state (left panel), and decides to implement an urban planning framework (e.g. zoning) at time t=0. This steepens the supply curve for growth beyond the current level, which reduces the rate at which new dwellings are constructed in response to higher prices. Initially, this may have little effect on the market. However, as demand rises (time t=1), housing supply lags behind where it would have otherwise been – rather than rising to Q_1, it only rises to Q_2. Furthermore, the cost of housing is higher – rising to P_2 rather than P_1 – reflecting less competitive supply.

Figure 5: Impact of reducing elasticity of housing supply (single city, ignoring externalities)



A number of papers (e.g. Mayer and Somerville, 2000; McLaughlin, 2011; Quigley and Raphael, 2005) find evidence that more restrictive planning regulations reduce the elasticity of housing supply (in US, Australian, and Californian cities, respectively). Gyourko and Molloy (2014) observe that these findings are consistent with relevant economic models but note that more panel studies of long-term housing supply dynamics are needed to fully understand the relationship.

Saiz (2010) provides one of the most comprehensive empirical studies of the impact of planning regulations, measured using the Wharton Residential Land Use Regulation Index (WRI), on housing supply dynamics in 95 large US cities over the 1970-2000 period.[8] This study importantly controls for the impact of geographic constraints, which limit the flexibility of housing supply.[9] Saiz (2010) finds that both more restrictive regulation and tighter geographic constraints are associated with lower supply elasticities. Moreover, geographic constraints appear to cause more restrictive regulation. Taking these effects into account, Saiz finds that more restrictive regulations are associated with significantly lower elasticity of supply:

> *a move across the interquartile range in the WRI of a city of one million inhabitants with average land availability is associated with close to a 20% reduction in supply elasticity: from 1.76 to 1.38.*

A movement across the interquartile range is equivalent to going from a WRI of 0.6 to a WRI of -0.4. This is approximately equal to the difference in regulatory restrictiveness between San Francisco and Houston.

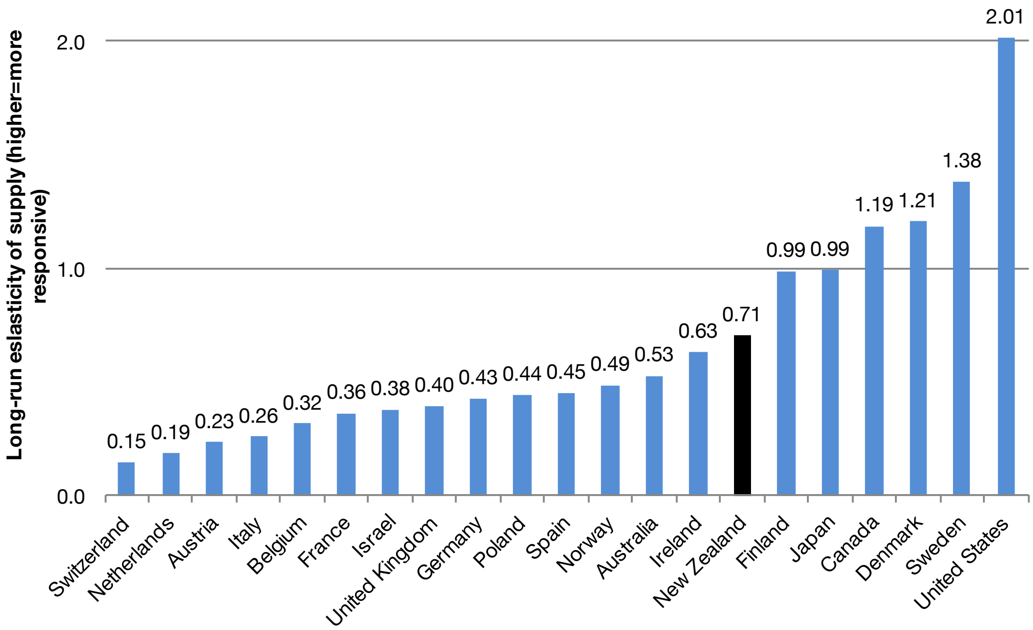
Saiz estimates that roughly one-fifth of US cities have inelastic housing supply (with an elasticity less than 1) as a result of a combination of geography and regulation. Cities without geographic constraints tend to have elasticities significantly above one, resulting in significantly greater supply responsiveness. This in turn limits the degree to which prices rise in response to increased demand for housing in those cities.

2.3.1 New Zealand-specific evidence on supply elasticities

The available data suggests that New Zealand's housing supply is, on the whole, inelastic. Caldera Sanchez and Johannson (2011) estimate the long-run price elasticity of supply for 21 OECD countries, including New Zealand, over the period from the 1980s to mid 2000s. Their results, summarised in

Figure 6, suggest that a 10% rise in house prices leads to only a 7.1% increase in the rate of construction in New Zealand. This finding is consistent with Grimes (2007), who estimates that New Zealand's elasticity of housing supply is between 0.5 and 1.1.

Figure 6: Long-run price elasticity of supply for housing in 21 OECD countries (Source: Caldera Sanchez and Johansson, 2011; Table 3)



[8] The WRI measures multiple dimensions of planning policies and processes, including local political pressure in development processes, state court involvement, project approval requirements, minimum lot sizes and open space requirements, and development contributions. For a full explanation, see Gyourko, Saiz and Summers (2008).

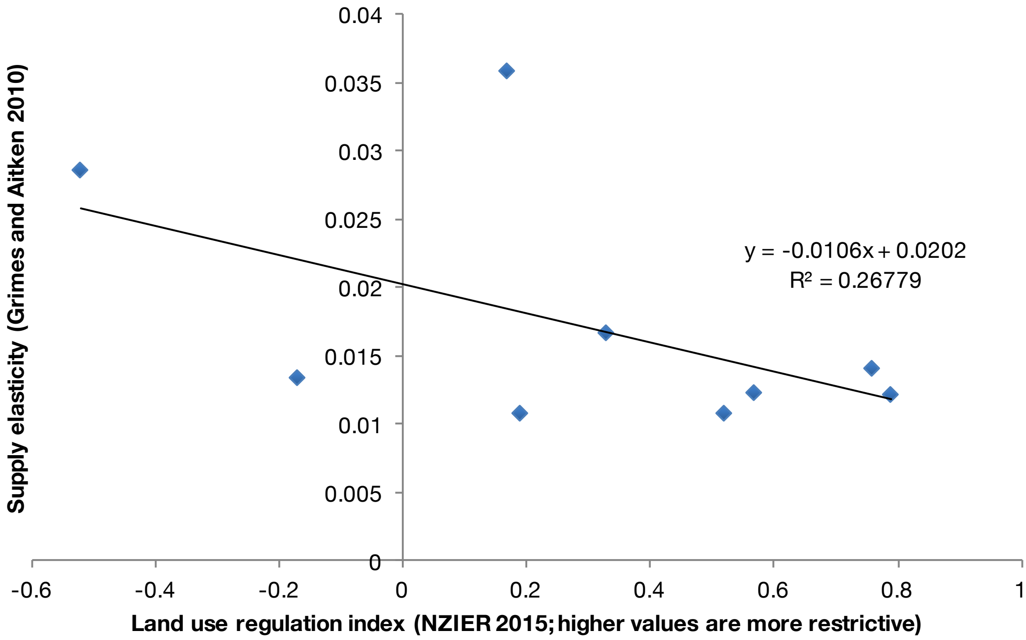
[9] As NZIER (2014) notes, Auckland is highly geographically constrained relative to large Australian cities, which we would expect to lead to a lower elasticity of supply even in the absence of restrictive planning regulations. Many other medium to large New Zealand cities are similarly constrained.

There is less data on regional housing supply elasticities. Grimes and Aitken (2010) provide some evidence on the flexibility of housing supply in response to increased demand at a territorial local authority (TLA) level, based on data from 1992 to 2004. They find that:

> *If we divide regions into urban and rural, we find faster adjustment in urban areas (average γ_{1i} = 0.0093) than in rural areas (average γ_{1i} = 0.0064). This result is consistent with an active development industry, based principally in cities, facilitating new construction.*[10]

Their coefficient for urban areas (0.0093) indicates that the rate of housing construction is expected to increase by 9.3% in response to a 10% increase in prices. Interestingly, Grimes and Aitken's TLA-level estimates of supply elasticities are negatively correlated with a WRI-style land use regulation index that NZIER (2015c) estimated for nine New Zealand councils. This relationship, which is shown in Figure 7, is consistent with overseas evidence on the relationship between restrictive urban planning policies and practices and less elastic housing supply.

Figure 7: Relationship between land use regulation index and supply elasticity for nine NZ councils



[10] γ_{1i} is a parameter estimating the responsiveness of new housing supply to demand shocks / price increases.

3 Are existing urban policies efficient?

In this section, we briefly survey existing evidence on the costs and benefits of specific planning rules in Auckland. We make two key observations about this literature:

- First, it is open to challenges of *incompleteness*, as it is common to quantify the costs of specific planning rules but not the benefits associated with those rules
- Second, previous attempts to evaluate planning regulations have employed *static models* that focus on the cost of regulations at a point in time rather than their impact on market dynamics. They may therefore underestimate the long-run effects of some regulations.

We address the first critique in this section by estimating the magnitude of benefits associated with planning rules, e.g. from avoided negative externalities or avoided infrastructure costs, and comparing them with previous modelled estimates of the cost of two selected regulations: Auckland's MUL and building height limits. Even ignoring the effects of these regulations on the competitiveness of land and development markets, their costs appear to outweigh the benefits by a significant margin. This suggests that current policies are inefficient at managing market failures in the built environment.

In the next section, we address the second critique, at least in part, by looking at some simple ways to analyse the costs and benefits associated with changes to urban planning policies that affect market dynamics.

3.1 Previous evidence on the costs of regulations

Some evidence on the costs of regulation is summarised in Table 3. These studies suggest that regulations are likely to impose significant costs on development in Auckland, with specific regulations that impose costs in the range of tens of thousands of dollars on households or businesses.[11]

However, less evidence is available comparing the costs and the benefits of planning regulations in New Zealand. The only study to comprehensively undertake such a comparison is MRCagney (2013), who compare the costs of MPRs with the benefits in terms of avoided parking management costs. MRCagney (2014) also provides evidence that suggests that the health and amenity benefits of minimum apartment size rules are likely to be considerably smaller than the economic costs. This may open these studies up to challenges of incompleteness, making it difficult for policymakers to accept findings.

A further observation is that all of these studies assess the costs of regulations using static models. In other words, they assess the costs of regulations at a single point in time by comparing between two equilibrium states. Key approaches include the Alonso-Mills-Muth model, a general equilibrium model of city structure used by NZIER, 2014, 2015a, partial equilibrium approaches employing comparative statics or empirical analysis of prices (e.g. MRCagney, 2013, 2014), and surveys of developer responses to regulatory requirements (Grimes and Mitchell, 2015).

As we demonstrate below, results from these studies can be used as a starting point for understanding the relative magnitude of costs and benefits of specific planning regulations at a point in time.

[11] Unfortunately, a similar level of evidence is not available for other New Zealand cities.

Table 3: Overview of recent findings on the cost of legacy zoning provisions in Auckland

Study	Dwelling type / regulation type	Estimated gross cost
MRCagney (2013)	Impact of minimum parking rules on the value of retail development in town centres	$19,000 per excess parking space Based on an estimated oversupply of 25-50%, this suggests that MPRs reduce the value of three mid-sized retail centres by a total of $75.7m to $157.5m, plus added congestion costs of $12.3m. The net benefit of this policy is negative.
MRCagney (2014)	Impact of minimum dwelling size rules on the cost of small (city centre) apartments	$50,000 to $100,000 per apartment
NZIER (2014)	Impact of MUL on Auckland households' housing and transport costs	Annual cost of $859-$4,560 per household per annum, depending upon the degree to which the MUL could be expanded. This equates to a total cost of $10,500-$55,600 per household in present value terms (30 years; 8% discount rate)
NZIER (2015a)	Impact of building height limits (and other limits on density) on Auckland households' housing and transport costs	Annual cost of $933 per household per annum, based on a 3-storey building height limit. This equates to a total cost of $11,300 per household in present value terms (30 years; 8% discount rate)
Grimes and Mitchell (2015)	Impact of provisions governing building heights, floor to ceiling heights, dwelling mix, and other design features on the cost of apartments	$65,000 to $110,000 per apartment
	Impact of provisions governing section size, dwelling density, site coverage, and other design features on the cost of standalone houses	$32,500 to $60,000 per house

3.2 Auckland's Metropolitan Urban Limit

The key costs and benefits of Auckland's MUL are as follows:

- **Costs**: Higher housing costs as a result of constrained land for development
- **Benefits**: Reduced external costs of infrastructure provision to greenfield areas; reduced congestion from shorter travel distances;[12] preservation of peri-urban open space.

NZIER (2014) use the Alonso-Muth-Mills "monocentric city" model to estimate the impact of expanding Auckland's MUL on housing and transport costs faced by city residents. This model is a standard urban economics model that is commonly used to simulate the impacts of development restrictions, albeit with some simplifying assumptions about household and developer behaviour (e.g. that all residents commute to central employment). It assumes that all households rent dwellings and as a result directly bear the costs of development restrictions. NZIER have calibrated this model to Auckland using observed data on the city's geography, household incomes, housing costs, and travel costs. They model a 22% increase in the amount of land available within the MUL – resulting in a considerable increase in the city's urbanised area.[13] These modelling results can be used to understand the costs and benefits of Auckland's MUL.

The following diagram displays the modelled outcomes from this policy change (alongside other scenarios modelled in the paper). The key changes are a reduction in housing costs, an increase in dwelling sizes as people are able to afford larger houses, and a reduction in population density throughout the city. The land price gradient also changes, with prices falling nearer the centre and rising at the outskirts of the city. Average travel

[12] See Nunns (2014) for an analysis of Census data on commuting distances, as well as overall location-based costs, in Auckland, Wellington and Christchurch. This analysis shows that average commute distances rise with distance from the city centre in all three cities.

[13] However, this modelling does not take into account the impact of other regulatory constraints, such as building height limits.

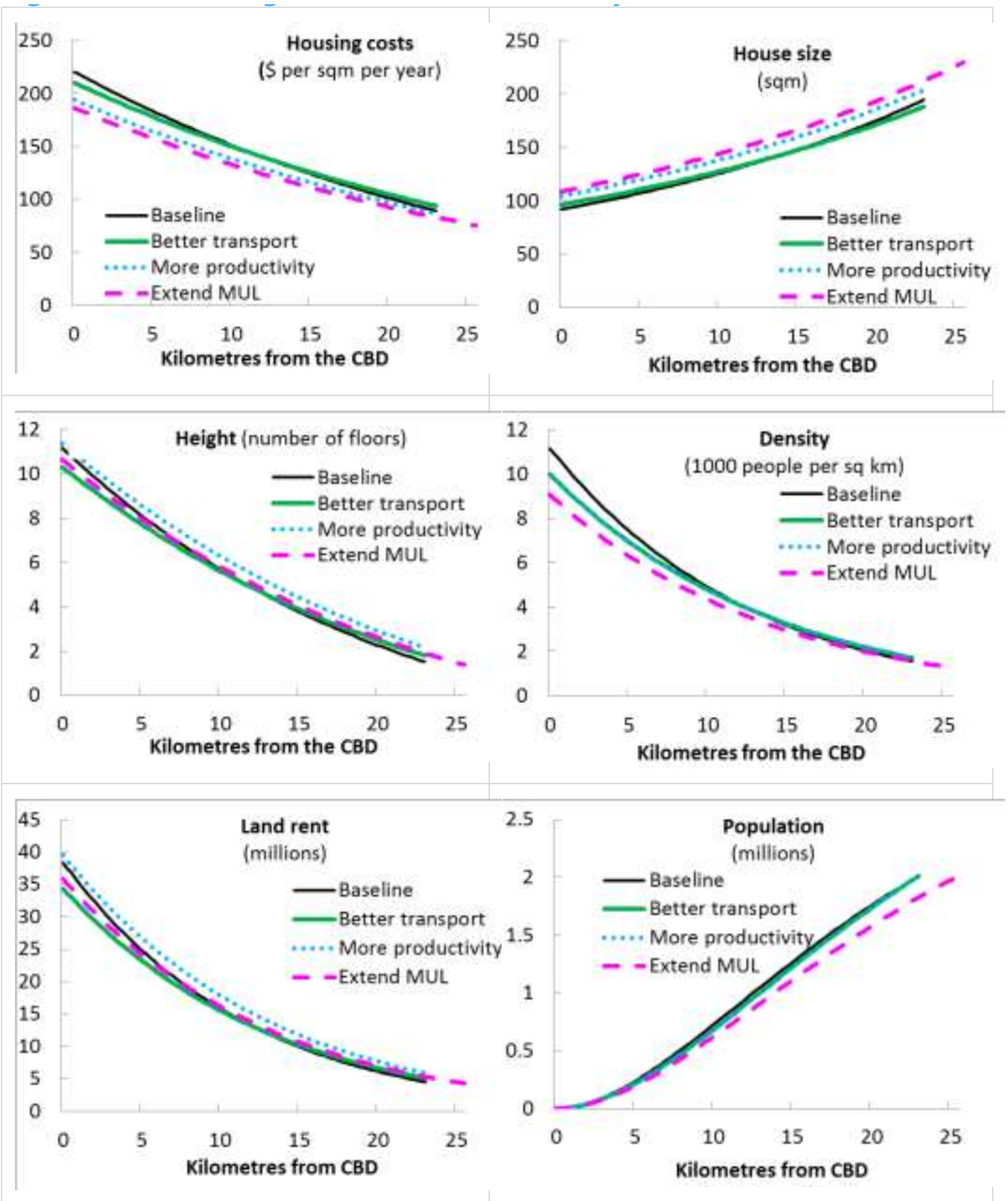
distances increase by 8.21% as a result of the fact that households live further from the centre of gravity for employment (see Figure 15 in NZIER, 2014).

The overall effect of relaxing the MUL is to reduce the combined housing and transport costs facing Auckland households by $859 per annum. The following table estimates the total benefits in present value terms.

Table 4: Benefits of relaxing Auckland's MUL

Variable	Value	Source
Annual benefit per household	$859	Lees (2014)
Number of households in Auckland	469,497	Statistics NZ, 2013 Census
Total annual benefits	$403m	Calculated based on above figures
Present value of benefits	$5,761m	7% discount rate

Figure 8: Impact of extending Auckland's MUL (Source: NZIER, 2014)



We can also employ NZIER's modelling results to estimate the additional externalities associated with expanding Auckland's MUL. In the Appendix, we review a range of empirical evidence on the magnitude of various externalities associated with urban growth, including congestion, infrastructure costs, and loss of access to peri-urban open space.

First, we estimate the costs of additional road use associated with increasing the MUL. Following Wallis and Lupton (2013), we estimate that the long run average cost of additional road use, in terms of requirements to expand road capacity to offset worsening travel speeds, is $0.65 per peak vehicle kilometre (in 2015 NZD). This reflects a rough estimate of the external costs associated with added road travel that are not borne by users. The following table estimates the total road infrastructure cost associated with expanding the MUL.

Table 5: Added road infrastructure costs from expanding the MUL

Variable	Value	Source
Modelled increase in peak travel	8.21%	NZIER (2014)
Estimated peak vehicle kilometres in Auckland (2006)	6,682,878	Wallis and Lupton (2013)
Long run average cost per added peak vehicle kilometre ($/year/peak veh-km)	$0.65	Wallis and Lupton (2013), updated to 2015 NZD
Annualisation factor	250	Assuming 250 working days per annum
Estimated daily increase in peak vehicle kilometres	548,664	Calculated based on above figures
Annual cost of additional road travel	$89m	Calculated based on above figures
Present value of costs	$1,270m	7% discount rate

We note that there are likely to be further costs for other network infrastructure such as water, wastewater, and stormwater. However, an analysis of Auckland Council's development contributions policy, Watercare's Infrastructure Growth Charges, and available data on infrastructure costs suggests that these costs are likely to be comparable in magnitude to or smaller than road infrastructure costs.

Second, we estimate the costs of foregone access to peri-urban open space. Following Brander and Koetse (2011), we estimate that city residents derive present value benefits of $38,750-$67,750 per hectare of peri-urban open space. The following table uses this figure to estimate this cost of expanding the MUL.

Table 6: Cost of foregone access to open space from expanding the MUL

Variable	Value	Source
Modelled increase in urbanised land area	130.2	NZIER (2014) models an increase in the MUL area from 577.7 km2 to 707.9 km2
Hectares per square kilometre	100	
Present value of external value of peri-urban open space	$44,395 to $77,620 / ha	Brander and Koetse (2011), converted to 2015 NZD
Present value of costs	$578m to $1,011m	7% discount rate

We note that this is likely to overstate the value of peri-urban open space preserved by the MUL, as Brander and Koetse (2011) find that the per-hectare value of open space is lower for larger areas. However, we have also not accounted for other externalities associated with conversion of open space to urban use, such as water quality impacts, due to difficulty estimating impacts, although our analysis in the Appendix suggests that they are smaller in magnitude than the costs of lost peri-urban open space.

The following table puts this together. On the whole, expanding Auckland's MUL is likely to lead to substantial net benefits, on the order of $3 billion in present value terms. Conversely, this analysis suggests that maintaining this policy is likely to be economically inefficient.

Table 7: Net benefits of expanding Auckland's MUL

Variable	Present value (7% discount rate)
Benefits for city residents (lower housing costs)	+$5,761 million
Cost of additional road infrastructure	-$1,270 million
Cost of other network infrastructure	Not estimated but we assume that other infrastructure costs are similar in magnitude to road infrastructure costs
Cost of foregone peri-urban open space	-$578 million to -$1,011 million
Net benefits	**+$3,481 million to +$3,914 million**

3.3 Building height limits in Auckland

The key costs and benefits of Auckland's building height limits are as follows:

- **Costs**: Higher housing and transport costs as a result of constraints on development capacity; increased congestion (or infrastructure requirements) as a result of the fact that people must live further away from key destinations
- **Benefits**: Avoided overshadowing / blocked views from development of tall buildings.

NZIER (2015a) use the Alonso-Muth-Mills "monocentric city" model to estimate the impact of Auckland's building height limits on housing and transport costs faced by city residents. This model is a standard urban economics model that is commonly used to simulate the impacts of development restrictions, albeit with some simplifying assumptions about household and developer behaviour (e.g. that all residents commute to central employment). It assumes that all households rent dwellings and as a result directly bear the costs of development restrictions. NZIER have calibrated this model to Auckland using observed data on the city's geography, household incomes, housing costs, and travel costs. They estimate the impact of a three-storey building height limit throughout the city.[14] These modelling results can be used to understand the costs and benefits of height limit policies.

The following diagram displays the modelled outcomes from this policy change (alongside other scenarios modelled in the paper). The key changes are a reduction in housing costs, an increase in dwelling sizes, an increase in population density in the inner areas of the city, and a *reduction* in population densities in the outer areas of the city. The land price gradient also changes, with prices rising nearer the centre and falling at the outskirts of the city. Average travel distances fall as a result of the fact that households are able to live closer to the centre of gravity for employment.

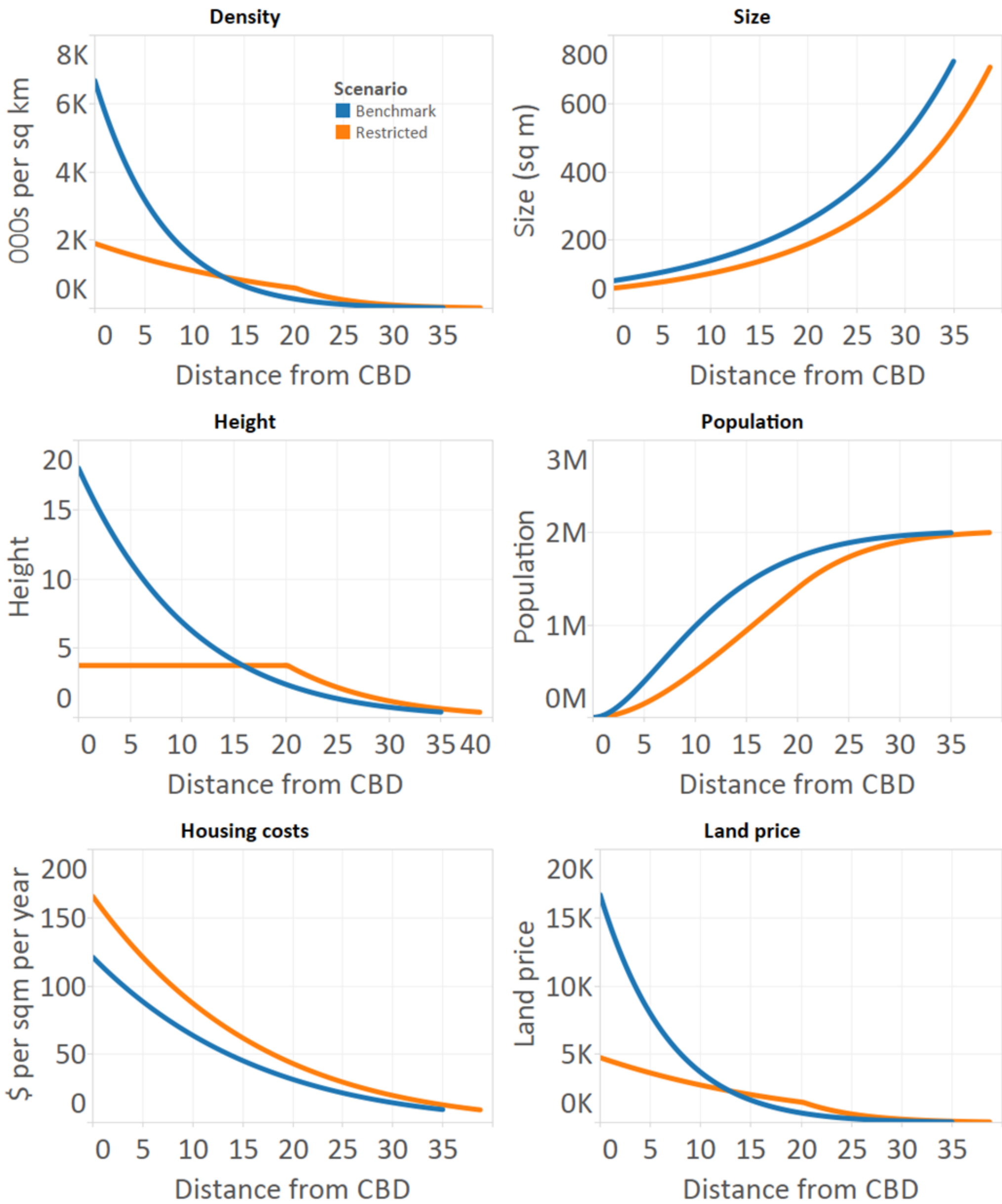
The overall effect of relaxing building height limits is to reduce the combined housing and transport costs facing Auckland households by $933 per annum. The following table estimates the total benefits in present value terms.

[14] NZIER calibrate the city's building height limits to roughly match observed population densities. However, we note that Auckland's existing and proposed residential zoning policies often result in a lower building height limit of two storeys. Conversely, building height limits are considerably higher in the city centre, where considerable residential development has occurred over the last two decades. In addition, it is unclear how NZIER have factored in limits on maximum site coverage, which also constrain density.

Table 8: Benefits of lifting Auckland's building height limits

Variable	Value	Source
Annual benefit per household	$933	NZIER (2015a)
Number of households in Auckland	469,497	Statistics NZ, 2013 Census
Total annual benefits	$438m	Calculated based on above figures
Present value of benefits	$6,258m	7% discount rate

Figure 9: Impact of Auckland's building height limits (Source: NZIER, 2015a)



We can also employ NZIER's modelling results to estimate the additional externalities that are either controlled or exacerbated by Auckland's building height limits. In the Appendix, we review a range of empirical evidence on the magnitude of various externalities associated with urban growth, including congestion and the costs of overshadowing.

First, we estimate the costs of additional building overshadowing associated with relaxing building height limits. We begin by observing (following Figure 8 in NZIER, 2015a) that the expected impact will be higher population densities within 8 kilometres of the city centre, and lower population densities in more outlying areas.

Consequently, by focusing on the additional costs of overshadowing within inner areas, we may fail to account for benefits related to reduced overshadowing or crowding externalities in outlying parts of the city.

NZIER's model suggests that the inner areas of Auckland would be more continuously developed, with higher-rise buildings in these areas. Consequently, we follow Strømann-Andersen and Sattrup (2011), who model the externalities associated with increased household energy costs in "urban canyons".[15] However, we also sensitivity test a higher scenario in which new apartments overshadow lower-density areas. The following table estimates the negative overshadowing externalities associated with relaxing Auckland's building height limits.

Table 9: Added overshadowing costs from lifting building height limits

Variable	Value	Source
Estimated share of households living in areas with tall buildings	50%	Estimated based on modelling results from NZIER (2015a) – roughly equivalent to 10km radius around city centre
Number of households in Auckland	469,497	Statistics NZ, 2013 Census
Estimated present value cost of overshadowing per dwelling	$4,230 to $9,832	See Appendix for calculations
Present value of costs	$993m to $2,308m	7% discount rate

Second, we estimate the benefits associated with reduced traffic congestion. NZIER do not provide an estimate of the modelled change in peak travel resulting from a relaxation of building height limits. However, we note that their model implies that the city would occupy approximately 15% less land in the absence of building height limit.[16] As NZIER (2014) found that a 22% increase in the city's urbanised area was associated with an 8.21% increase in peak travel, we therefore estimate that a 15% reduction in urbanised land area would be associated with a proportionate reduction in peak travel – 5.6%.[17] The actual effect may be different, as building height limits will also change the distribution of population (and employment) within the city.

Table 10: Benefit of reduced road infrastructure costs from lifting building height limits

Variable	Value	Source
Estimated reduction in peak travel	5.60%	Estimated based on NZIER (2014, 2015a)
Estimated peak vehicle kilometres in Auckland (2006)	6,682,878	Wallis and Lupton (2013)
Long run average cost per added peak vehicle kilometre ($/year/peak veh-km)	$0.65	Wallis and Lupton (2013), updated to 2015 NZD
Annualisation factor	250	Assuming 250 working days per annum
Estimated daily reduction in peak vehicle kilometres	374,241	Calculated based on above figures
Annual benefit of reduced road travel	$61m	Calculated based on above figures
Present value of benefits	$866m	7% discount rate

We note that there are likely to be some further cost savings for other network infrastructure such as water, wastewater, and stormwater. As above, these costs are likely to be comparable in magnitude to transport infrastructure costs; however, they are difficult to precisely estimate.

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[15] As we discuss in the Appendix, in intensely developed areas, when an apartment blocks the views or access to sunlight of another apartment, it will tend to gain access to said views/sunlight. Consequently, we would expect these external costs to be cancelled out within these areas.

[16] Estimated based on Figure 10, which shows that the city would extend 35 kilometres without height limits, or 38 kilometres with height limits.

[17] Calculated as 8.21% * 15% / 22%.

The following table puts this together. On the whole, lifting Auckland's building height limits is estimated to result in substantial net benefits, on the order of $3-5 billion in present value terms. Conversely, this analysis suggests that maintaining this policy is likely to be economically inefficient.

Table 11: Net benefits of raising Auckland's building height limits

Variable	Present value (7% discount rate)
Benefits for city residents (lower housing and transport costs)	+$6,258 million
Benefits of reduced road infrastructure costs	+$866 million
Benefits of reduced costs for other network infrastructure	Not estimated but we assume that other infrastructure costs are, on average, similar in magnitude to road infrastructure costs
Cost of overshadowing	-$993 million to -$2,308 million
Net benefits	**+$4,816 million to +$6,131 million**

4 Is enabling urban growth beneficial?

Section 2 described how urban planning policies can alter the dynamics of urban development markets, making them less elastic in response to growing demand for housing (or business space). As we demonstrated in Section 3, it is possible to analyse the costs and benefits of specific planning regulations using static models that do not take into account these dynamic effects.

However, capturing dynamic effects related to the competitiveness and responsiveness of land and development markets may be important for a more holistic analysis, e.g. for strategic policy-making at the regional or national level. To that end, we consider some simple, quantitatively tractable models that can be applied to quantify the relative magnitude of several costs and benefits and understanding the net implications for wellbeing:

- First, more enabling urban planning policies can allow development to happen more flexibly and at a lower cost. This will result in **benefits to consumers of housing (or business space)**, who will be able to locate in New Zealand cities at a lower cost.
- Second, setting all else equal, enabling policies will allow New Zealand cities to grow larger, and potentially with different spatial forms. This may result in **additional positive and negative externalities** associated with housing / business development and city size.

There will also be some transfers of value between current and future residents. For example, if housing prices appreciate less rapidly, then newcomers to the city will benefit. However, if they are buying housing from existing residents, then there will also be a countervailing cost for those who are selling.[18]

4.1 Analysing the consumer benefits of enabling urban development

We employ two microeconomic models of aggregate urban housing markets in order to estimate the potential effects of enabling urban development for new urban residents. These models enable us to estimate the following key variables:

- Changes in housing costs for new residents – i.e. changes in average house prices[19]
- Impacts on city size – i.e. the degree to which lower house prices would encourage more people to move to the city, either from other parts of New Zealand or overseas[20]
- Consumer surplus arising from lower housing costs.

At this stage, we have not "disaggregated" these models to analyse housing "sub-markets" such as apartment markets versus standalone house markets, or markets for houses of different size. This represents a limitation of these models and a potential area for further research.[21]

However, we consider that achieving lower prices (relative to the status quo scenario) will require the construction of a variety of housing, rather than a single type (e.g. only standalone houses). Housing demand is

[18] There will also be some costs as a result of reduced value of property sales to foreign investors. Here, we discount these costs as the available evidence suggests that overseas buyers probably make up a small share of the market – noting that there is some uncertainty on these issue.0

[19] Variants of these models could focus instead on rents, or even combined housing and transport costs.

[20] We then use estimates of the impact on city size to estimate the additional positive and negative externalities associated with growth.

[21] One potential approach for extending these models is the general equilibrium approach developed by Coleman and Scobie (2009). They model the interactions between home ownership and rental markets, which are substitutes for each other. They find that restrictions on one market lead to some spillovers between markets as well as some offsetting effects. For example, raising the cost of home ownership (e.g. through higher mortgage interest rates) will encourage some people to rent instead, which will in turn push up prices in the rental market. However, it will also cause some formerly owner-occupied homes to be converted into rental properties, which will partially offset rent increases. Coleman and Scobie's approach could be adapted to examine the relationship between, for example, markets for standalone houses and apartments.

not homogenous – different people need and desire different types of housing in various locations, and face different costs and budget constraints in meeting their needs. Failing to meet some of these demands will reduce wellbeing even if the *aggregate* quantity of housing is large enough to meet aggregate demand.

Our first model is a "comparative statics" model of housing supply dynamics under alternative scenarios for elasticity of housing supply. The key assumption underpinning this model is that planning regulations can reduce the elasticity, or flexibility, of housing supply. Over time, this means that less housing will be built in response to rising demand, leading to higher prices, and ultimately a smaller city (in terms of both number of dwellings and urban population) than would otherwise be the case.[22]

Our second model is an econometric model estimating the quantity of new construction required to stabilise housing price growth in urban areas. This model was developed by the California Legislative Analyst's Office (LAO, 2015) for use in policy analysis in the Californian context.[23] The key assumption underpinning this model is that if housing supply is constrained, prices must rise until some households exit the market, which may mean moving to another location or crowding into existing dwellings. Once again, this assumption is supported by economic theory and empirical evidence – the LAO finds that cities that experience lower growth in housing stock also experience more rapid price increases.

4.1.1 Model 1: A model of housing supply elasticity under alternative regulatory regimes

Our first model attempts to understand how urban housing markets may evolve under more or less stringent planning regulations using a "comparative statics" approach.[24] This model draws upon empirical insights from the international literature on the impact of planning regulations on housing supply summarised in Section 2.

Over time, less elastic supply will lead to increased housing prices and larger economic costs, as growth in housing supply lags behind growth in demand. The economic costs are deadweight losses; these are the losses of consumer surplus (the difference between the benefits that would have been obtained by the owners of the houses that have not been built and the costs of their construction) that arise because of inflexible supply. People who would have purchased houses end up with some outcome they regard as inferior, e.g. sharing accommodation, renting or moving somewhere else.

Figure 10 illustrates these dynamics in a simple supply and demand diagram. It includes the following elements:

- A demand curve that shifts outwards over time, showing the impact of population growth from natural increase or migration as well as income growth increasing demands for housing
- Two supply curves – the "status quo" curve is steeper than the "option" curve, indicating that housing will be constructed more slowly in response to rising demand.

We can use this analysis to estimate net consumer benefits for entrants to the housing market (e.g. new entrants to the city, people forming new households, or people buying new rental properties to meet demand), as well as transfers between existing households and new entrants that do not result in net benefits (or disbenefits) but which may have distributional consequences.

If we compare between the two supply scenarios, we observe that:

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[22] It will also tend to contribute to residential overcrowding and the health problems associated with poor housing stock.

[23] The LAO recently undertook a review or urban planning issues that covered much of the same territory as the Productivity Commission's recent inquiries.

[24] Comparative statics is the comparison of economic outcomes before and after changes to exogenous parameters – e.g. shocks to supply or demand. This analysis does not consider the path that markets may follow in transitioning between two alternative equilibrium states.

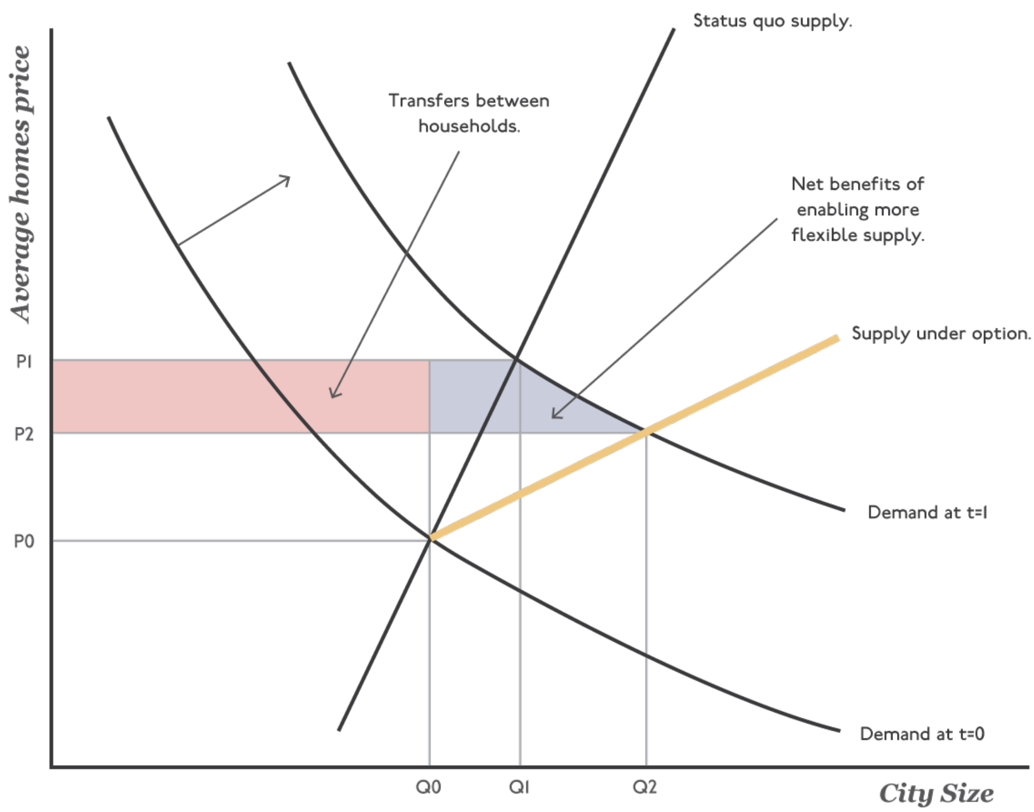
- Growth under the "status quo supply" scenario will result in some increase in city size (Q1) and significantly higher prices (P1) relative to time t=0. This primarily reflects the fact that some people will be unable to live in the city due to high prices (or will be forced to accept crowded living conditions).
- Growth under the "option" scenario will result in a larger city size (Q2) than at time t=0 and relative to Q1, and lower prices (P2) than for the same point in time under the status quo supply option.

The blue-shaded area between Q_0 and Q_2 represents an increase in consumer surplus that accrues to those who constitute the additional demand. This reflects the fact that there is an increase in dwellings due to construction of new supply. This area can be estimated as follows:

$$Consumer\ surplus = (P_1 - P_2) * \left[\frac{(Q_1 + Q_2)}{2} - Q_o\right]$$

By contrast, the red-shaded area between zero and Q_0 represents a *transfer* between households. This reflects the fact that the value of existing homes (Q0) will tend to appreciate less rapidly if more new homes are built in response to growth. This is described as a transfer, rather than a net benefit or net cost, because the benefits accruing to buyers of these houses (in terms of cheaper housing) are offset by the fact that existing owners can't sell (or rent) their houses for as much. We have therefore excluded the red-shaded area from our calculations of consumer surplus to avoid over-stating the benefits of enabling a more responsive urban development market. However, we note that under this set of assumptions, existing residents will not incur any actual *losses*, as house prices would continue to rise at a slower pace.

Figure 10: Additional consumer surplus arising from increased elasticity of housing supply



In order to estimate a simple model of housing supply dynamics under different scenarios for housing supply elasticity, we need to specify:

- An aggregate demand curve for housing in a single city. Typical variants are linear demand curves and constant-elasticity demand curves (Parker, 2013)
- An aggregate supply curve for housing in that city, with the existing (status quo) planning regulations staying in place
- An aggregate supply curve for housing in that city, under a policy option that encourages councils to adopt a more flexible approach to urban planning to enable housing supply

If we impose linearity on the supply and demand curves, then we can estimate them using the equations in Table 12.

Table 12: Linear supply and demand curves for modelling city growth under alternative elasticity of supply scenarios

Curve	Functional form
Demand at t=0	$Q_D = \frac{P_{max} * Q_o}{P_{max} - P_o} - \frac{Q_o}{P_{max} - P_o} * P$
Demand at t=1	$Q_D = \frac{P_{max} * Q_o}{P_{max} - P_o} * g - \frac{Q_o}{P_{max} - P_o} * P$
Supply under status quo regulation	$Q_{dm} = \left(E_{dm} * \frac{Q_o}{P_o}\right) * P + (Q_o - E_{dm} * Q_o)$
Supply with policy option	$Q_{opt} = \left(E_{opt} * \frac{Q_o}{P_o}\right) * P + (Q_o - E_{opt} * Q_o)$

Table 13 summarises the parameters that we used for estimating this model.

Table 13: Model variables and sample values

Variable	Description	Example value
Q_o	City size at time t=0 (e.g. number of residents or number of households)	500,000 households – roughly equivalent to Auckland today
P_o	Price of living in the city at time t=0 (e.g. average home price)	$750,000 / dwelling – approximately equal to current median Auckland house price[25]
P_{max}	Intercept for demand curve – implicitly, the average price at which the quantity of people living in the city would be equal to zero	$2.5 million average dwelling price
g	Growth in demand – modelled here as an increase in the demand curve intercept	20% - roughly equivalent to Auckland population increase from 2001 to 2013
E_{dm}	Elasticity of housing supply under the status quo scenario	0.8 (in range of current Auckland outcomes)
E_{opt}	Elasticity of housing supply under the option scenario	A baseline value of 1.0 (based on Saiz's finding that a one-point reduction on the WRI index is associated with a ~25% increase in elasticity) and a range of 0.9 to 2.0

Table 14 summarises modelled outcomes for housing prices and city size under a range of supply elasticities. Under our benchmark calibration, which is highlighted in bold, we obtain the following results if the elasticity of housing supply increased from 0.8 to 1.0:

- The city would be larger – over the modelled period population would increase by 23.3% rather than 18.6%. This would result in an additional 23,300 households living in Auckland.
- House prices would rise more slowly in response to growing demand – 20% rather than 23.3%.
- This would lead to a total of $2.6 billion in consumer surplus (in undiscounted terms), as new entrants to the housing market would be able to access housing (including newly constructed housing) at lower prices.

[25] From REINZ: http://www.interest.co.nz/charts/real-estate/median-price-reinz

This equates to approximately $110,000 in added consumer surplus per additional household living in the city.

Table 14: Simulated outcomes of increasing elasticity of housing supply

Elasticity under policy option	Status quo scenario (elasticity=0.8)		Impact of policies to increase supply elasticity		Added consumer surplus[26]
	Average house price (P_{SQ})	City size (households) (Q_{SQ})	Average house price (P_{Opt})	City size (households) (Q_{Opt})	
0.9	$924,419	593,023	$911,290	604,651	$1.3bn
1.0			**$900,000**	**616,279**	**$2.6bn**
1.1			$890,187	627,907	$3.8bn
1.2			$881,579	639,535	$5.0bn
1.3			$873,967	651,163	$6.2bn
1.4			$867,188	662,791	$7.3bn
1.5			$861,111	674,419	$8.5bn
1.6			$855,634	686,047	$9.6bn
1.7			$850,671	697,674	$10.7bn
1.8			$846,154	709,302	$11.8bn
1.9			$842,025	720,930	$12.9bn
2.0			$838,235	732,558	$14.0bn

One feature of this model is that the added consumer surplus per additional household living in the city is not very sensitive to assumptions about how much the elasticity of supply may change under a policy option. If the elasticity rises significantly – to, say, 1.5, the city will increase to a larger size as a result of growth in demand. However, the consumer surplus per added household will only fall slightly – to approximately $104,000 per added household. This suggests that there may be relatively little potential for "diminishing returns" from enabling increasingly flexible / responsive urban development.

4.1.2 Model 2: Supply, prices, and the "rationing" of housing

The California Legislative Analyst's Office (LAO) recently undertook a review of the causes and consequences of California's high housing costs. The LAO concluded that "building less housing than people demand drives high housing costs". In order to quantify this relationship, and understand the quantity of housing that would have to be constructed in order to satisfy demand and stabilise prices, they developed an econometric model of the relationship between housing supply and prices.

The LAO estimated this model using panel data on housing prices and supply in large US counties (>850,000 people) from 1980-2010, controlling for exogenous supply and demand factors (geographic constraints, climate, unemployment). The model finds that a 10% increase in house prices in a county is associated with 8.3% less growth in housing supply – a finding that they interpret as evidence that places that experience lower rates of construction must *also* experience more rapid price increases in order to "ration" some people out of the market.

[26] Consumer surplus is equivalent to the shaded blue area in Figure 10 above. It is calculated as follows:

$$Consumer\ surplus = (Q_{SQ} - Q_0) * (P_{SQ} - P_{NPS}) + \frac{1}{2} * (Q_{NPS} - Q_{SQ}) * (P_{SQ} - P_{NPS})$$

Higher prices in neighbouring counties also tend to push up local demand for housing – evidence of "spatial spillovers" between adjacent housing markets.

Table 15: California LAO model of the relationship between housing supply and prices

Figure A-1

Housing Demand Regression Results

Dependent Variable: Ten-Year Growth in Housing Units

Independent Variable[a]	Coefficient	Standard Error
Home price	-0.83[b]	0.10
Average of neighboring counties' home prices	0.16[b]	0.05

[a] Control variables were also included, but are not reported here. All independent variables, except for dummy variables, are in logs.

[b] Statistically significant at 1 percent level.

Based on this model, the LAO estimates that California would have had to build new homes 60-90% faster than it actually did in order to keep California's housing prices in line with national housing prices over the 1980-2010 period.

While there are institutional and economic differences between New Zealand and the US,[27] we can apply this model in the New Zealand context to obtain a rough estimate of the additional quantity of housing that Auckland (or other large cities) would have had to supply in order to reduce the rate of house price appreciation over the 2001-2013 Census period.[28]

We use this model to analyse the effects of enabling more responsive urban development over the past three Census periods. In other words, this model considers an alternative scenario for the recent past, rather than a scenario for the near future along the lines of Model 1.

To that end, Table 16 summarises data on Auckland's usually resident population and total (occupied and unoccupied) dwellings from the 2001, 2006, and 2013 Census, and REINZ's stratified median house price index over the same period. (The REINZ index has been converted from nominal to real terms using Statistics NZ's consumer price index.) Over this period, Auckland's population grew by 22%, its housing stock increased by 19%, and real median house prices increased 78%. However, it is possible – indeed likely – that population would have increased faster if the supply of new housing had been less constrained.

Table 16: Auckland region population, housing supply, and median home prices

Time	Usually resident population	Total dwellings (occupied + unoccupied)	Real median house price index
2001	1,160,271	424,848	100
2006	1,304,958	473,031	151
2013	1,415,550	506,811	178
% change	22%	19%	78%

[27] Institutional differences include different government models – the US has a federal system while NZ is more strongly centralised – and economic differences include differences in scale and composition of economies. One particular issue for transferring the model is that the structural relationship that it estimates between house price growth and supply growth depends upon the background level of population/income growth in the US. World Bank data suggests that New Zealand and the United States experienced similar growth rates over the period covered by the LAO's model – New Zealand's population grew 39.8% from 1980 to 2010, while the US population grew 36.1%.

[28] Prices may be high even in a competitive market. However, there is evidence that Auckland's housing prices are distorted by regulations that limit the competitiveness of land and development markets, such as building height limits and the city's MUL.

The LAO model allows us to "simulate" the impact of a lower rate of real house price inflation on housing demand in Auckland. For example, if Auckland's real house prices had appreciated half as rapidly over this period – i.e. if they had gone up 39% rather than 78% - then the resulting increase in household formation in the city can be calculated as follows.

Equation 1: Estimated increase in housing demand associated with a lower rate of house price inflation

$$\begin{aligned} &\mathit{Increase\ in\ household\ formation} \\ &\quad = (\mathit{Reduction\ in\ real\ house\ price\ increase}) \\ &\quad * (\mathit{Elasticity\ of\ housing\ demand\ w.r.t.real\ price}) = (-0.39) * (-0.83) \\ &\quad = +32\% \end{aligned}$$

This suggests that, to halve the city's rate of real house price inflation from 78% to 39%, Auckland would have had to increase its housing stock by 32% over the 2001-2013 period. This modelled rate of growth in dwellings exceeds the population growth that actually occurred over the same period. While this seems somewhat counterintuitive, it reflects several underlying economic factors:

- Latent demand to live in Auckland that is currently going unmet – this may reflect people who used to live in Auckland but moved away to other cities due to high house prices, or people from other New Zealand regions or overseas who would like to live in Auckland but are unable to afford to do so.
- Latent demand for household formation that is currently going unmet – i.e. people who are flatting for longer or living in crowded housing due to inability to afford housing.[29]
- Income growth, which will increase demand for housing quality / quantity even if population is not increasing (Rosenthal, 2014).

We can compare these two scenarios – what actually occurred, versus an alternative scenario in which Auckland built more dwellings – in order to estimate the benefits to new residents of enabling more urban development. Table 17 summarises the estimated impacts on dwelling supply and median house prices over the 2001-2013 period. It compares the status quo scenario with an alternative scenario in which added housing supply reduced the rate at which prices increased.

Table 17: Modelled impact on dwelling supply and median house prices, 2001-2013

Time	Total dwellings in Auckland		Real median house prices (Mar13 base)[30]	
	Status quo scenario	Higher supply scenario	Status quo scenario	Higher supply scenario
2001	424,848	424,848	$285,461	$285,461
2006	473,031	482,149	$430,723	$358,092
2013	506,811	562,371	$509,250	$397,355
% change 2001-2013	19%	32%	78%	39%

Based on these figures, we estimate the housing prices facing new entrants to the Auckland housing market over this period. Once again, we have calculated the consumer surplus associated with lower house price growth as equivalent to the shaded blue area in Figure 10.

[29] According to Goodyear and Fabian (2014), in 2013 8.3% of Auckland households were crowded (as measured on the Canadian National Occupancy Standard, which the authors describe as the best fit for the New Zealand social context). Because crowded households tend to be larger than uncrowded households, this means that 15.5% of Aucklanders live in crowded housing. Auckland is the only region in which crowding rates did not fall between the 1991 and 2013 Censuses.

[30] These figures have been back-casted them from REINZ figures for 2013 and as a result may not exactly match actual data.

Table 18 calculates the consumer surplus associated with faster growth in housing supply for new entrants over the 2001-2013 period. We find that the potential consumer surplus for new entrants over this period is large – in undiscounted terms, it totals over $7 billion. The majority of these benefits accrue to new households that *did* form in Auckland over this period, but who would have been able to access cheaper housing as a result of increased development. However, the city would have also grown to a larger size – adding another 55,600 households over this period.

Table 18: Estimated consumer surplus for new entrants to the Auckland household market

Time period	Added dwellings		Estimated difference in house prices[31]	Added consumer surplus for:	
	Status quo scenario	Higher supply scenario		New entrants under status quo	Additional new entrants from enabling growth
2001-2006	48,183	9,118	$36,316	$1.75bn	$0.17bn
2006-2013	33,780	46,442	$92,263	$3.12bn	$2.14bn
Total[32]	81,963	55,560	N/A	$4.87bn	$2.31bn

This analysis suggests that enabling more urban development would result in approximately $129,000 in consumer surplus for each of the 55,560 additional dwellings that would have been constructed if Auckland's urban development market had been more responsive. Reassuringly, this figure is on the same order of magnitude as the estimate of consumer surplus per added household that we obtained from our first model.

4.2 Positive and negative externalities associated with urban development

A perennial challenge for cost benefit analysis of urban planning policies is that there is usually poor information on the magnitude (or even net direction) of various externalities associated with development, both in existing urbanised areas and in greenfield sites. Because cities are (by definition) concentrations of people and economic activity, there is potential for a range of positive and negative spillovers within them, including but not limited to:

- Agglomeration economies, which describe the benefits arising from proximity between households and firms, either in production or consumption
- External infrastructure costs, arising where new entrants do not pay for the full costs of connecting to public infrastructure networks
- Congestion, arising when transport network performance deteriorates due to high levels of peak use
- Overshadowing and blocked views from tall buildings
- Loss of the social benefits of peri-urban open space
- Air and water quality externalities.

It is possible to qualitative *describe* these externalities, but it is rare to have data to quantify them. This can make it difficult to analyse the overall effects of urban planning policies on wellbeing, and, in turn, to identify an appropriate policy direction to maximise wellbeing.

To begin filling this knowledge gap, we have estimated the magnitude of a wide range of externalities for development in Auckland. The Appendix provides a full description of this evidence base. Where possible, these estimates are sourced from the existing New Zealand-specific evidence base or empirical literature from other jurisdictions. In some cases (e.g. with congestion and overshadowing externalities) it has been necessary to

[31] We have taken the simple average in differences in prices between the Census years, to reflect the fact that prices have inflated gradually over the period.

[32] No discounting has been applied to total figures for consumer surplus.

develop estimates, as none have been previously available. In other cases (e.g. crowding externalities, agglomeration economies in consumption) we have not been able to establish a good empirical basis on which to make an estimate. However, these externalities are not likely to be large enough to affect our overall results.

The estimated magnitude of the externalities associated with for new dwellings developed in the existing urban area or in greenfield locations is summarised in the following table. These externalities have been estimated on a marginal basis – i.e. looking at the impact of adding a small number of dwellings (and hence households) that would not have otherwise located in the city.[33] We have estimated and reported a range of values for both urban intensification and greenfield development scenarios, reflecting either uncertainty about estimates or spatial variations in externalities.

Table 19: Estimated magnitude of externalities associated with housing development in urban and greenfield areas (externalities per household)

Externalities	Urban intensification		Greenfield	
	Low	High	Low	High
External infrastructure costs				
• Transport	$0	$0	-$6,787	-$10,298
• Water / wastewater	-$3,240	-$12,740	-$3,240	-$21,432
• Stormwater	$0	-$1,626	$0	-$1,626
• Open spaces and community facilities	$0	$0	-$2,086	-$3,186
Congestion	-$22,717	-$29,682	-$35,228	-$48,975
Overshadowing from tall buildings[34]	$0	-$9,832	$0	$0
Blocked views from tall buildings[35]	$0	-$10,219	$0	$0
Loss of peri-urban open space	$0	$0	-$2,664	-$4,657
Air quality	-$3,814	-$4,217	-$3,204	-$3,814
Freshwater quality[36]	$0	-$2,229	-$1,783	-$3,566
Coastal water quality[37]	$0	-$779	-$1,914	-$3,829
Noise, smells, and nuisances from incompatible activities	(Unknown)	(Unknown)	(Unknown)	(Unknown)
Agglomeration economies in production	$92,895	$46,419	$92,895	$46,419
Agglomeration economies in consumption	(Unknown)	(Unknown)	(Unknown)	(Unknown)
Total	$63,124	-$24,904	$35,990	-$54,964
Total excluding agglomeration economies	*-$29,771*	*-$71,323*	*-$56,905*	*-$101,383*

[33] In reality, some new dwellings will house people who already live in the city in crowded or inadequate accommodation. In these cases, externalities per added dwelling will tend to be smaller, as many of the positive and negative effects of these peoples' presence in the city (e.g. traffic congestion) will already be present.

[34] We considered three scenarios for the cost of overshadowing from new development in urbanised areas: (1) a low scenario in which the potential for overshadowing from tall buildings is controlled by height and setback controls, which results in an overshadowing cost of $0 per added dwelling; (2) a medium scenario in which areas are built out to mid-rise (4-8 storey) density, resulting in an increase in household energy costs from overshadowing that is equal to $4,230 per apartment (in present value terms); and (3) a high scenario in which tall (4-8 storey) apartment buildings block sun from neighbouring standalone houses, resulting in an overshadowing externality of approximately $9,832 per apartment.

[35] The empirical literature suggests that, in Auckland, water views are highly valued while views of land are less valuable. As a relatively small share of Auckland properties (~13% of houses sold between 2011 and 2014) have water views, view-related externalities are not likely to be common. However, in some particular cases they may be larger than the upper bound of the range reported here.

[36] These effects are likely to be addressed under the NPS on Freshwater Quality; consequently, these figures are likely to be pessimistic.

[37] These effects are likely to be addressed under the NZ Coastal Policy Statement; consequently, these figures are likely to be pessimistic.

While these estimates are explained in greater detail in the Appendix, it is worth noting a few key facts:

- First, consistent with some other findings in the economics literature (Glaeser, 2011; Combes et al, 2012; de Groot et al, 2015), the net direction of externalities associated with urban development is not necessarily negative. Even under relatively conservative assumptions about agglomeration economies from larger city size, they are similar in magnitude to the external costs of development.
- Second, external infrastructure costs are the only externalities with direct financial implications for local and central governments. Other externalities are reported in monetary terms for comparability, but they generally reflect non-monetary impacts on amenity or environmental quality. We note that infrastructure costs are difficult to estimate with precision, as they may be highly site-specific and dependent upon capacity constraints in existing infrastructure networks. The cost to serve some individual locations with infrastructure may be higher; however, the figures that we have used represent the best available estimates of average infrastructure costs.
- Third, many "localised" externalities associated with development, such as overshadowing, blocked views, and noise and nuisances from incompatible activities, are controlled by existing planning regulations. The same is true for some environmental effects, e.g. on freshwater and coastal water quality. We consider a "high" scenario that implicitly assumes that planning regulations are relaxed in a way that increases the likelihood that these externalities occur. However, in many situations, zoning rules will continue to manage these externalities while enabling additional development.

4.3 Summary: The costs and benefits of enabling urban development

Lastly, we combine our modelled estimates of the consumer surplus arising from enabling more flexible urban growth with our estimated per-household externalities associated with increased urban growth in either urban or greenfield areas to understand whether enabling marginally more flexible / responsive urban development is likely to result in net social benefits.

Table 20 and Table 21 summarise the results of this cost benefit analysis. Under both modelling approaches, and under a range of assumptions about the external costs associated with additional development in either urban or greenfield locations, a policy of enabling more flexible / responsive urban growth will result in net social benefits. The consumer surplus benefits associated with doing so outweigh added negative externalities and socialised infrastructure costs. Furthermore, the presence of agglomeration economies in production and consumption means that the net direction of externalities associated with urban growth may in fact be *positive*.

In particular:

- A less restrictive approach to urban planning policy that results in a 25% increase in elasticity of housing supply (Model 1) will result in net benefits of $1.3 billion to $4.0 billion in response to a 20% increase in demand for housing in a city (e.g. through population and / or income growth). The modelled level of growth is roughly equivalent to a decade's worth of population growth in Auckland.
- A less restrictive approach to urban planning that enabled sufficient supply of housing to reduce the rate of price inflation by 50% (Model 2) would have resulted in net benefits of $1.4 billion to $10.7 billion over the 2001-2013 period.

These net benefits are likely to be largest, in absolute magnitude, in urban areas like Auckland that are experiencing substantial growth in demand for urban development. In these cases, the number of new entrants to the housing market (e.g. young people seeking to buy housing) is larger and hence the benefits of enabling them to provide for their social and economic wellbeing in housing are *also* larger. However, it is plausible to expect enabling more flexible and responsive urban development to deliver net benefits under a wide range of scenarios.

Table 20: Costs and benefits based on Model 1 results

Variable	Value			
Modelled added consumer surplus relative to status quo scenario	$2.6bn			
Modelled additional change in city size relative to status quo scenario (households)	23,256			
Per-household externalities				
Growth scenario	Urban: Low	Urban: High	Greenfield: Low	Greenfield: High
Total negative externalities per household	-$29,771	-$71,323	-$56,905	-$101,383
Agglomeration economies per household	$92,895	$46,419	$92,895	$46,419
Total externalities				
Negative externalities	-$0.7bn	-$1.7bn	-$1.3bn	-$2.4bn
Agglomeration economies	$2.2bn	$1.1bn	$2.2bn	$1.1bn
Net benefits	**$4.0bn**	**$2.0bn**	**$3.4bn**	**$1.3bn**

Table 21: Costs and benefits based on Model 2 results

Variable	Value			
Modelled added consumer surplus relative to status quo scenario	$7.2m			
Modelled additional change in city size relative to status quo scenario (households)	55,560			
Per-household externalities				
Growth scenario	Urban: Low	Urban: High	Greenfield: Low	Greenfield: High
Total negative externalities per household	-$29,771	-$71,323	-$56,905	-$101,383
Agglomeration economies per household	$92,895	$46,419	$92,895	$46,419
Total externalities				
Negative externalities	-$1.7bn	-$4.0bn	-$3.2bn	-$5.6bn
Agglomeration economies	$5.2bn	$2.6bn	$5.2bn	$2.6bn
Net benefits	**$10.7bn**	**$5.8bn**	**$9.2bn**	**$4.1bn**

5 Discussion and conclusions

To conclude, we highlight some potential implications of this analysis for researchers and policymakers.

5.1 Some outstanding research needs

The analysis in this paper highlights several areas where more information is needed in order to make better decisions about urban planning. These are likely to present opportunities for researchers.

First, theory and evidence suggests that overly restrictive planning regulations can affect the competitiveness and long-run dynamics of urban development markets. However, this does not provide a firm guide about two important questions for policy analysis:

- In the New Zealand context, how much of an impact can we expect policy changes to have on housing supply elasticity? Evidence from the US (e.g. Saiz, 2010) provides a rough guide of the potential gains, but it is unclear whether these estimates will translate to New Zealand.
- Which regulatory policies and processes have the largest impacts on the dynamics of land and development markets in New Zealand? For instance, is it sufficient to reform specific regulatory policies, e.g. around greenfield land supply, building height limits, or dwelling density controls, or do we also need to pay attention to regulatory processes driving the cost and complexity of consenting and plan changes?

Second, while analysis of price discontinuities in land and development markets can provide empirical evidence of regulatory constraints on competition, there is relatively little evidence on how policy changes can improve competitiveness. Better evaluation of changes in these measures following policy changes is therefore desirable.

Third, there is an ongoing need for better evidence on the magnitude of various positive and negative externalities from urban development. This paper compiles the existing New Zealand-specific evidence base and extends it in several important areas. In order to do so it has frequently been necessary to draw upon models, extrapolations from limited data, or evidence from other jurisdictions. Further research is needed to improve our understanding of the various positive and negative effects of development in cities, including their distribution between groups.

5.2 Some questions for policymakers

Rough cost benefit analyses undertaken in Section 3 suggests that some current urban policies are likely to be inefficient – and that reforming urban planning to enable more competitive, responsive land and development markets in cities can result in strong net social benefits.

However, in saying this we are not blind to the distributional impacts of policy changes, and the consequences for local government decision-making. Our analysis in Section 4 indicates that the gains from enabling more elastic housing supply accrue mainly to new entrants to the housing market, who may be existing residents seeking to form their own households (e.g. by moving out of shared flats) or people newly migrating to the city. These people are not necessarily well-represented in local decision-making processes.

By contrast, the potential costs of enabling growth are more likely to fall on existing residents, who have more opportunities to object to policy changes to enable development. It is therefore not especially surprising that urban planning policies err on the side of restrictiveness.

But by the same token, there may be benefits of rethinking our overall framework for urban planning policy. If we were to pursue an economically efficient urban planning policy that managed market failures in the built environment without inappropriately constraining the competitiveness of land and development markets, what would it look like? For example:

- Should we reconsider the desirability of relatively inflexible zoning rules that define where specific activities can occur in cities and limit the degree to which land can be developed more intensely?
- Is there a case to make greater use of price mechanisms, e.g. to internalise congestion costs and parking spillover costs, or to “tax” unwanted developments rather than regulate them?
- Is there more scope for “Coaseian” solutions that encourage developers to “contract” with affected residents to ensure that some of the gains from development can be used to “compensate” people who bear costs in the process?

Fully addressing these challenging policy questions is beyond the scope of this paper and hence we leave them as an exercise for the reader.

Appendix: External costs of urban growth

The following table summarises the different broad categories of externalities that may arise from urban development. These externalities are described and estimated in the following sections of this Appendix.

Table 22: Market failures in urban development

Externality	Applies to:	Explanation
External infrastructure costs	Greenfield / urban intensification	Where new entrants do not pay for the full marginal costs of connecting to infrastructure networks they pass costs on to the rest of the community
Congestion	Greenfield / urban intensification	Additional concentrations of people add vehicles to congested roads, further slowing traffic and resulting in trip avoidance
Crowding	Greenfield / urban intensification	Congestion relates to the physical carrying capacity of a situation, crowding results from the psychological carrying capacity (Neuts et al, 2013). We have not estimated this due to a lack of robust methodology; however, it is likely to be partly or fully captured when discussing other localised externalities.
Overshadowing from tall buildings	Urban intensification	Higher or more densely concentrated buildings may cast shadows over surrounding properties, reducing amenity for their inhabitants
Blocked views from tall buildings	Urban intensification	In some parts of the city (e.g. coastal areas), tall buildings may block views from neighbouring properties
Loss of peri-urban open space	Greenfield	Development at the fringe of the city may reduce city residents' amenity by reducing the availability / accessibility of peri-urban open space
Air quality	Greenfield / urban intensification	Increased urban population may increase exposure to poor air quality, especially for residential developments in areas with poor air quality (e.g. near motorways and heavy industry areas)
Water quality	Greenfield / urban intensification	Urban development may increase runoff of heavy metals and other contaminants into waterways (e.g. runoff from roads and roofs). This may affect both freshwater quality and coastal water quality
Noise, smells, and nuisances from incompatible activities	Greenfield / urban intensification	Urban development may result in localised nuisances as a result of the colocation of incompatible activities, such as heavy industry and residential uses, or farming activities and housing. This may include noise, smells, and "reverse sensitivities", which refer to the vulnerability of an established activity to objections from new land uses moving into the area.
Agglomeration economies	Greenfield / urban intensification	Agglomeration economies describe the benefits arising from proximity between households and firms. Agglomeration economies can reflect the presence of economies of scale in production and/or consumption, which can be both internal and external to the agents involved. Positive externalities in production may result from, e.g., sharing of knowledge and technologies with increased density of employment Positive externalities in consumption arise when increased population density or city size enable more consumption opportunities, e.g. sports stadiums or theatres

The estimated magnitude of these externalities for new dwellings developed in the existing urban area or in greenfield locations is summarised in the following table. These externalities have been estimated on a marginal basis – i.e. looking at the impact of adding a small number of dwellings (and hence households) that would not have otherwise located in the city.[38]

The basis for these estimates is explained in detail in the following sub-sections of this Appendix. We have reported a range of values for both urban intensification and greenfield development scenarios, reflecting either uncertainty about estimates or spatial variations in externalities.

[38] In reality, some new dwellings will house people who already live in the city in crowded or inadequate accommodation. In these cases, externalities per added dwelling will tend to be smaller, as many of the positive and negative effects of these peoples' presence in the city (e.g. traffic congestion) will already be present.

Table 23: Estimated magnitude of externalities associated with housing development in existing urban areas and greenfield areas (externalities per added dwelling/household)

Externalities	Urban intensification		Greenfield	
	Low	High	Low	High
External infrastructure costs				
• Transport	$0	$0	-$6,787	-$10,298
• Water / wastewater	-$3,240	-$12,740	-$3,240	-$21,432
• Stormwater	$0	-$1,626	$0	-$1,626
• Open spaces and community facilities	$0	$0	-$2,086	-$3,186
Congestion	-$22,717	-$29,682	-$35,228	-$48,975
Overshadowing from tall buildings[39]	$0	-$9,832	$0	$0
Blocked views from tall buildings[40]	$0	-$10,219	$0	$0
Loss of peri-urban open space	$0	$0	-$2,664	-$4,657
Air quality	-$3,814	-$4,217	-$3,204	-$3,814
Freshwater quality[41]	$0	-$2,229	-$1,783	-$3,566
Coastal water quality[42]	$0	-$779	-$1,914	-$3,829
Noise, smells, and nuisances from incompatible activities	(Unknown)	(Unknown)	(Unknown)	(Unknown)
Agglomeration economies in production	$92,895	$46,419	$92,895	$46,419
Agglomeration economies in consumption	(Unknown)	(Unknown)	(Unknown)	(Unknown)
Total	$63,124	-$24,904	$35,990	-$54,964
Total excluding agglomeration economies	*-$29,771*	*-$71,323*	*-$56,905*	*-$101,383*

External infrastructure costs

Infrastructure or network utilities for new developments are provided through a mix of private and public providers. This includes:

- Local and central government provided infrastructure, including:
  - Transport infrastructure and services, including state highways (100% funded by the National Land Transport Fund), local roads (jointly funded by the NLTF and local government), and public transport services (jointly funded by the NLTF and local government);
  - Water and wastewater infrastructure (funded by local government and council-controlled organisations);
  - Stormwater infrastructure (funded by local government);
  - Social facilities, such as libraries (funded by local government), schools (central government), and hospitals (central government);

[39] We considered three scenarios for the cost of overshadowing from new development in urbanised areas: (1) a low scenario in which the potential for overshadowing from tall buildings is controlled by height and setback controls, which results in an overshadowing cost of $0 per added dwelling; (2) a medium scenario in which areas are built out to mid-rise (4-8 storey) density, resulting in an increase in household energy costs from overshadowing that is equal to $4,230 per apartment (in present value terms); and (3) a high scenario in which tall (4-8 storey) apartment buildings block sun from neighbouring standalone houses, resulting in an overshadowing externality of approximately $9,832 per apartment.

[40] The empirical literature suggests that, in Auckland, water views are highly valued while views of land are less valuable. As a relatively small share of Auckland properties (~13% of houses sold between 2011 and 2014) have water views, view-related externalities are not likely to be common. However, in some particular cases they may be larger than the upper bound of the range reported here.

[41] These effects are likely to be addressed under the NPS on Freshwater Quality; consequently, these figures are likely to be pessimistic.

[42] These effects are likely to be addressed under the NZ Coastal Policy Statement; consequently, these figures are likely to be pessimistic.

    - Waste and recycling services (funded by local government in urban areas or privately).
- Privately-provided infrastructure, including
    - Electricity supply;
    - Reticulated gas supply;
    - Communications including telephone and internet.

These costs are funded through a variety of mechanisms including:

- User charges (including network connection charges);
- Rates; and
- Development contributions

Externalities may arise when infrastructure is not priced efficiently, i.e. when new users do not bear the full marginal costs of the infrastructure serving their location. This is relevant to the analysis because:

- The true social cost of infrastructure supply is relevant to the definition of the social cost of land supply limits as it defines the size of deadweight loss; and
- Under-pricing of infrastructure can result in inefficient usage, including where pricing does not provide locational signals reflecting differences in costs based on geographical differences.

The Productivity Commission (2012) notes that "*Charging for infrastructure, if implemented well, encourages efficient locational choices in the development of housing. It requires considerable skill and information, however, to design and implement charges that accurately reflect costs.*"

Development Contributions

Development Contributions (DCs) are charges imposed on developers by councils to recover some of the costs incurred when providing infrastructure services for the development. DCs are used to cover the costs of:

- Community infrastructure – such as community centres/halls, public toilets, and play equipment;
- Reserves – land purchases plus developments of reserve land (where the development involves the creation of additional housing or accommodation); and
- Network infrastructure – roads, water, wastewater, and stormwater.

Councils vary in the extent to which they use DCs versus other funding mechanisms. In Auckland, for example, stormwater is charged via DCs but costs for water supply and wastewater are made through Watercare Infrastructure Growth Charges (see below).

Table 24 shows levels of DCs in Auckland. The amounts are not additive because areas with the lowest (or highest) cost in one category may not be lowest (or highest) cost in all categories, e.g. reserve acquisition and development DCs are highest in greenfield developments but community infrastructure DCs are highest in existing urban areas. Average DCs in Auckland are approximately $20,000.

Table 24 Development Contributions per Unit of Demand 1 July 2015 - 30 June 2016 (Source: Auckland Council, 2015a)

Purpose	Amount (excl GST)
Reserve acquisition	$2,537 - $5,450
Reserve development	$1,936 - $2,170
Stormwater	$33 - $8,648
Transport	$3,641 - $6,825
Community infrastructure	$765 - $2,179

Water and Wastewater

As shown in Figure 11, most councils in New Zealand fund water infrastructure through rates. However, Auckland is one of the few councils that funds water infrastruture largely through user charges.

Figure 11: Share of water infrastructure funding from rates (Source: Castalia Strategic Advisors, 2014)

0% — 10% — 50% — 90% — 100%

Auckland	South Taranaki*	Hamilton	Thames-Coromandel	Christchurch
Tauranga*	Waikato	Wellington	Hastings	Queenstown-
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 significantly different proportion of wastewater costs through rates

Water and wastewater charges in Auckland

New connections to the water supply network are charged an Infrastructure Growth Charge (IGC). The IGC is calculated as:

Equation 2: Auckland's Infrastructure Growth Charge for water networks

$$\text{IGC} = \frac{\sum(\text{Growth Capex})}{\sum(\text{Additional Demand})} - \text{PV}(\text{existing customer charge})$$

- Growth-related infrastructure costs are summed over a 15-year period (four years historical, the current year and 10 years forward);
- This sum is divided by the number of properties that are expected to connect;
- An amount is subtracted from this equal to the present value (over an average asset life) of the portion of estimated annual charges that are paying for the costs of depreciation and finance costs. This ensures the developer is not charged twice for the same asset.

Currently Watercare only charges a portion of the cost of growth-related infrastructure rather than the full amount. Its intention is to increase the IGC over time to recover more of the cost of growth-related infrastructure from the growth community. The current IGC is $10,760 (excl GST) per property (Watercare, 2015).

The methodology (formula 1) used is a simplification of a theoretically correct approach to defining the annualised cost of growth capital, which might be defined as:

Equation 3: A theoretically correct approach to determining growth charges

$$\text{Infastructure Charge} = \frac{\text{PV (Growth Capex)}}{\text{PV(Additional Demand)}}$$

This approach uses the present value of growth capex divided by the present value of physical connections.[43] Using average (undiscounted) costs per connection will tend to undercharge compared with the theoretical model in situations where capital costs are up-front and demand increases over time. Table 25 illustrates the different charging approaches. The capital costs in years 0, 10 and 20 have a NPV of $299 million at a 5% discount rate. The discounted stream of new connections (1,000 in year 0 and growing by 5% per year) adds to 21,000 over years 0 to 20 at the same discount rate. This results in a charge of $14,220 per connection which, if charged to each connection, would provide a revenue stream with an NPV of $299 million.

Table 25: Efficient charging for water infrastructure

Year	Capex ($ million)	New Connections	Efficient Charges	Inefficient charges
0	$150	1,000	$14.22	$12.60
1		1,050	$14.93	$13.23
2		1,103	$15.68	$13.89
3		1,158	$16.46	$14.58
4		1,216	$17.28	$15.31
5		1,276	$18.15	$16.08
6		1,340	$19.06	$16.88
7		1,407	$20.01	$17.73
8		1,477	$21.01	$18.61
9		1,551	$22.06	$19.54
10	$150	1,629	$23.16	$20.52
11		1,710	$24.32	$21.55
12		1,796	$25.54	$22.62
13		1,886	$26.81	$23.76
14		1,980	$28.15	$24.94
15		2,079	$29.56	$26.19
16		2,183	$31.04	$27.50
17		2,292	$32.59	$28.88
18		2,407	$34.22	$30.32
19		2,527	$35.93	$31.84
20	$150	2,653	$37.73	$33.43
NPV	**$299**	**21,000**	**$299**	**$265**

In contrast, a charge based on average costs (Equation 2 above) results in a charge per connection of $12,600; the revenues from applying such a charge would result in an NPV of only $265 million, 11% below the funding requirements.

The degree of underfunding (or over-funding with a different profile of costs and demand) will differ with the specific circumstances, but typically average cost funding will under-charge.

We might assume that, across councils, the gap between efficient charging of water connections and actual charges might range from 100% below (no connection charges) to 10% below the efficient charge.

The figure of $10,760 is lower than estimated by CIE and Arup (2015), who recently estimated costs of approximately $7,000-$11,000 for wastewater and $7,000-$12.500 for water and a total of $14,000-$20,000 based on a sample of 12 recent developments in Auckland.

[43] The use of a discounted present value (PV) of additional demand in the theoretical model ensures that account is taken of the timing of growth in demand in addition to the timing of capital spend. The infrastructure charge derived using this method, if multiplied by the quantities (of consumption or of households) in future years, will result in a discounted present value of revenue equal to the present value of the capital costs. In contrast, if the additional demand is not discounted then too little may be recovered.

For our analysis we assume an internalised cost of $10,760 (using Auckland data) and external costs of $3,000 - $10,000. In other parts of New Zealand the total cost might be external.

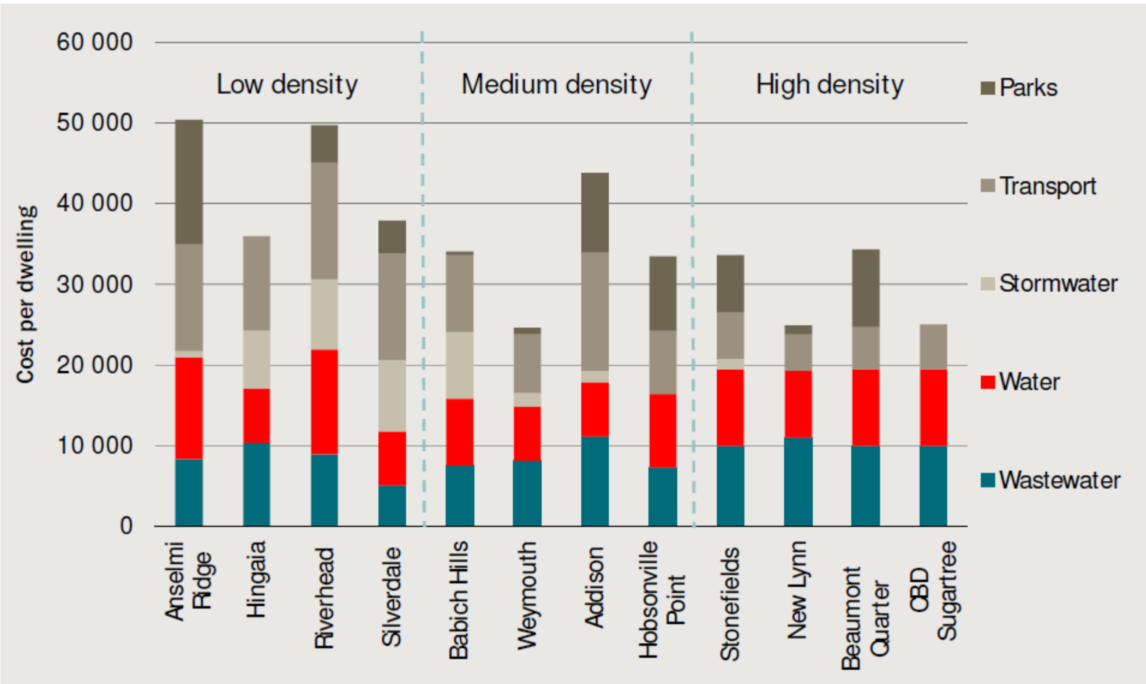
Estimated magnitude of infrastructure costs in Auckland

There are economies of scale in infrastructure provision which suggest that an infrastructure provider might be able to increase prices above the marginal cost of supply: an individual land owner would need to pay a larger amount to obtain an individual connection than would be possible through a system of connections shared with others, e.g. a local network or a shared road. However, in general:

- infrastructure suppliers are either a regulated industries or are part of council. This limits them to charging actual costs; and
- New residential developments are likely to develop in clusters, rather than as individual houses.

Recent work for Auckland Council by the Centre for International Economics (CIE) has identified the costs of infrastructure for residential land in a number of case study areas. The costs included were for the three waters, transport (roads) and the provision of parks. Total infrastructure costs ranged between approximately $25,000 and $50,000 per property depending on location (Figure 12). Costs are, on average, lower in high density developments than low density developments, although outcomes vary considerably between sites.

Figure 12 Summary of infrastructure costs by density and asset type (Source: CIE and Arup, 2015)



New developments in greenfield areas on the urban fringe tend to incur higher infrastructure costs than infill or brownfield development (Trubka et al, 2008; CIE and Arup, 2012; CIE and Arup, 2015). However, infrastructure costs can be extremely site-specific and depend upon the existence of capacity constraints within existing infrastructure networks.[44] For example, adding new dwellings in an existing urbanised area may require the duplication of at-capacity water mains or the construction of new schools.

We employ the CIE and Arup figures to estimate the degree to which infrastructure costs are not covered by DCs and IGCs. Based on these figures, there may be an implied subsidy for water and wastewater services, while stormwater, transport, and parks are more likely to be fully covered by DCs.

[44] In its submission to the Productivity Commission's 2012 report, Housing New Zealand notes that "*In theory, brownfield development should cost less as it requires connection to existing services. However, in many New Zealand cities this is not the case as existing connections are sometimes almost at capacity … To utilise these services a higher premium must be paid, increasing the cost of the development.*"

On a per-dwelling basis, assuming an average property size of 600m^2 and an average cost of $50,000 per property in greenfield areas, infrastructure costs which are capitalised into land prices explain around 22% of the cost differential for land inside and outside the MUL (or 13% using the higher Productivity Commission multiplier). Other externalities associated with greenfield development, which are not necessarily capitalised into land prices, may explain a portion of the remaining gap.

A second estimate of the cost to service greenfield areas with bulk infrastructure – i.e. excluding local roads and pipes within subdivisions, which are paid for by developers – is provided by Auckland Council's (2015b) *Future Urban Land Supply Strategy* (FULSS). 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 employees. (By comparison, Auckland currently has approximately 500,000 households and 700,000 employees.) Auckland Council expects total bulk infrastructure costs of $17 billion, in undiscounted terms, to enable this growth.

Table 26 summarises the estimated per-dwelling cost of infrastructure in these greenfield areas.

Table 26: Bulk infrastructure costs per dwelling in greenfield growth areas identified in Auckland Council's Future Urban Land Supply Strategy (Source: Auckland Council, 2015b)

Type of bulk infrastructure	Low dwelling capacity scenario (87,600 dwellings)	High dwelling capacity (110,200 dwellings
Transport	$68,493	$54,446
Water / wastewater	$53,653	$42,650
Stormwater	$17,123	$13,612
Open space / community	$53,653	$42,650
Total	**$192,922**	**$153,358**

A portion of this infrastructure will be funded by user charges (DCs or IGCs) or out of the National Land Transport Fund (NLTF) administered by the NZ Transport Agency. And it is likely that they reflect, in part, "future proofing" for later stages of urban growth. We therefore make the following (optimistic) assumptions about actual infrastructure costs borne by Council:

- 50% of transport infrastructure costs are for new or improved state highways, which are funded 100% by the NLTF, and the remaining 50% are local roads or public transport funded 50/50 by NLTF (or fares). (This ignores the issue of cross-subsidisation between fuel taxes or road user charges paid on new versus existing roads.) Under these assumptions, the remaining 25% of bulk transport infrastructure costs must to be funded by DCs or rates.
- Actual costs of water/wastewater will only be 60% of the reported figures, reflecting optimistic assumptions about what may happen to costs as a result of further investigations
- Actual stormwater costs will only be 60% of the reported figures, reflecting optimistic assumptions about what may happen to costs as a result of further investigations
- Open spaces and community facilities will be 90% paid by developers or DCs, or paid by central government, who would otherwise have to expand schools / hospitals / etc elsewhere.

Under these assumptions about infrastructure costs in future urban areas, and CIE and Arup's estimates of infrastructure costs for brownfield development areas, we estimate the following infrastructure costs for urban intensification and greenfield areas. In the case of stormwater infrastructure costs for urban intensification, good data was not available and hence we used the upper bound figure for greenfield areas.

Figure 13: Estimated gross infrastructure costs (Source: CIE and Arup, 2015; Auckland Council, 2015b; authors' calculations)

Type of infrastructure	Urban intensification		Greenfield	
	Low	High	Low	High
Transport	$0	$5,000	$13,612	$17,123

Type of infrastructure	Urban intensification		Greenfield	
Water / wastewater	$14,000	$23,500	$14,000	$32,192
Stormwater	$0	$10,274	$8,167	$10,274
Open space and community facilities	$0	$0	$4,265	$5,365

Following on this, we estimate the typical range of DCs or user charges that would apply to development in urban intensification areas and greenfield areas. These figures are reported in the following table.

Figure 14: Estimated DCs and IGCs (Source: Auckland Council, 2015a; Watercare, 2015)

Type of infrastructure	Urban intensification		Greenfield	
	Low	High	Low	High
Transport	$3,641	$6,825	$6,825	$6,825
Water / wastewater	$10,760	$10,760	$10,760	$10,760
Stormwater	$8,648	$8,648	$8,648	$8,648
Open space and community facilities	$2,179	$2,179	$2,179	$2,179

Putting it together, the following table summarises the difference between gross infrastructure costs and user charges (DCs and IGCs). In some cases, but not all, there is a deficit that must be borne by councils (and hence passed on to ratepayers more generally).

Figure 15: External infrastructure costs that are not borne by users

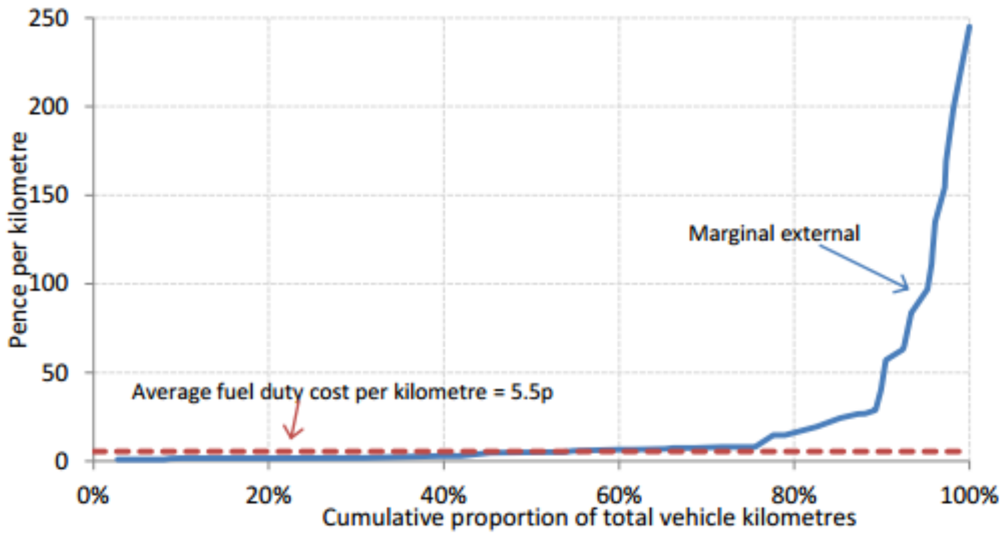
Type of infrastructure	Urban intensification		Greenfield	
	Low	High	Low	High
Transport	$0	$0	-$6,787	-$10,298
Water / wastewater	-$3,240	-$12,740	-$3,240	-$21,432
Stormwater	$0	-$1,626	$0	-$1,626
Open space and community facilities	$0	$0	-$2,086	-$3,186

Congestion

Congestion occurs when the quality of service of a facility depends upon the intensity of use (Small and Verhoef, 2007; p. 69). While congestion can, in principle, arise for many facilities, the term is most commonly used to refer to road networks. Generally speaking, traffic speeds decline when additional people attempt to drive on road links or through bottlenecks such as intersections.

The consequence of this is that the marginal cost imposed by additional users tends to exceed the average cost incurred by those added users. In plain English, each additional vehicle on the road imposes some delays on other users. In the absence of congestion pricing, users do not bear the full cost of these delays. This is illustrated in Figure 16, which compares the marginal external cost of driving with fuel taxes in the UK. The result is a negative externality that is concentrated on busy urban roads.

Figure 16: Distribution of the marginal external cost of driving in the UK (Source: Johnson et al, 2012)



Other transport facilities are also congestible, albeit in different ways. For example, public transport vehicles can become crowded (i.e. all seats full, people standing in the aisles), which reduces comfort for users but does not affect travel speed. But as a general principle, public transport, walking, and cycling modes are *less* prone to congestion than road traffic. Consequently, people in a position to access these transport modes have the option to avoid participating in congestion[45].

Microeconomic models of congestion

Small and Verhoef (2007) review various models of congestion on road links and through bottlenecks. While these models differ in various respects, they all predict a nonlinear relationship between traffic volumes and traffic speeds.

Static congestion on a single road link is commonly modelled using the Bureau of Public Roads (BPR) function. This results in the following average cost and marginal cost curves, where c_0 is free-flow user cost; α is the value of time; T_f is the free-flow travel time; and a, V_k, and b are constants. Following Wallis and Lupton (2013), we choose a=0.2, V_k=3,000, b=4, and T_f=0.01hr/km – consistent with a motorway lane – to illustrate how congestion externalities arise. (We do not use this model to estimates of congestion externalities, as it applies only to a single road link.)

Equation 4: Average cost of road use

$$c = c_o + \alpha T_f a(\frac{V}{V_k})^b$$

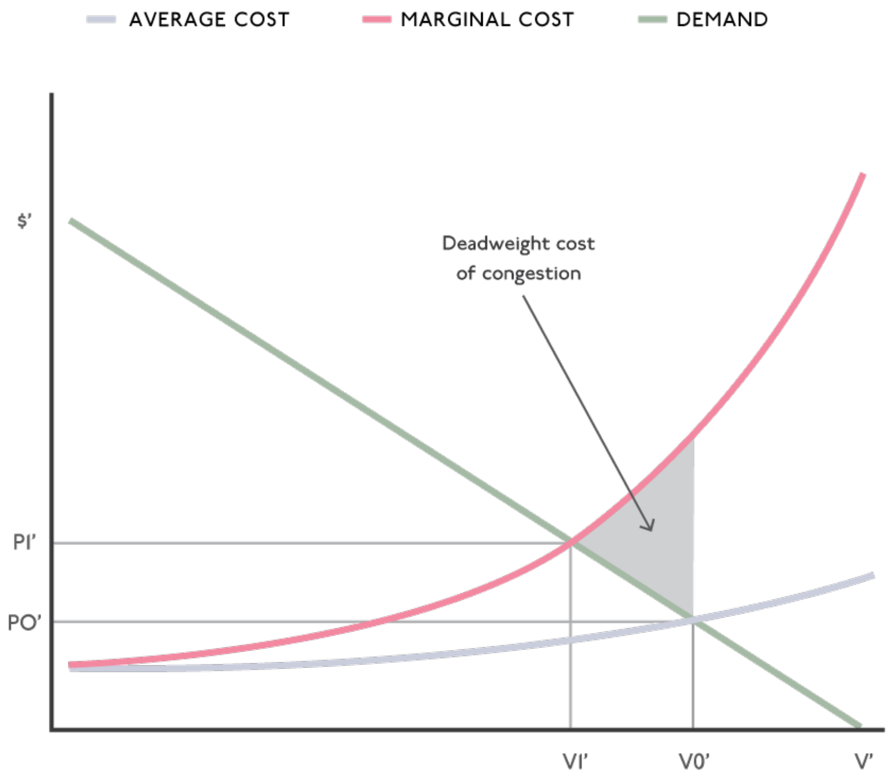
Equation 5: Marginal cost of road use

$$mc = c + \alpha T_f ab(\frac{V}{V_k})^b$$

The outcome is the following relationships between demand and cost on road networks. In the absence of congestion pricing, traffic volumes will be set at the point at which the marginal benefit of driving is equal to the average cost of driving. As the marginal cost of driving is higher than the average cost, this results in a deadweight loss equivalent to the shaded grey triangle.

[45] A corollary to this is that the availability of non-congestible transport modes – e.g. grade-separated rapid transport – can help in "regulating" levels of congestion.

Figure 17: A simple model of congestion externalities



Congestion and city size

One implication of the BPR model is that the external costs of congestion tend to increase *faster* than traffic volumes. In other words, doubling traffic volumes will tend to more than double congestion externalities.

As outcomes for congestion depend upon a variety of factors, such as road network structure, latent capacity, existence of bottlenecks, and availability of non-car modes, it is difficult to extend a simple BPR model to the city as a whole. However, Fujita et al (2001) and other authors suggest that congestion levels will also tend to rise with city size.

To quantify this relationship, we gathered data on city size and estimated avoidable congestion costs for six large Australasian cities, including Auckland, over the 2004-2014 period[46]. Data for the most recent year available (2014) is summarised in the following table. Auckland has the lowest estimated per-capita cost of congestion.

Table 27: Urban population and costs of congestion in Australasia

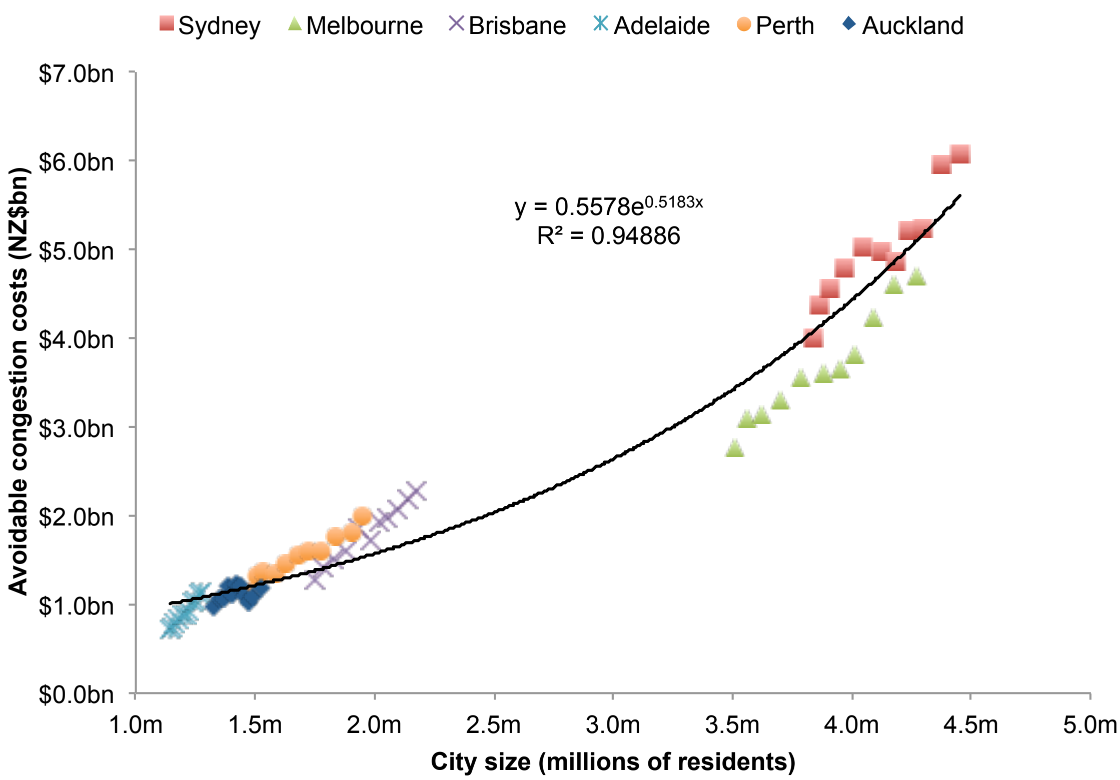
City	Urban population (million)	Estimated deadweight cost of congestion ($bn, 2015 NZD)	Cost of congestion per capita
Sydney	4.45	$6.08	$1,366
Melbourne	4.27	$4.71	$1,102
Brisbane	2.18	$2.28	$1,045
Perth	1.95	$2.00	$1,026

[46] Australian data was obtained from BITRE (2015) and ABS (2015); Auckland-specific estimates were derived using Ministry of Transport (2015) 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 – i.e. 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.

City	Urban population (million)	Estimated deadweight cost of congestion ($bn, 2015 NZD)	Cost of congestion per capita
Adelaide	1.28	$1.13	$883
Auckland	1.53	$1.18	$770

Data for all years is graphed in Figure 18 – each point represents an observation from a city in a single year. A regression line through these points suggests that there is an exponential relationship between city size and congestion. However, two of these cities – Auckland and Sydney – experienced periods when increasing city size coincided with falling congestion levels.

Figure 18: Urban population and deadweight congestion costs in large Australian / NZ cities



This relationship takes on the form specified in Equation 6, where C is the annual congestion costs (in billion dollars) and X is city size (in million residents).

Equation 6: Relationship between congestion costs and city size in Australasia

$$C = 0.5578 * e^{0.5183X}$$

We can differentiate this function with respect to X to estimate the marginal impact of added residents on annual congestion costs. This relationship is shown in Equation 7. It suggests that for a city of Auckland's size (X=1.5), adding another million residents would increase the annual cost of congestion by $0.63 billion. In other words, each additional resident would be associated with an added $630 in deadweight congestion costs per annum (on average).

Equation 7: Estimated marginal impact of added residents on congestion costs

$$\frac{dC}{dX} = 0.5578 * 0.5183 * e^{0.5183X} = 0.2891 * e^{0.5183X}$$

Estimates of the marginal external cost of congestion in Auckland

Wallis and Lupton (2013) provide the most comprehensive review of the cost of congestion in Auckland. Based on an analysis of ART3 transport modelling results for the 2006 AM peak period, they calculate the annual costs of congestion, including schedule delay costs. They estimate the short run marginal cost (SRMC) of congestion – i.e. the delay imposed on other travellers – as well as the long run marginal cost (LRMC) of congestion – i.e. the cost to expand the road network to accommodate additional journeys. Their estimates are summarised in Table 28, and updated to 2015 values.

Table 28: Short-run and long-run costs of congestion in Auckland (Source: Wallis and Lupton, 2013)

Type	Cost per peak period trip (2010 NZD)	Cost per peak period vehicle-km (2010 NZD)	Cost per peak period trip (2015 NZD)[47]	Cost per peak period vehicle-km (2015 NZD)
Short run marginal cost	$7.86	$0.54	$9.13	$0.63
Long run marginal cost	$8.35	$0.57	$9.46	$0.65

Based on Wallis and Lupton's data, we estimate that the average resident makes 0.35 peak period car trips per day.[48] If we assume that there are 250 working days in a year, this implies an annual short-run congestion cost of $790. As the short-run costs of congestion are similar to the long-run costs of adding road capacity, we assume that the Auckland road network is close to equilibrium and that increased demands can be met at a similar level of congestion cost.

Consequently, the following table summarises our two estimates of the annual and present value of congestion costs from added residents and households. These estimates are on the same order of magnitude, which is reassuring.[49]

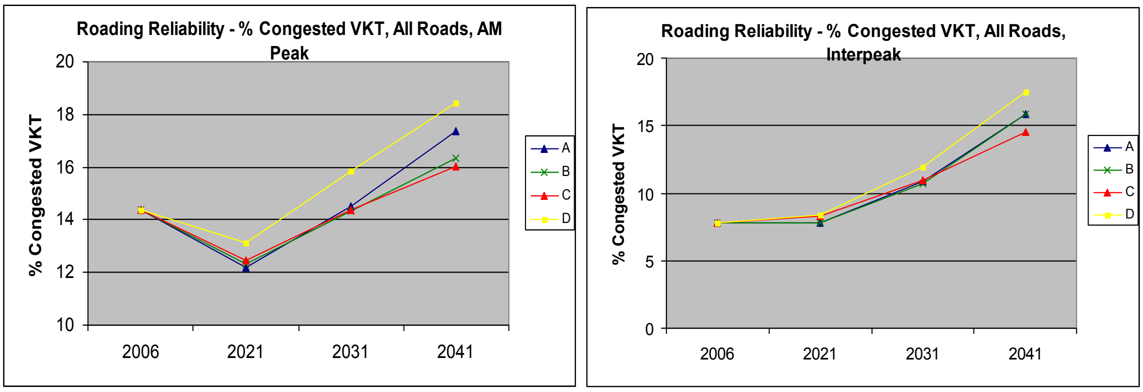
Table 29: Alternative estimates of the cost of congestion from added households in Auckland

Estimate	Annual cost per added resident	Present value cost per added resident (7% discount rate)	Present value cost per added household
Low estimate	$629	$8,987	$27,095
High estimate	$822	$11,742	$35,403

However, congestion costs are also likely to differ between greenfield and urban developments. According to an Auckland Council (2011) evaluation of alternative future growth scenarios, a predominantly greenfield growth scenario is likely to result in higher congestion impacts (and significantly longer travel times) than infill or intensification scenarios.

This is illustrated in Figure 19, which shows the share of vehicle kilometres that would be travelled in congested conditions under alternative land use scenarios. The greenfield-only scenario (Scenario D, in yellow) results in higher congestion costs than three scenarios with a greater share of growth through infill / intensification.

Figure 19: Modelled congestion impacts of alternative future land use scenarios (Source: Auckland Council, 2011)



As a basis for quantifying differences in congestion costs between urban and greenfield development scenarios, we use 2013 Census data on commute journeys taken in Auckland, grouped by area unit of origin and destination and split by

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[47] SRMC figures have been updated to 2015 values using the Benefit Update Factors published in NZTA's *Economic Evaluation Manual*; LRMC figures have been updated to 2010 values using Statistics NZ's Capital Goods Price Index for Civil Construction.

[48] Wallis and Lupton present modelling that shows a total of 453,600 vehicle trips in the average 2006 AM peak period. According to Census data, there were 1,305,000 Auckland residents in 2006.

[49] They are also on the same order of magnitude as a Transport for New South Wales (2013) estimate of the marginal cost of congestion in Sydney. Based on an analysis of changes in vehicle kilometres travelled and social costs of congestion in Sydney, TfNSW estimates that additional driving imposes social costs of A$0.32/km. This figure is lower than Wallis and Lupton's estimate of the cost of congestion in Auckland due to the fact that it is averaged over all time periods – roads are generally less congested in off-peak times.

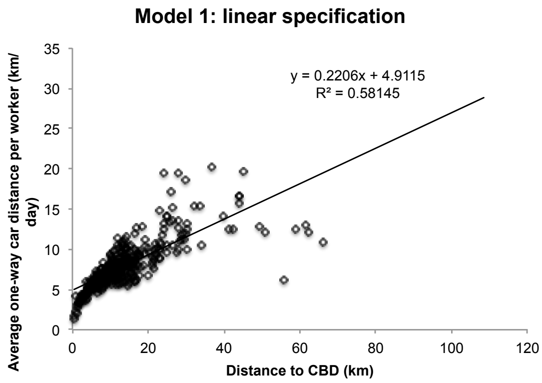
mode of travel. Nunns et al (2014) previously used this dataset to estimate the financial costs of commuting for Auckland households. We employ their estimates of the average distance commuted by car for workers in each area unit in Auckland. This measure encompasses:

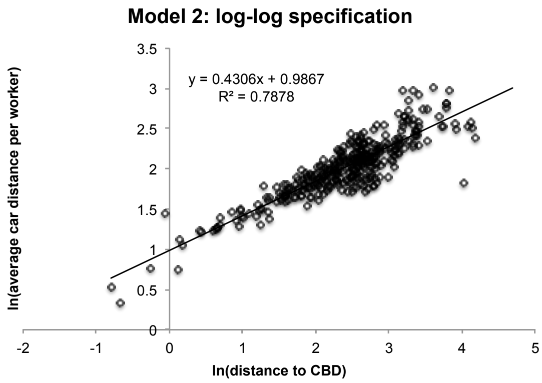
- Mode choice – i.e. areas with a greater share of people commuting by public transport or active modes will have lower car distances per worker
- Distance to employment destinations throughout the city – i.e. areas that are closer to more jobs will tend to have shorter commuting distances

After excluding area units with low density (defined as less than 1 household per hectare)[50], we tested two simple models of the relationship between distance to the city centre and average car distance per worker: A linear OLS model and a log-log model. These are shown in Figure 20. While neither model is fully satisfactory – they exhibit non-constant variance in error terms – they provide a rough indication of the underlying relationship.

One key insight from both models is that average commuting distances increase more slowly than distance to the city centre. That is, a one-kilometre increase in distance from the city centre is associated with *less* than a one-kilometre increase in car commuting distance. This reflects the fact that jobs are distributed throughout the city, giving people local employment opportunities. (And, similarly, local retail, entertainment, and education options.)

Figure 20: Relationship between distance to the Auckland city centre and average commuting distance by car (Source: further analysis of data from Nunns et al, 2014)





Model 1 suggests that a one-kilometre increase in distance to the city centre is associated with a 0.22 kilometre increase in daily one-way car commuting distance. Model 2 suggests that a 1% increase in distance to the city centre is associated with a 0.43% increase in car commuting distance.

Assuming that the modelled relationships will continue to hold true for new households, we can estimate the impact of development in greenfield areas versus in the urbanised area. The following table summarises modelled commuting distances at the 50th percentile of distances to the city centre (the urban development scenario) and the 95th percentile (the greenfield development scenario).

This suggests that car commuting distances will be approximately 55% longer in the greenfield development scenario. We use this figure as a benchmark for differentiating between congestion impacts of development in different locations.

Table 30: Expected difference in average car commuting distance between urban and greenfield developments

Scenario	Average distance to town hall (km)	Model 1 estimated car commute distance per worker	Model 2 estimated car commute distance per worker
Urban (50th percentile of distance to city centre)	12.3	7.6	7.9
Greenfield (95th percentile)	32.4	12.1	12.0

[50] Rural areas tend to have shorter average commuting distances due to the larger role of home employment on farms.

Scenario	Average distance to town hall (km)	Model 1 estimated car commute distance per worker	Model 2 estimated car commute distance per worker
Percentage change	*164%*	*58%*	*52%*

We therefore estimate the following range of congestion externalities for development in greenfield areas versus in existing urbanised areas.[51]

Table 31: Estimated congestion externalities for urban intensification and greenfield developments (present value at 7% discount rate)

Estimate	Urban intensification	Greenfield
Low	$22,717	$35,228
High	$29,682	$48,975

Crowding

Crowding represents the psychological cost, not the physical cost, of more densely used urban environments. While this effect has been described in the literature, we do not identify any robust methods for measuring it. In addition, we note that it may be difficult to empirically distinguish between observable nuisances, such as increased traffic noise, and psychological costs.

Consequently, while we note this externality we do not provide an estimate of its magnitude.

Overshadowing and blocked views

Development of tall buildings in existing urbanised areas can potentially have negative effects on neighbouring properties by overshadowing them (reducing access to daylight) or blocking views. The available empirical literature does not provide a robust basis for estimating the cost of foregone access to daylight, although it does provide relevant evidence on the cost of blocking views.

In saying this, we note that there is a "property rights" question related to overshadowing. Property owners do not have any formal property rights over the airspace above adjacent properties, although they may feel that existing regulations create a "customary right". In that context, perhaps it is more accurate to think of taller buildings as eliminating benefits – access to sunlight and views – that were previously provided free to neighbours, rather than imposing negative externalities.

Furthermore, building height limits are not the only, or even the primary, mechanism through which urban plans regulate overshadowing. Building coverage rules, boundary setbacks, and height in relation to boundary (HIRB) rules will tend to minimise overshadowing and visual dominance.

In principle, there are several "channels" in which adverse effects 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.

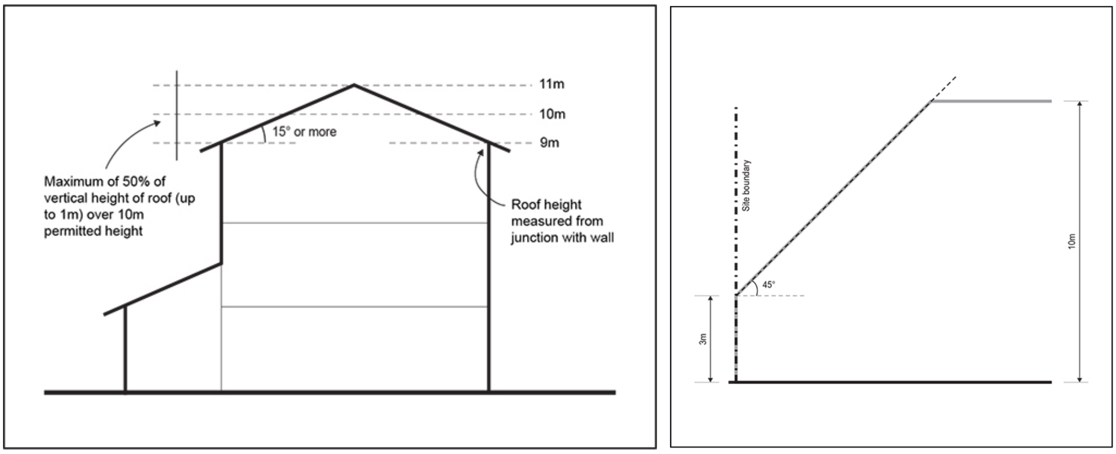
In a similar vein, blockage of views could reduce the value of neighbouring properties by making them less desirable for residents. Reduced property values would reflect the loss of amenity from views.

[51] In applying this scaling, we assume that 65% of future development will occur in existing urbanised areas, in line with Auckland Council's aspiration to accommodate 60-70% of future population growth within existing urban boundaries.

However, it is important to note that many infill / redevelopment projects will not overshadow or block the views of neighbouring buildings. Many of these developments will be under 3 storeys – terraced houses and low-rise apartments/flats. Unless these buildings are on south-facing slopes, they are not likely to overshadow neighbouring buildings of a similar height.

In addition, zoning rules typically include building height limits, height in relation to boundary and setback controls to limit the potential for overshadowing or blocking the views of neighbouring sites. A representative example – Auckland's Mixed Housing Urban zone – is illustrated in Figure 21. 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.

Figure 21: Height limit and height in relation to boundary rules in Auckland's Mixed Housing Urban zone (Source: Auckland Council)



Consequently, many developments in existing urbanised areas will result in **zero costs** as a result of overshadowing or blocking views.

Costs of overshadowing / reduced access to daylight

There is evidence for the existence of links between natural light and health outcomes, especially around depression (Chism, 1988; Brown and Jacobs, 2011). This means that reducing the sunlight received by neighbouring buildings can have adverse effects. However, the literature has not identified the magnitude of these effects, making it difficult to use this information to make an estimate of the cost of overshadowing from taller buildings.

The evidence on the other two "channels" is more tenuous. There are only a small number of studies that addressed the relationship between overshadowing and power bills, and no studies that identified a link between overshadowing and property values.[52] In part, this is due to the difficulty of modelling shading in an urban environment (see e.g. Jones et al., 2004; Fung and Lee, 2012).

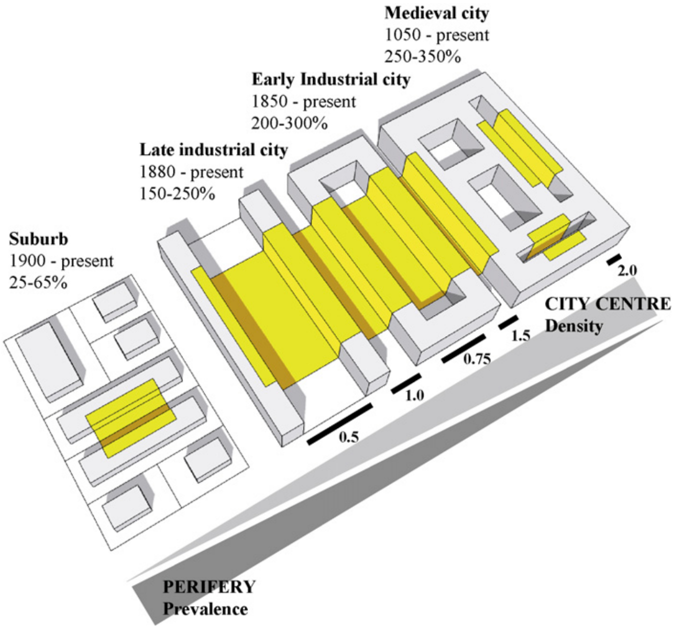
However, existing papers suggest that the impact of overshadowing on power bills is ambiguous. Strømann-Andersen and Sattrup (2011) find that narrow "urban canyons" in a northern European climate raise modelled residential energy consumption by approximately 19% relative to dwellings with open horizons. Donovan and Butry (2009) found that shading from street trees in Sacramento, California tended to *lower* summer cooling costs. Kolokotroni et al (2006) observe a "heat island" effect in intensely developed areas such as central London, which raises summer cooling costs while *lowering* winter heating costs.

Strømann-Andersen and Sattrup's (2011) model can be used to estimate the external costs of overshadowing associated with a densely developed urban area. It suggests 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

[52] We searched for studies in Google Scholar, searching for various permutations of the phrases {overshadowing, daylight, shading, sunlight} and {heating costs, electricity costs, property prices, property values, sale prices, hedonic price}.

two-lane Auckland street (~10 metres wide, including footpaths), this would equate to 5-8 storey buildings. As Figure 22 shows, this would represent a relatively intensive development pattern even in the older areas of northern European cities.

Figure 22: Height to width ratios in built-up areas of Copenhagen (Strømann-Andersen and Sattrup, 2011)



We assume that other factors such as access to views are equalised within this area – i.e. apartments that block views will themselves *gain* the same view, for no net change access to views within the area.[53] Consequently, the overshadowing externality in densely developed urban areas can be estimated as a 13% increase in household energy costs – the mid-range of Strømann-Andersen and Sattrup's estimates.

Table 32 shows the annual and present value impact of a 13% increase in household energy use for an average household in New Zealand regions. These figures are likely to overstate the true external cost of densely developed areas, as they do not account for the "heat island" effect documented by Kolokotroni et al (2006) or the fact that average household sizes are likely to be smaller in these areas.[54]

Table 32: Estimated impact of urban canyons on household energy consumption in New Zealand

Region	Average annual household energy costs (2013)[55]	Annual cost of a 13% increase in energy costs	Present value cost (7% discount rate)
Auckland	$2,408	$313	$4,471
Wellington	$2,278	$296	$4,230
Rest of North Island	$2,569	$334	$4,771
Canterbury	$2,423	$315	$4,500
Rest of South Island	$2,439	$317	$4,529

We also estimate the externalities that may arise when tall buildings overshadow individual neighbouring properties without creating an "urban canyon". As no relevant empirical studies or models are available for these cases, we have gathered data on recent apartment sales in Auckland to estimate the price premium for north-facing dwellings.[56] Table 33

[53] There may in fact be an increase in the total number of people who can experience views, as the upper storeys of apartment buildings will have better vistas than buildings at ground level.

[54] In addition, heating accounts for a smaller share of household energy use in New Zealand than in northern Europe. See EECA for New Zealand-specific data: http://enduse.eeca.govt.nz/.

[55] Source: Statistics New Zealand. 2013. *Household Expenditure Survey 2012/13.* Available online at http://nzdotstat.stats.govt.nz/wbos/Index.aspx?DataSetCode=TABLECODE7552.

[56] We gathered data on advertised apartment characteristics, including advertised price, apartment size, number of carparks, storey, and whether or not the apartment had a northern aspect, for two apartment buildings currently on the market: Daisy (an Ockham development) and Citizen (Urban Collective).

summarises our hedonic analysis of these apartment sales. Our key finding is that a north aspect is associated with a 17.3% higher sale price (statistically significant at the 5% level, with a standard error of 7.7%).

Table 33: Hedonic model of the value of north-facing dwellings

	Dependent variable:
	log(Sale_price)
log(Floorspace)	0.584***
	(0.203)
Carparks	0.294***
	(0.096)
Storey	0.051**
	(0.021)
Aspect_north	**0.173****
	(0.077)
BuildingDaisy	0.007
	(0.135)
Constant	10.753***
	(0.877)
Observations	79
R^2	0.616
Adjusted R^2	0.590
Residual Std. Error	0.284 (df = 73)
F Statistic	23.422*** (df = 5; 73)
Note:	*p<0.1; **p<0.05; ***p<0.01

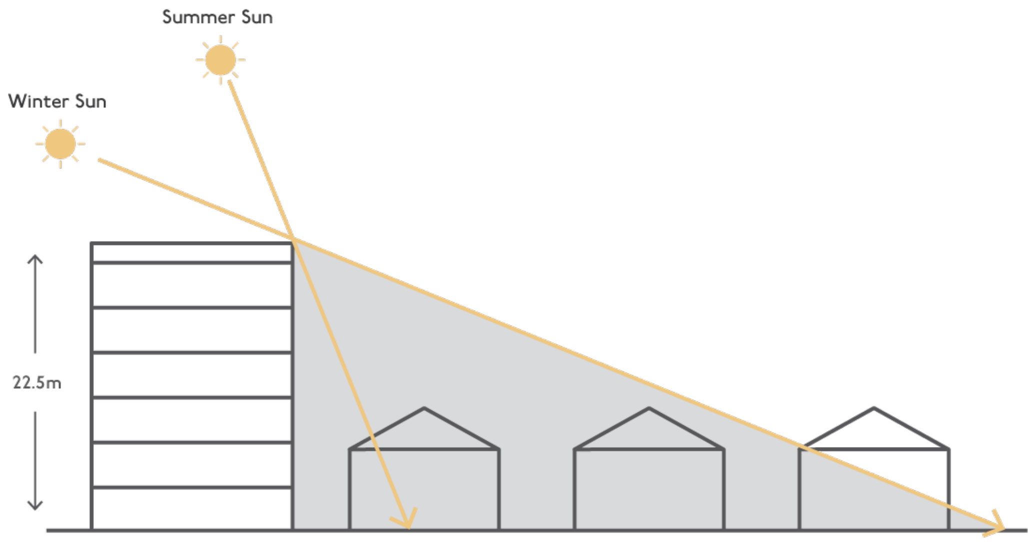
As tall buildings may cause neighbouring buildings to lose access to direct sunlight for at least part of the day, we can use this figure – a 17.3% price premium for north-facing dwellings – to estimate the external costs associated with overshadowing. This is likely to result in an over-estimate of the costs of overshadowing, as a single tall building may only block sun during part of the day (or part of the year).

Figure 23 presents a hypothetical scenario in which a seven-storey apartment building is erected in a low-density residential area.[57] No height in relation to boundary controls have been applied – these will tend to reduce the potential for overshadowing. We have calculated the number of buildings that would be shaded based on the height of the apartment building and the sun angle in the winter (22 degrees) and summer (68 degrees).[58] In the winter, this building would fully overshadow two adjacent houses, and partially shade a third. In the summer, only one building would receive partial shade. On average, across the course of the year, two buildings would be overshadowed.

[57] Key assumptions: a 7-storey apartment building would be 22.5 metres tall, while neighbouring buildings would be two storeys with pitched roofs. The average residential site in Auckland is approximately 18-20 metres wide. We have also assumed flat terrain for simplicity.

[58] Auckland Council. 2012. *Auckland Design Manual*. Available online http://www.aucklanddesignmanual.co.nz/project-type/buildings-and-sites/housing/terraces/guidance/the-building/new_building_performance/new_keeping_heat_in_house

Figure 23: Overshadowing from a seven-storey apartment building



If we assume that the two buildings being overshadowed are worth, $1 million apiece, and that they are 17.3% more valuable as a result of the absence of overshadowing, this would result in a total external cost of $ $294,970. If we assume that the apartment building would include 30 apartments,[59] then this would imply a per-apartment overshadowing externality of $9,832.

Costs of loss of views

There is a large empirical literature on the value that people place on views. This literature suggests that there is a positive relationship between access to views and residential property values. This can provide a basis for valuing the cost of foregone views from taller buildings.

Table 34 summarises some Auckland-specific studies on the value of views. These studies indicate that the price premium for water views is potentially large, while views of land are less valued. These findings are generally consistent with international research – see Bourassa et al (2004) for a review of international studies of the value of views. Glaeser et al (2005) also estimate the value of views in their analysis of the "regulatory tax" associated with Manhattan's building height limits. They find that the cost of building height limits is roughly 10 times higher than the value of views preserved by height limits.

We prefer the estimate of Nunns et al (2015) that water views are associated with an 8.3% price premium and views of land are not, on average, associated with a price premium. (This is the most recent study and the only one to employ spatial regression techniques.) However, there is also a case for sensitivity testing a higher value of 20%, which is within the range of estimates by Bourassa et al (2004) and Rohani (2012).

Table 34: Hedonic pricing studies of the value of views in Auckland

Study	Summary
Bourassa et al (2004)	In Auckland, a view of land was associated with a 4-6% higher price for houses sold in 1996. 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.

[59] This is based on the assumption that the 7-storey apartment building occupies 50% of a 1000m2 site, that the ground floor is used for podium parking, and that the average apartment occupies 100m2 of space, including services and common areas. These figures are based on designs for recent apartment developments in Auckland.

Study	Summary
Rohani (2012)	In 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 et al (2015)	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%). (Based on the preferred spatial regression model; OLS models produced higher coefficients. Note that most previous research on Auckland is limited to OLS.) 13.2% of residential sales had views of water.

Following Glaeser et al (2005), we assume that the view-related externality equals the number of views blocked by a new apartment times the hedonic value of those views.

The number of views blocked by a single apartment building will depend upon local topography and built form. However, as a starting point we assume that a new apartment block will only block the views of two buildings immediately behind it. Those buildings are in turn assumed to block the views of previous rows of buildings. (We also note that this scenario may result in a significant net *gain* in the number of people who can access views of water.)

We therefore apply similar assumptions as in the above analysis of overshadowing – two houses whose water views are blocked by 30 new apartments. However, we assume that these houses are worth $2m apiece, reflecting generally higher coastal property values. If the value of a water view adds 8.3%-20% of a property's value, then the total cost of blocking two views is $305,556-$666,667. This would imply a per-apartment view externality of $10,219 to $22,222 for apartments that block water views.

According to Nunns et al (2015), only 13.2% of recent house sales in Auckland had water views, and some of these are directly on the waterfront or on a hillside where their views are unlikely to be blocked. Consequently, there are relatively few situations in which a new apartment building would block a highly valued view of water. In most cases, the view-related externality associated with apartment development will be smaller or equal to zero.

Overall overshadowing and view externalities

Table 35 summarises the overall externalities associated with development in existing urbanised areas. We consider four scenarios: One in which new development complies with height limits and height in relation to boundary controls and hence does not overshadow or block the views of neighouring properties, and three in which varying levels and locations of development result in higher externalities.

Table 35: Overall costs of overshadowing and loss of views from tall buildings in Auckland

	Scenario 1: Development with height and setback controls	Scenario 2: Intensely developed "urban canyon"	Scenario 3: Tall building in low-rise area without water views	Scenario 4: Tall building in low-rise area with water views (less than 13% of sites)
Cost of overshadowing	$0	$4,230	$9,832	$9,832
Cost of blocked views	$0	$0	$0	$10,219 to $22,222
Total	$0	$4,230	$9,832	$20,051 to $32,055

Loss of amenity from access to peri-urban open space

Greenfield developments consume open space, such as reserves or farmland, at the city fringe. This may in turn reduce amenity for city residents, who may value access or proximity to that open space. In this context, McCann (2001) observes that urban limits will therefore create or preserve localised amenities:

> *"If environmental amenities are relatively localized and it is perceived that the greenbelt policy will be maintained in the long term, this implies that the persons who are resident on the urban fringes will always enjoy superior environmental amenities in comparison to those who are resident closer to the city centre."*

This amenity value is expected to be capitalised into property prices near the urban fringe. One effect of this may be to increase the discontinuity in land prices at the MUL – as prices just inside the MUL account for the positive amenity provided by preserved open space. However, we note that Grimes and Liang (2007) do not find strong evidence of this effect in Auckland. In their analysis of Auckland's MUL, they conclude that:

> *"distance variables are capturing the values of land just inside the MUL boundary, implying that there is no extra amenity value placed on this land. Second, even if there were such higher amenity value, it is likely that higher income (and less deprived) households will move into the sought-after area. Our extended model controls for these household characteristics and hence indirectly controls for such amenity values."*

However, other studies have attempted to more explicitly account for the relative costs and benefits of policies to preserve open space at the city fringe or within the city.

Cheshire and Sheppard (2002) collected house sales data and household survey data to analyse the welfare impacts of greenbelt and MUL policies in Reading (UK), which "faces some of the most restrictive land use planning in Britain". They used this data to calibrate a microeconomic model of household utility (wellbeing) that enabled them to estimate the value that households derive from three "planning amenities": accessible open space, inaccessible open space (e.g. agricultural land at the city periphery), and industrial land use. Their results, which are summarised in Table 36, suggest that the average household derives substantial gross benefits from Reading's planning regulations. The per-household value of accessible open space is roughly 2.4 times higher than the value of inaccessible open space.

Table 36: Gross value of benefits from planning amenities (Source: Cheshire and Sheppard, 2002)

Amenity	Amount available in the absence of planning	Average annual value per household (£)	Standard deviation (£)
Accessible open space	Zero accessible open space in urban area	2424.45	1745.05
Inaccessible open space	Zero inaccessible open space in urban area	1029.65	1223.90
Industrial land use	47% of land in every part of the city is in industrial use	1092.00	600.96

Second, the authors calculate the net costs associated with planning amenities (i.e. benefits minus costs). In order to do so, they model three scenarios in which Reading's greenbelt and MUL policies are relaxed, leading to lower housing costs (or increased housing consumption) as well as a reduction in the amenity value of open space. Their results, which are summarised in Table 37, suggest that relaxing planning regulations would improve wellbeing for the average household even after accounting for the loss of amenity from reduced open space.

Table 37: Net costs of planning amenities compared to several scenarios for relaxing rules (Source: Cheshire and Sheppard, 2002)

Scenario for relaxing rules	Description of scenario	Average annual net cost per household (£)	Standard deviation (£)
Reduced internal open space	17.23% reduction in open space within Reading's MUL – i.e. enabling development on some greenbelt sites	45.55	61.20
Modest relaxation of MUL and greenbelt policies	46.9% increase in urbanised land area as a result of a 17.23% reduction in internal open space and a relaxation of the MUL	210.94	376.68
Significant relaxation of MUL and greenbelt policies	70.7% increase in urbanised land area as a result of a 17.23% reduction in internal open space and a more significant relaxation of the MUL	407.44	335.40

In a similar exercise, Rouwendal and van der Straaten (2008) propose the following cost-benefit test for provision of open space within cities:

"Open space should be provided until the sum of the marginal willingness to pay of all the inhabitants in of a neighbourhood is equal to the market value of residential land in the neighbourhood."

Rouwendal and van der Straaten use house sales data to estimate the value of public and private space to households in the Netherlands' three largest cities. By dividing the marginal price of floor area into the marginal price of open space, they obtain an estimate of the population densities that would be required to obtain an optimal balance of public parks and housing.

Table 38 summarises the results of their analysis, which suggests that Amsterdam is over-supplied with open space, the Hague is under-supplied with open space, and Rotterdam is about right. This finding suggests that the value of open space may vary significantly between cities, even if they share other cultural similarities.

Table 38: Willingness to pay for open space and housing in three Dutch cities (Source: Rouwendal and van der Straaten, 2008)

City	Marginal price of open space (€ / m2 / hectare / household)	Marginal price of floor area (€ / m2 / household)	Optimal number of households per hectare	Actual number of households per hectare
Amsterdam	4.01 (1.38)[60]	806 (42)	201	72
The Hague	14.55 (1.04)	606 (38)	42	59
Rotterdam	9.87 (1.79)	429 (47)	43	42

There are no studies that estimate the value of open space in Auckland. Consequently, in seeking to estimate the value of preserved open space at the urban fringe, we must draw upon the international literature instead.

Brander and Koetse (2011) underook a meta-analysis of contingent valuation and hedonic pricing studies of the value of urban open space. The contingent valuation studies they surveyed are more relevant to this analysis, as they estimate the per-hectare value of urban and peri-urban open space.[61]

The authors found 20 contingent valuation studies that provide a total of 73 suitable values. The mean value of urban and peri-urban open space is US$13,210 per hectare per annum (2003 USD), while the median value is only US$1,124. Based on a meta-regression of study outcomes and characteristics, Brander and Koetse concluded that:

- The value of open space with "average" characteristics is US$1550/ha/year. (Corresponding to a 9918 ha forest providing environmental / agricultural services in a country with GDP per capita of US$20,542 and regional population density of 218 people per km^2 – similar to Auckland's GDP per capita but with a lower average population density).
- Parks and green spaces are more highly valued than forests (coefficient positive and statistically significant), but it is unclear whether agricultural / undeveloped land is more highly valued (coefficient positive but statistically insignificant)
- Larger open spaces are less valued on a per-hectare basis, indicating diminishing marginal value of larger open spaces.

Consequently, we estimate a range for the value of open space in Auckland based on the results of Brander and Koetse's meta-analysis. We assume the following:

- A lower-bound value of US$1550/ha/year based on the "average" value from the meta-regression. This corresponds to a large tract of forest land.
- An upper-bound value of US$2710/ha/year, which corresponds to a similarly-sized tract of agricultural / undeveloped land.[62]

[60] Standard errors are given in parentheses to provide an indication of the potential uncertainty in these estimates. All coefficients are highly statistically significant.

[61] By contrast, the hedonic pricing studies Brander and Koetse review measure the value of increased proximity to the nearest park or reserve. While there is an argument to be made in favour of hedonic pricing approaches, as they analyse actual behaviour and preferences rather than hypotheticals, the hedonic pricing studies reviewed in this meta-analysis do not provide an easily interpretable

[62] Calculated by multiplying together relevant coefficients from their meta-analysis regression model.

The following table converts these figures from annual US dollars into present value New Zealand dollars, and hence into estimated costs of foregone amenity value per house.

Table 39: Estimated value of peri-urban open space

Type of open space	Annual value (2003 USD per hectare per year)	Annual value (2014 NZD per hectare per year)[63]	Present value per hectare (7% discount rate)	Cost of foregone open space per house[64]
Forest (lower bound)	$1,550	$3,108	$44,395	$2,664
Agricultural / undeveloped land (upper bound)	$2,710	$5,433	$77,620	$4,657

Air Quality

Increased population levels and increased transport of those people can result in increased emissions of pollutants and increased exposure to pollution concentrations.

There have been a number of studies that have assessed the overall impacts of air pollution in New Zealand, particularly the Health and Air Pollution in New Zealand (HAPiNZ) study, 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). The results of the HAPiNZ studies have been used as inputs to a national cost benefit analysis of air quality standards (e.g. NZIER, 2009). In New Zealand, as elsewhere, economic analyses have suggested that the adverse impacts are dominated by the health effects, particularly the impacts on premature deaths. They have also suggested that concentration of PM_{10} is regarded as the best available summary indicator of air pollution exposure in New Zealand (Covec, 2015).

In Auckland, emissions of PM_{10} were estimated to total 3,170 tonnes in 2006, with 38% from transport, 47% from domestic fires and 15% industry (Xie et al, 2014). This compares with estimates for New Zealand as a whole of: 56% due to domestic fires, 22% to motor vehicles, 10% to industry and 12% to open burning (Kuschel et al, 2012).

We estimated the impacts of changes in population in urban airsheds, which tend to have poorer air quality, on health costs using the following assumptions:

- We use estimates of damage from air pollution in Auckland as a basis for estimating the impacts of PM_{10} in an urban area.
- We divide total estimated costs by population as an estimate of the long-term impacts of adding an additional person to the Auckland region.
- We use recent analyses of the impacts of policies to estimate the difference between long-run average effects and marginal impacts of policies that change emission quantities.

Marginal effects of poor air quality

The difference between static effects and marginal effects as a result of changes in emissions needs to be explained.

The mortality impacts across a wide range of studies are dominated by the chronic effects. The studies used to assess the chronic effects suggest that people are frail as a result of a long time living in elevated concentrations of pollutants.[65] Even if air pollution is cut to zero tomorrow, these people might still be frail and some will die prematurely because of this frailty. The cessation of emissions stops additional frailty and would be expected to allow some repair. However, even if all pollution is eliminated, it might take many years without pollution for the full benefits to be realised.

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[63] According to World Bank World Development Indicators: 2003 PPP conversion rate was 1.50 NZD per 1 USD. [http://data.worldbank.org/indicator/PA.NUS.PPP?page=2] NZ GDP deflators were: 81.1 in 2003; 108.4 in 2014. [http://data.worldbank.org/indicator/NY.GDP.DEFL.ZS?page=2] Consequently, the conversion rate from 2003 USD to 2014 NZD is given by (1.50)*(108.4/81.1)=2.0.

[64] Assuming an average of 600m2 per house, or roughly 16 houses per hectare. This figure includes roads and reserves.

[65] Seethaler, RK, Künzli N, Sommer H, Chanel O, Herry M, Masson, S, Vergnaud J-C, Filliger P, Horak F Jr, Kaiser R, Medina S, Puybonnieux-Texier V, Quénel P, Schneider J, Studnicka M and Heldstab, J (2003) Economic Costs of Air Pollution Related Health Impacts: An Impact Assessment Project of Austria, France and Switzerland. Clean Air and Environmental Quality, 37/1: 35-43

Given this, most international studies now include a lagged benefit of reducing air pollution (or a lagged cost of increasing emissions), including using an approach with benefits distributed over 20 years as advocated by the US EPA (US EPA, 2004; Cameron and Ostro, 2004; US EPA, 2011) and alternative structures (US EPA, 2011; Roosli et al, 2005; COMEAP, 2010; Walton, 2010).

Impact studies in New Zealand have characterised the mortality impacts as increases in premature mortality, measured using the value of statistical life (VoSL). This has been used as simple shorthand to explain the nature of impacts, but can be somewhat misleading when examining the impacts of policy which will not eliminate pollution but change emission levels and concentrations. 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. When examining policy the effect is better measured as a change in life years (and value of life year or VOLY), and this is consistent with international policy studies (COMEAP, 2010; Defra et al, 2007; OMB, 2003; US EPA, 2011).

The question of VoSL vs VoLY was canvassed in recent air quality policy analysis by Covec (2015). It produced results in which the difference in benefits using a VoSL approach was 6-21 times the benefit measured using VoLY.

We use the assumptions shown in Table 40 in our analysis.

Table 40: Assumptions used in Air Quality Analysis (Source: Covec, 2015)

Variable	Value
Value of Statistical Life (VoSL)	$3,948,300
Value of life year (VoLY)	$25,000
Cardiac hospital admission	$6,810
Respiratory hospital admission	$4,864
Restricted activity day	$66
Life years per premature mortality (adult)	13
Life years per premature mortality (babies)	81

Note: The life years lost per premature mortality are estimated using life tables that distribute changes to probability of death across all age classes.

We use these input data with estimates of the impacts of air pollution in Auckland from Kuschel et al (2012) and the Auckland population in 2012 (1,476,500) to estimate total costs of air pollution as averaging $89-$805/person ($41,000 – 375,000 per tonne based on 3,170 tonnes). These estimates might be used as broad estimates of the impacts of new people moving to Auckland as a proxy for an urban region. Our preference is for the lower value in this range which takes better account of the marginal impact.

Table 41: Annual Impacts of PM_{10} in Auckland

	Premature mortality (Adults)	Premature mortality (Babies)	Cardiac hospital admissions	Respiratory hospital admissions	Restricted Activity Days	Total
Domestic Fires	112	0.6	25.7	50.4	191,590	
Motor Vehicles	126	0.6	28.2	57	214,980	
Industry	22	0.1	3.8	7.6	30,810	
Open Burning	31	0.2	7.2	14.9	55,320	
Total	291	1.5	64.9	129.9	492,700	
Cost ($m)	$1,149	$6	$0	$1	$33	$1,189
Total (VoLY)	$95	$3	$0	$1	$33	$131
$/person (VoSL)	$778	$4	$0	$0	$22	$805

	Premature mortality (Adults)	Premature mortality (Babies)	Cardiac hospital admissions	Respiratory hospital admissions	Restricted Activity Days	Total
$/person (VoLY)	$64	$2	$0	$0	$22	$89

Source: impacts data from 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 Volume 1: Summary Report. Prepared for Health Research Council of New Zealand, Ministry of Transport, Ministry for the Environment and New Zealand Transport Agency.

Using average household sizes from the 2013 census, the costs by location are estimated as shown in Table 42. Assuming no rapid future improvement in vehicle technology to eliminate particulate emissions, e.g. rapid uptake of electric vehicles, we calculate the present value of these costs at a 7% discount rate.

Table 42: Air pollution costs per additional household

Location	Average household size (Statistics NZ, 2013a)	Cost per annum	Cost (present value at 7% discount rate)
Auckland Council	3.0	$267	$3,814
Hamilton City	2.7	$240	$3,433
Waipa District	2.6	$231	$3,306
Waikato District	2.8	$249	$3,560
Environment Waikato	2.6	$231	$3,306
Tauranga City	2.5	$223	$3,179
Western Bay of Plenty District	2.6	$231	$3,306
Bay of Plenty Region	2.6	$231	$3,306
Christchurch City	2.5	$223	$3,179
Waimakariri District	2.6	$231	$3,306
Selwyn District	2.9	$258	$3,687
Environment Canterbury	2.6	$231	$3,306
Queenstown-Lakes District	2.6	$231	$3,306
Otago Region	2.4	$215	$3,051

Furthermore, we recognise that these outcomes may vary between different locations, as air pollution levels vary throughout the city. Consequently, we use HAPiNZ data to estimate scenarios for the cost of air quality in different locations. Their modelled estimates of air quality in Auckland area units indicate that in 2006

- The population-weighted average PM_{10} concentration was 15.4µg/m^3. We use this as a benchmark for the lower end of costs in urban intensification and the upper end in greenfield areas, which are assumed to have better air quality.
- The 10^{th} percentile of PM_{10} concentration was 12.9µg/m^3, or approximately 16% less polluted than average. We use this as a benchmark for the lower end of costs in greenfield areas.
- The 90^{th} percentile of PM_{10} concentration was 17.0µg/m^3, or approximately 11% more polluted than average. We use this as a benchmark for the upper end of costs in urban intensification areas.

We use these figures to scale the average air quality costs per household reported in the above table. The following table reports our high and low estimates for urban intensification and greenfield development.

Table 43: Estimated air quality externalities for urban intensification and greenfield developments (present value at 7% discount rate)

Estimate	Urban intensification	Greenfield
Low	$3,814	$3,204
High	$4,217	$3,814

Flooding and Water Quality

Urban run-off has risks of flooding and can affect the water quality of water bodies and the marine environment. Increased surface run-off and increased contamination of that run-off can result from a greater percentage of an area being covered with paved surfaces or buildings and reduced areas of natural infiltration.

Surface run-off is generally 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. A summary of the ecological impacts of stormwater is provided in Table 44.

Table 44: Ecological impacts of stormwater (Source: 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.

Stormwater systems to reduce the impacts of surface run-off are funded by councils and paid for through a mixture of rates and Development Contributions (DCs). Our concern here is in whether there are external costs not currently covered by the engineering costs of stormwater infrastructure.

Flood Risk

Flood risks are examined by councils as part of their investment decisions for stormwater infrastructure. For example 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[66] 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.

For individual households, the risk of flood costs is reduced through insurance. Households only gain from investments in stormwater assets to the extent that these investments reduce their uninsured costs if a flood eventuates, or where these investments lead to insurance companies reducing premiums. To the extent that insurance companies do not respond efficiently to risk reductions, making stormwater investment decisions on the basis of costs of flooding absent insurance

[66] https://riskscape.niwa.co.nz/

may lead to over-investment. At the national level this would be rendered irrelevant if insurance companies were New Zealand-owned, but most are not.[67]

Investigating this issue is beyond the scope of this project. If we assume that insurance companies respond efficiently to risk in setting premiums, flooding costs are already considered in stormwater investment decisions and could be regarded as already internalised.

Freshwater quality

To estimate the impacts on water quality would require an estimate of the effects of each additional house (or household) on water quality and a valuation of the impacts. Some values exist on the value the households place on water quality, and the impacts of changes in water quality, e.g. Kerr and Sharp (2003a; 2003b; 2008) have examined the impacts of changing stream quality from high to low ecological value on the "existence value" of Auckland households. However, these would need to be combined with an estimate of marginal impact per household. These effects would be highly site-specific, both in terms of the environmental impact and the households that would be directly affected by changes at that location.

Similar problems arise in valuing, e.g. the impacts on marine water quality and the effects on recreational activity (swimming, fishing etc) and existence values.

To gain a rough ball-park approximation of water quality value, we might use the results of Kerr and Sharp's existence value analysis. The study used statistical techniques to estimate the changes to total existence value as a result of changes in different components of environmental quality; with the exception of stream channel shape, we show the values for river degradation in Table 45. The total row is estimated as the value of degradation of a stream from high to low value.

Table 45: Components of existence value for Auckland urban streams (Source: Kerr and Sharp, 2008)

Attribute	Explanation	Value ($/household per year)	
		2003 $	2015 $
Water clarity	Clear to muddy (or low visibility)	$79 ($53 - $148)	$103 ($69 - $193)
Native fish	One fewer species	$14 ($8 - $27)	$18 ($10 - $35)
Vegetation	Moderate to little or no vegetation High to moderate vegetation	$42 ($1 - $115) $35 ($13 - $81)	$55 ($1 - $150) $46 ($17 - $106)
Stream channel	Stream channel from straight to natural form[68]	$69 ($44 - $126)	$90 ($57 - $165)
Total (estimated)	Change from high ecological value to degraded	$239 ($119 - $497)	$312 ($155 - $649)

Thus if a new development affected a stream because of the run-off effects and other disturbances, the costs would be approximately $312 per annum per household affected if a stream is highly degraded as a result. In order to translate these estimates into external costs associated with new dwellings, we have had to make some high-level assumptions about the magnitude of impacts.

In greenfield areas, we assume that:

- The affected population is approximately double the size of the new development; and
- The reduction in stream value ranges from 20% to 40% of the drop from good to low quality.

In urban intensification areas, we assume that:

- The affected population is approximately ten times the size of the new development, reflecting greater density of population in existing urban areas; and

[67] The main insurance companies operating in New Zealand are owned by shareholders resident overseas. This includes State insurance, IAG, Vero, AMP, Axiom, QBE, and Chartis/AIG. New Zealand owned-companies include FMG (Farmers Mutual Group), that largely insures rural property (and is based in Wellington), and Tower Insurance that has some ownership by Auckland-based shareholders.

[68] Kerr and Sharp only produce values for stream enhancement to natural form; we assume the values are the same magnitude in the other direction.

- The reduction in stream value ranges from 0% to 5% of the drop from good to low quality, reflecting the fact that urban streams are already likely to be heavily degraded.

The resulting estimates are summarised in the following table.

Table 46: Estimated freshwater quality externalities for urban intensification and greenfield developments

Variable	Urban intensification		Greenfield	
	Low	High	Low	High
Annual value of Auckland urban streams ($/household/year)	$312	$312	$312	$312
Affected households per new dwelling	10	10	2	2
Assumed reduction in water quality	0%	5%	20%	40%
Annual cost of reduced freshwater quality	$0	$156	$125	$250
Present value cost of reduced freshwater quality (7% discount rate)	$0	$2,229	$1,783	$3,566

Coastal and marine environmental quality

The coastal and marine environment will be affected by the quality of the water entering it, particularly the presence of heavy metals, sediment, faecal matter and gross pollutants. Given the large volume of water in the marine environment relative to that entering from the stormwater system, generally temperature and nutrients are not regarded as important issues. 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.

A later study by some of the same authors examined the willingness to pay (WTP) of Auckland residents for improvements in the marine environment resulting from stormwater system alternatives (Batstone, 2010; Batstone et al, 2010; Batstone and Sinner, 2010).[69] They found a WTP for an improvement in water quality from low to high was valued at $335, $109 and $114/household per year in outer (consisting primarily of beach locations), middle and upper harbour areas respectively.[70] We use these figures to estimate a potential range of impacts for development in different locations.

However, as above, robustly applying these values would require an understanding of the marginal impacts of additional housing on the quality of the marine environment, and the number of households affected by any change in quality. We do not have good information to estimate these effects; as a result, it is necessary to make some high-level assumptions as above. We note that these assumptions are likely to be pessimistic given policy directions in the NZ Coastal Policy Statement to avoid negative effects on coastal water quality, albeit at some cost for developers.

In greenfield areas, we assume that:

- WTP for an improvement in coastal water quality is $335 per household per annum, reflecting Batstone's estimate for outer harbour areas;
- The affected population is approximately double the size of the new development; and
- The reduction in coastal water quality ranges from 20% to 40% of the difference from good to low quality (consistent with the above assumptions for freshwater).

In urban intensification areas, we assume that:

- WTP for an improvement in coastal water quality is $109 per household per annum, reflecting Batstone's estimate for middle harbour areas closer to existing urban areas;

[69] An alternative approach used by van den Belt and Cole (2014) estimated the value of the ecosystem services provided by marine areas on a hectare basis, building on Costanza et al (1997).

[70] Original values converted into 2015$ values.

- The affected population is approximately ten times the size of the new development, reflecting greater density of population in existing urban areas; and
- The reduction in coastal water quality ranges from 0% to 5% of the difference from good to low quality, reflecting the fact that the ill effects of urban development are already being felt in these areas (consistent with the above assumptions for freshwater).

The resulting estimates are summarised in the following table.

Table 47: Estimated coastal water quality externalities for urban intensification and greenfield developments

Variable	Urban intensification		Greenfield	
	Low	High	Low	High
Annual WTP for an improvement in coastal water quality ($/household/year)	$109	$109	$335	$335
Affected households per new dwelling	10	10	2	2
Assumed reduction in water quality	0%	5%	20%	40%
Annual cost of reduced coastal water quality	$0	$55	$134	$268
Present value cost of reduced coastal water quality (7% discount rate)	$0	$779	$1,914	$3,829

Noise, smells and other nuisances from incompatible land uses

Anas, Arnott, and Small (1998) observe that "cities are awash in very localized externalities, from the smells from a fish shop to the blockage of ocean views by neighbors' [sic] houses." It can be challenging for individuals to negotiate or "contract" with each other to manage these externalities. If regulations are able to manage these externalities, they can result in social or environmental benefits that would not otherwise have occurred.[71]

Localised nuisance externalities may arise from incompatible land uses. These include, but are not necessarily limited to, effects such as:

- Noise from loud industrial or transport activities (e.g. 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). As above, we would expect these negative externalities to be capitalised into residential property values.
- Poor air quality, odours, or dust from industrial, transport, or rural activities (e.g. 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; however, we would also expect these negative externalities to be capitalised into residential property values.
- 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.

We also note that people may also place some value on inflexible zoning as a form of "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 (2003) interpreted this effect as the value of an "insurance policy against the invasion of commercial or industrial activity that would create strongly negative effects".

[71] Planning regulations are not the only way to manage localised externalities. For example, Bertaud (2014) describes several examples where "spontaneous settlements" in developing-world cities have successfully established "good neighbour norms" that govern the form of development.

Cost of noise impacts

There are a range of empirical studies on the impact of higher noise levels on residential property values, a proxy measure for residential amenity. These studies often focus on the impact of airport noise, a frequently controversial issue in urban planning.

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 (2013) 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 negative effects of high noise may not be fully capitalised into residential property prices.

While the impacts of higher noise levels on property value are reasonably well understood, the literature does not provide a strong basis for estimating the impacts of new development on noise levels.

Analysis of noise is complicated by the existence of many noise sources and the fact that higher noise levels 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).

New activities (e.g. increased traffic) may raise noise levels, but it can be challenging to precisely estimate the increase in decibels due to difficult-to-model variations in noise at the point of origin and impact on properties. For example, Nunns, Varghese and Adli (2015) develop a simple tool for estimating the impact of bus operations on on-street noise levels, but the reported range of outputs is wide.[72] The NZ Transport Agency (2013) 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.

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 – i.e. noise levels are *lower* in more populated areas.

This data does not provide a firm basis for estimating negative noise and nuisance externalities from increased city population. In principle, more development will increase traffic volumes. However, there is relatively little data on the impact of urban and greenfield development on local and regional traffic patterns. Similarly, this data may provide a basis for estimating negative externalities from invasion of incompatible uses, if data on noise impacts was available.

If a positive relationship between population density and traffic noise holds true in Auckland, we would expect it to be factored into property prices. Nunns et al (2015) find that there is a negative relationship between local (meshblock) population density, but a relatively weak one – doubling population density is estimated to reduce property values by 1.1%. This can be compared with the estimates above. NZTA suggests that doubling traffic volumes increases noise level by 3 dB, which would (under its valuation rules) equate to a 3.6% decline in property values. This is larger than the estimated impact of doubling local population density.

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.

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[72] This is due to the fact that bus noise at source may vary considerably depending upon whether the bus is accelerating, cruising, or stopping. See Nunns, Varghese and Adli (2015) for some indicative data on this issue.

Empirical studies suggest that the presence of industrial (and potentially commercial) land uses are associated with lower residential property values in adjacent areas. (See e.g. Irwin, 2002; Song and Knaap, 2004; Rouwendal and van der Straaten, 2008; de Vor and de Groot, 2010.) These effects are relatively localised – 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.

At this stage, we have not estimated the magnitude of these externalities, as their existence is likely to be highly dependent upon the location of new residential and business activities. However, we note that they may be relevant for analysis of changes to planning regulations that may result in increased (or decreased) potential for colocation of incompatible activities.

We also note that 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. In our view, most of the perceived "incompatibility" is likely to be reflected in quantifiable externalities such as overshadowing and noise. However, there may be some additional impacts due to perceptions of reduced "social cohesion" in communities with more mixed types of dwellings, levels of income, or ethnic composition.[73]

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. ("Moving to the nuisance".) 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. (See Davidson, 2003 for 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. At this stage, we have not estimated the magnitude of these externalities, as their existence is likely to be highly dependent upon the location of new residential and business activities. However, we note that they may be relevant for analysis of changes to planning regulations that may result in increased (or decreased) potential for colocation of incompatible activities.

Agglomeration

Agglomeration economies are a general rubric used to describe a variety of microeconomic benefits arising from proximity between households and firms. Agglomeration economies can reflect the presence of economies of scale in production and/or consumption, which can be both internal and external to the agents involved. In this context, increased proximity between firms, employees, and customers can deliver both increased productivity and improved consumption opportunities.

Agglomeration economies in production

Agglomeration in production arises from fixed costs in production / increasing returns to scale at the firm level (Fujita, Krugman and Venables, 2001) or knowledge spillovers or improved potential for specialisation between firms and workers (Glaeser, 2008). This enables businesses located in larger or denser areas to be more productive. Following Alfred Marshall, there are three main "micro-foundations" for agglomeration:

- Geographically concentrated industries can support a wider and more specialised range of local providers of inputs and better supply-chain linkages
- Increased accessibility between firms and workers can support labour market pooling, which increases productivity by better matching workers to jobs and enabling firms to better adjust their labour input in response to demand shocks
- Geographic proximity facilitates knowledge spillovers between firms and between workers.

[73] However, this may be offset by preferences for community diversity at various spatial scales. Fischel (2015) argues that consumer demands for tuition support for low-income students at private universities and voter support for inclusionary housing mandates are evidence of a demand for "(limited) community diversity".

Formalising and modelling these interactions at a detailed level is challenging, although Glaeser (2008, chapter 4) presents some partial models that demonstrate how each of the three effects can endogenously result in city formation or the formation of concentrated business areas. The empirical literature[74] suggests:

- Both urban scale (i.e. total size of labour market area) and density (i.e. proximity to surrounding firms) can lead to higher productivity.[75]
- There is endogeneity between scale / density and productivity – in simple terms, increased density of firms leads to increased productivity, and productivity leads to greater density (Graham et al, 2010).
- Agglomeration elasticities vary between industry sectors – they are consistently highest in knowledge-intensive service sectors such as finance and professional services, and lowest in manufacturing and transport and logistics.

Maré (2008) and Maré and Graham (2009) provide New Zealand-specific evidence on agglomeration, finding evidence for an "Auckland productivity premium" and for a positive relationship between employment density and productivity.

Agglomeration economies in consumption

Agglomeration in consumption arises from increasing returns to scale in the production of consumer amenities or the "public good" character of some consumer amenities (Glaeser et al, 2001). Consumer amenities include both market goods (e.g. retail and dining opportunities, museums, live music) and non-market goods (e.g. public parks, romantic relationships / dating). Larger or denser places tend to provide greater variety of services and consumer goods, which can enhance choice for all residents (Donovan and Munro, 2013). In a similar vein, McCann (2009) comments:

> *"urban scale and density also allows for consumption opportunities that are not possible in other locations. While the availability of many consumption goods such as television and beer is largely independent of location, the availability of certain consumption possibilities such as high quality restaurants, theatre and boutique shops, do vary with location."*

Although economists have traditionally assumed that cities offer advantages in production and disadvantages in consumption, more recent empirical evidence suggests that this no longer holds true. According to McCann and Glaeser et al, relatively rapid increases in urban rents suggest that people increasingly value the amenities offered by urban areas as opposed to natural amenities that are more abundant in non-urban areas. Glaeser et al also observe the recent phenomenon of reverse commuting, in which people live in central cities and commute to outlying jobs.

Using data on land prices from the Netherlands, de Groot et al (2015) estimate the degree to which urban land premiums can be attributed to producer amenities (e.g. access to a thick labour market) or consumer amenities (e.g. historical districts, performing arts, quality restaurants and bars). They conclude that:

> *"Factors on the production side (access to jobs) and consumer amenities each explain about 50% of the land price differences [between cities and rural areas]. The availability of luxury shops, a historical city centre, restaurants and cultural amenities together determine 30% of the land price differences."*

Furthermore, de Groot et al find that the urban land premium in the Netherlands exceeds the value of the urban wage premium.[76] This is consistent with the idea that agglomeration in consumption is additional to agglomeration in production. Because agglomeration economies exist in both production and consumption, it is possible that the net direction of the externalities associated with increased density of population or dwellings in existing neighbourhoods is positive, rather than negative.

Modelling agglomeration economies

Maré and Graham have analysed New Zealand data to estimate the relationship between employment density and gross output (agglomeration elasticities) that vary by industry and region. Table 48 summarises the agglomeration elasticities employed by the NZ Transport Agency to evaluate the productivity effects of transport investments that improve the

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[74] See Melo, Graham and Noland (2009) for a useful meta-analysis of empirical studies.

[75] McCann P (2003) Geography, Trade and Growth: Problems and Possibilities for the New Zealand Economy. New Zealand Treasury Working Paper 03/03

[76] After controlling for workers' characteristics, such as education levels.

accessibility of businesses, which are in turn based on results from Maré and Graham (2009). A higher elasticity indicates that firm productivity in a given sector is more responsive to increased employment density. Across all sectors and regions they estimate that a 1% higher effective density results in 0.065% higher productivity.

Table 48: Weighted average agglomeration elasticities for New Zealand industries (Source: NZ Transport Agency, 2016)

ANZSIC 2006	Industry	Agglomeration elasticity (ε)
A	Agriculture, forestry and fishing	0.032
B	Mining	0.035
D	Electricity, gas, water and waste services	
C	Manufacturing	0.061
E	Construction	0.056
F	Wholesale trade	0.086
G	Retail trade	0.086
H	Accommodation and food services	0.056
I	Transport, postal and warehousing	0.057
J	Information media and telecommunications	0.068
K	Finance and insurance services	0.087
M	Professional, scientific and technical services	
N	Administrative and support services	
O	Public administration and safety	
L	Rental, hiring and real estate services	0.079
P	Education and training	0.076
Q	Health care and social assistance	0.083
R	Arts and recreation services	0.053
	All industries	0.065

Maré and Graham's methodology is based on an analysis of the link between productivity and the effective density of employment. Effective density reflects the total number of jobs accessible from a given location.[77] This measure is more appropriate for capturing agglomeration economies that operate at a broader regional level, rather than at a micro-level (e.g. knowledge spillovers in dense urban centres).

Consequently, we can employ measured agglomeration elasticities to estimate the impact of an increase in urban population – assuming, effectively, that a larger city size translates into higher effective density of employment within the city. This is consistent with the modelling approach employed by Albouy et al (2014).[78]

We use the following equation, which is based on the NZ Transport Agency's evaluation procedures, to estimate the increase in productivity arising from a change in city size. We assume that the et benefits of higher productivity only accrue to the current city population, as new people moving into the city are presumed to internalise higher productivity levels in their decision to move or not move.

[77] Maré and Graham estimate effective density as:

$$U_i = \frac{E_i}{\left(\sqrt{A_i/\pi}\right)^{\alpha}} + \sum_{j}^{i\neq j}\left(\frac{E_j}{\left(d_{ij}\right)^{\alpha}}\right)$$

where E_i is employment in area unit i, d_{ij} is the straight-line distance between area units i and j, A_i is land area, and α is a distance decay factor (which they set to 1).

[78] Byett et al (2015) offer an alternative approach to modelling the relationship between regional labour pools and productivity. While this approach is potentially better suited to capturing region-wide and inter-regional productivity effects, it is not as well developed for evaluation purposes.

Equation 8: Estimated increase in productivity from a change in city size

$$\Delta Productivity = \left(\frac{New\ city\ size}{Current\ city\ size}\right)^{Elasticity} - 1$$

To be conservative, we also assume that the elasticity of productivity with respect to city size is considerably smaller than the agglomeration elasticity estimated by Maré and Graham – falling within the range of 0.02 to 0.04. This is at the bottom of the range of agglomeration elasticities that Albouy et al (2014) provide [0.03-0.08].

Table 49 summarises data on current regional GDP, regional population, and productivity levels for several New Zealand regions, based on Statistics New Zealand's (2015b) regional GDP series. It then models the estimated impact of a 100,000 increase in city population on productivity within those regions. We assume that this increase in population is due to increased migration from overseas or from rural areas / small towns, rather than from other New Zealand cities. This is a plausible assumption given New Zealand's high rates of emigration and immigration, which suggest that people are, on the margin, relatively indifferent between living in New Zealand or overseas. However, if population is instead redistributed between cities, there may be some offsetting effects as a result of reduced agglomeration economies in some locations (as modelled by de Groot et al, 2015 for the Randstad area of the Netherlands).

We note that the modeled agglomeration benefits per additional resident are large relative to negative externalities associated with urban growth. However, these results are not implausible, for two reasons:

- First, the modeled impact on productivity levels is small relative to background levels of GDP and productivity growth.[79] In other words, increased agglomeration economies from enabling more urban growth will not "dominate" other sources of increased productivity.
- Second, this finding is consistent with international evidence that suggests that the positive externalities associated with urban growth may be comparable in scale to the negative externalities (Combes et al, 2014).

Table 49: Agglomeration benefits from population growth

Region	Auckland	Wellington	Canterbury
Current (2015) regional GDP and population			
Regional GDP ($m)[80]	$88,295	$32,617	$32,882
Estimated residents	1,549,100	494,400	581,200
GDP per capita	$56,997	$65,974	$56,575
Modelled increase in city population (note: this represents a much larger % increase for Wellington and Canterbury; modelled productivity impacts are consequently higher)	100,000	100,000	100,000
Modelled agglomeration impacts (high scenario – 0.04 elasticity)			
Estimated percent change in productivity	0.24%	0.72%	0.62%
Increase in productivity for existing residents ($m per annum)	$216	$235	$204
Annual agglomeration benefits per added resident	$2,157	$2,352	$2,042
… per added household[81]	$6,503	$6,293	$5,378
Present value of agglomeration benefits (7% discount rate)	$92,895	$89,898	$76,831

[79] According to Statistics New Zealand's (2015) *Industry Productivity Statistics*, available online at http://nzdotstat.stats.govt.nz/wbos/Index.aspx?DataSetCode=TABLECODE7651, labour productivity in the measured sector rose 17.2% between 2000 and 2015. By comparison, using this approach to modelling agglomeration economies, Auckland's population growth is estimated to have raised productivity by 0.9% over the same period.

[80] Regional GDP statistics can be allocated down to the metropolitan urban area level using detailed data on employment by industry. We have not done this at this time, but it would be relevant if attempting to produce a more accurate estimate of agglomeration economies for Christchurch, which occupies a region that is geographically much larger than the urban area.

[81] Assuming that new households are similar in size to existing households. According to the 2013 Census, average household size was 3.0 in Auckland, 2.7 in Wellington, and 2.6 in Canterbury.

Region	Auckland	Wellington	Canterbury
Modelled agglomeration impacts (low scenario – 0.02 elasticity)			
Estimated percent change in productivity	0.12%	0.36%	0.31%
Increase in productivity for existing residents ($m per annum)	$108	$117	$102
Annual agglomeration benefits per added resident	$1,078	$1,174	$1,020
… per added household[82]	$3,249	$3,141	$2,685
Present value of agglomeration benefits (7% discount rate)	$46,419	$44,868	$38,356

As these figures do not account for consumer benefits of agglomeration, such as access to cultural amenities and public goods that are more available in larger cities, it is possible that they under-estimate the economies of scale that arise from increased urban scale and density.

[82] Assuming that new households are similar in size to existing households. According to the 2013 Census, average household size was 3.0 in Auckland, 2.7 in Wellington, and 2.6 in Canterbury.

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