NEW ZEALAND
INFRASTRUCTURE
COMMISSION
Te Waihanga

Does size matter? The impact of local government structure on cost efficiency

Te Waihanga Research Insights series

July 2022

New Zealand Infrastructure commission / Te Waihanga

Te Waihanga seeks to transform infrastructure for all New Zealanders. By doing so our goal is to lift the economic performance of Aotearoa and improve the wellbeing of all New Zealanders.

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Research Insights series contact

Peter Nunns
T: +64 21 535 185
E: peter.nunns@tewaihanga.govt.nz
Website: tewaihanga.govt.nz
Linkedin: tewaihanga

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Cut to the chase

Local government plays an important role in infrastructure planning and provision in New Zealand. Addressing New Zealand's infrastructure challenge will require local government to provide infrastructure and services efficiently and effectively. The *New Zealand Infrastructure Strategy* identifies a need to review the structure of local government to ensure that it provides infrastructure in an efficient and well-coordinated way, especially in growing urban areas that are spilling across existing council boundaries.

However, there is relatively little hard evidence on the impact of local government structure in New Zealand on performance. This Research Insights paper aims to improve the evidence base on local government performance in New Zealand, focusing on the cost efficiency of council infrastructure and service provision. As water, wastewater, and stormwater infrastructure has recently been the subject of research and analysis by the Department of Internal Affairs and others, this report focuses on other council activities.

Is bigger better? It depends who you ask

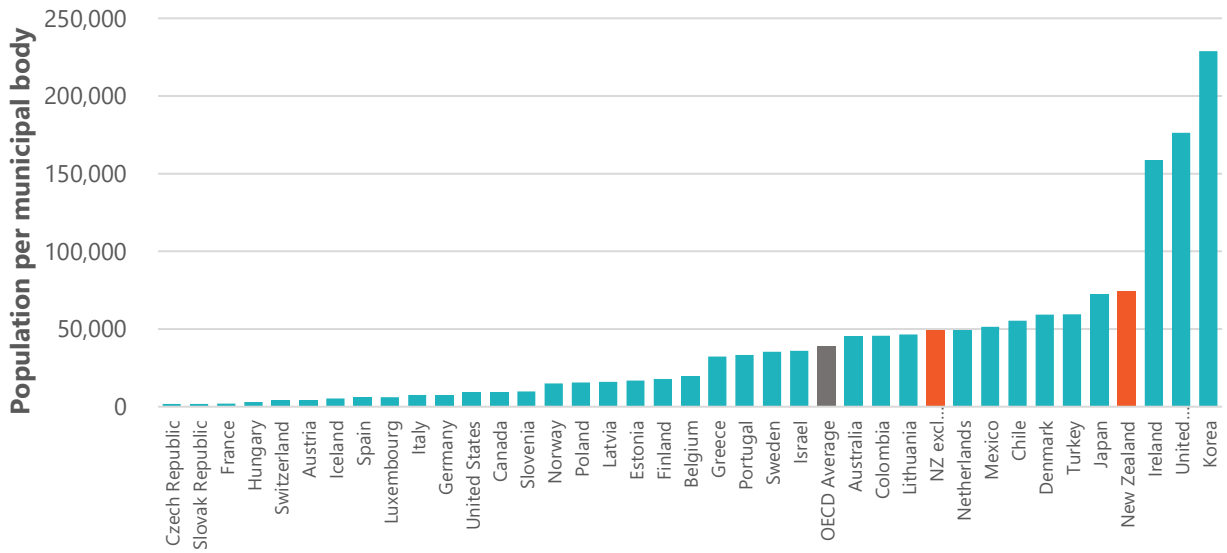
Local government structure can influence many outcomes, including quality of service provision, cost-efficiency of service provision, democratic representation, equity, and management of cross-border spillovers. In each of these areas, there is disagreement about whether it is better to have a few large local government bodies or many small local government bodies.

On one hand, 'regionalists' typically argue that consolidating local governments can reduce the cost to provide infrastructure and services through economies of scale and improved management of cross-border spillovers. On the other hand, 'localists' argue that local government fragmentation improves the diversity of service provision to meet local preferences and drives cost efficiency because smaller local governments must compete with their neighbours for residents.

New Zealand is already highly centralised and consolidated

A century ago, New Zealand had roughly one local government body for every 2000 people. Today, due mainly to large-scale local government consolidation in 1989, we have one local government for every 65,000 people.

Average population per municipal body, OECD countries 2019



Due to past consolidation, New Zealand has larger local government bodies and a smaller role for local government in provision of public infrastructure and public services than almost all other OECD countries. We have the fourth-highest average local government size in the OECD (Figure above), behind South Korea, the United Kingdom, and Ireland. Only 26% of total public capital investment in New Zealand is done by subnational governments, compared with the OECD average of 49%.

OECD countries where local governments play a larger role in public infrastructure provision tend to provide infrastructure more efficiently. However, the average size of local government does not appear to be related to infrastructure efficiency in OECD countries.

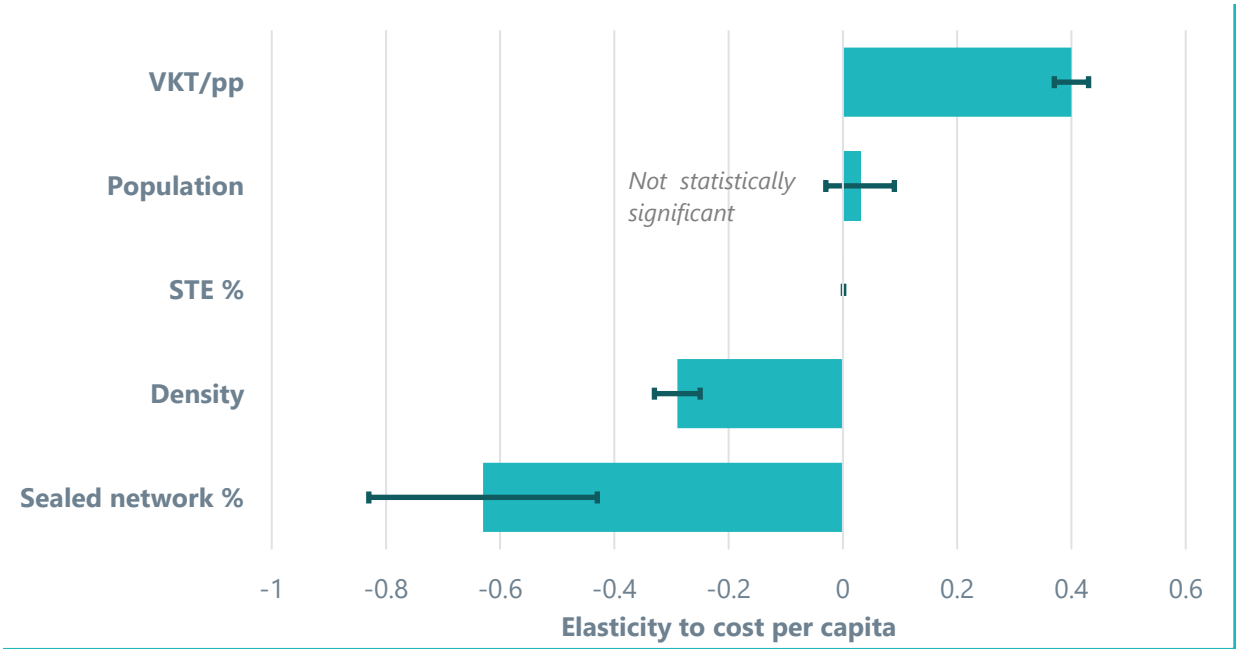
Council size neither increases nor decreases cost efficiency

Does council size affect cost-efficiency of service provision in New Zealand? We investigate this question using data on the cost to provide three standardised types of local government services: road maintenance, building consent processing, and overhead costs for governance and support services. These categories of activities represent over half (52%) of total local government operating expenses.

In all three cases, we find that council size (as measured by number of council residents) is neutral for cost efficiency: council size does not decrease or increase cost-efficiency.

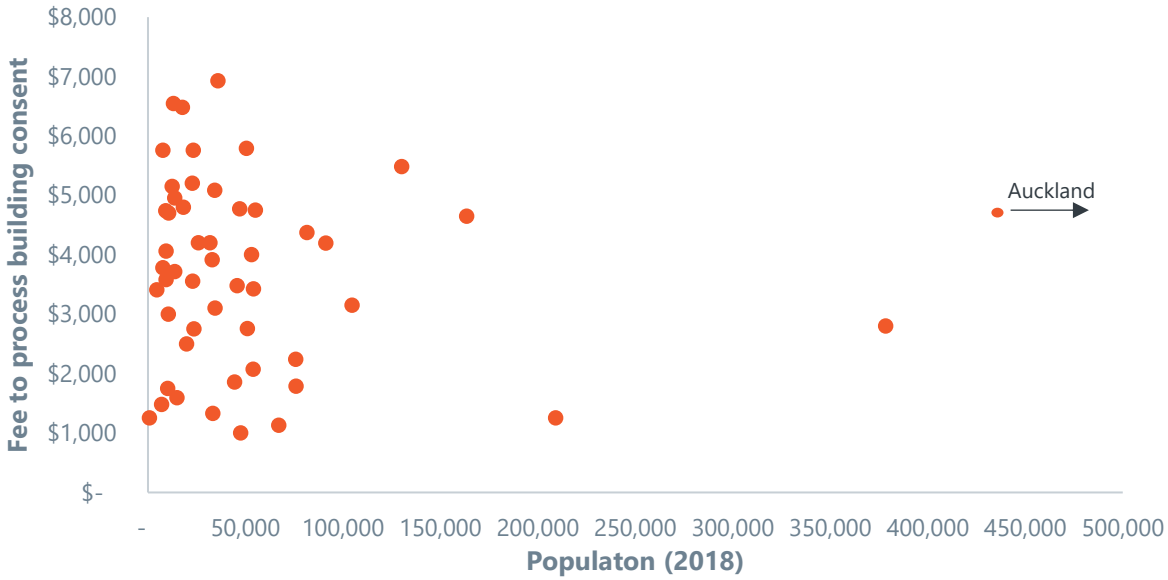
We measure the impact of council size on road maintenance costs using Waka Kotahi data on annual road maintenance costs for 66 councils over a 15-year period. After controlling for other factors that might affect costs, like road surface quality (smooth travel exposure, or STE), we find that council size does not affect maintenance costs. However, other factors do have a significant impact on road maintenance costs. Increasing population density tends to reduce per-capita road maintenance, increasing the sealed network reduces maintenance costs (Figure below), while increasing traffic volumes (VKT/pp) increase road maintenance costs.

Density and road maintenance costs per capita



We measure the impact of council size on building consent costs using published consent processing costs for a standard-sized residential house for 51 councils. All councils are legally required to provide a similar service and prohibited from charging more than the cost to provide the service. While there are large variations between councils – some councils charge as little as $1000, and others charge as much as $7000 – this does not seem to be related to council size (Figure below) or any other variables we tested.

Population and fee to process building consent for $350,000 residential house build



We examine the impact of Council population size on per-capita governance, support, and other costs over the 2003-2021 period. This reflects 'overhead' costs to service elected members, prepare annual and long-term plans, and provide back-office services like IT and human resources. We find that Council size neither increases nor decreases overhead costs.

These findings could be improved by studying the impact of past local government amalgamations, such as the 2006 merger of Christchurch City Council and Banks Peninsula District Council or the 2010 Auckland Council amalgamation. Unfortunately, the originally proposed post-implementation review of Auckland Council amalgamation has not been completed and published. Undertaking post-implementation reviews of past amalgamations could improve our understanding of the impact of local government structure on cost efficiency and other outcomes.

Other issues are also relevant for local government structure

While the cost efficiency of local government infrastructure and service provision is important, it is not the only consideration when considering the pros and cons of different local government structures. We have found that local government size has no impact on cost efficiency for three important council services – road maintenance, building consent processing, and governance and support services. Future analyses of local government structures should not assume that structural changes will inherently result in efficiency improvements – supporting measures are needed to ensure this outcome. In addition to efficiency, future areas of research could include the quality of service provision, democratic representation, equity, and management of cross-border spillovers.

This conclusion reinforces Recommendation 14 in the New Zealand Infrastructure Strategy. This recommendation highlights the need for local government structures that can coordinate regional infrastructure and planning, especially in growing urban areas that are spilling over existing council boundaries. This is important for ensuring efficient and effective provision of regional transport infrastructure and services and efficiently managing social, environmental, and economic spillovers.

Our research also highlights significant diversity in local government structure and responsibilities across OECD countries. Other developed countries tend to have more local governments that play a larger role in infrastructure planning and provision. There is a need to learn from other countries that do things differently.

Introduction

Local government is important for infrastructure

Local government plays a significant role in the planning and provision of infrastructure and implementing New Zealand's resource management, urban planning system, and building permit system. Addressing New Zealand's infrastructure challenge, which is outlined in Rautaki Hanganga o Aotearoa 2022 – 2052, *The New Zealand Infrastructure Strategy* (Te Waihanga, 2022), will require local government to provide their functions efficiently and effectively.

Recommendation 14 in the *Strategy* outlines a need to review the boundaries and responsibilities of local governments to achieve benefits of better coordination between local governments in growing urban areas. This recommendation highlights the need for local government structures that can coordinate regional infrastructure and planning, especially in growing urban areas that are spilling over existing council boundaries. This is important for ensuring efficient and effective provision of regional transport infrastructure and services and efficiently managing social, environmental, and economic spillovers. To inform such a review of local government structure, we need good evidence on the impact of local government structure on infrastructure service delivery and performance.

The aim of this Research Insights piece is to improve the evidence base on the impact of local government structure on performance in New Zealand. As water, wastewater, and stormwater infrastructure has recently been the subject of research and analysis by the Department of Internal Affairs and others, this report focuses on other local government infrastructure (e.g., transport infrastructure) and services (e.g., regulatory services and administration costs)[1].

Local government structure is complex, and has complex impacts

Internationally, there is significant diversity in local government structure and responsibilities – and vibrant debates about which structure is best.

Local government structure and responsibilities vary over three main dimensions:

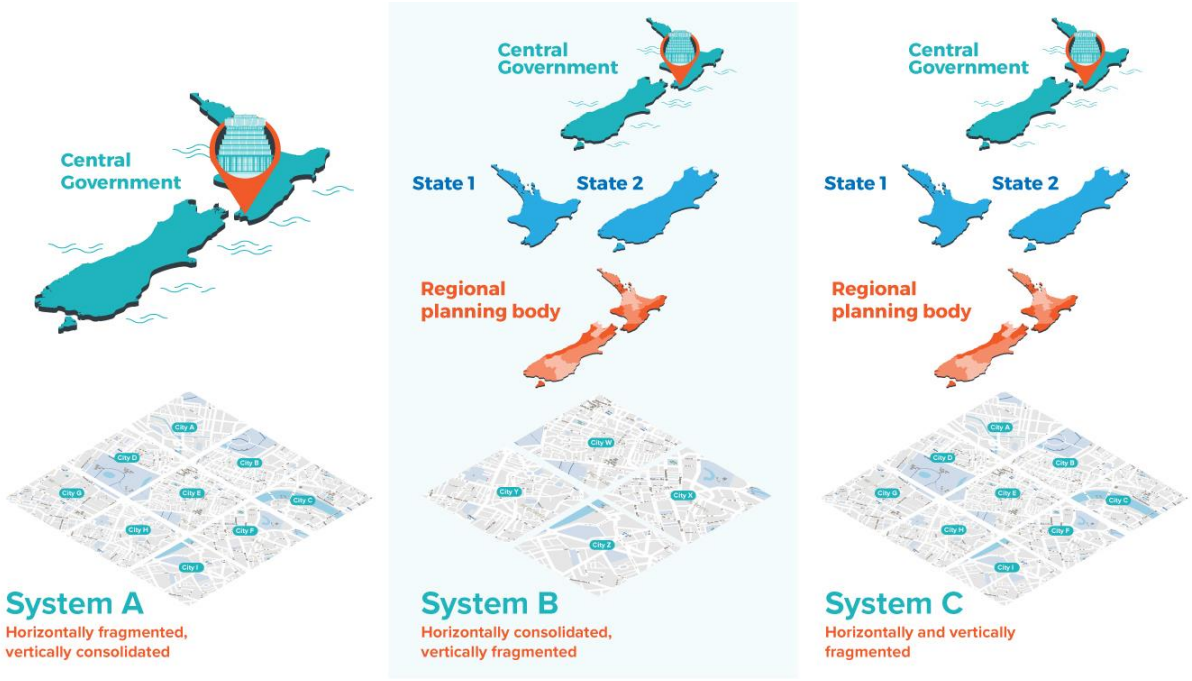
- **Centralisation / concentration**: How much spending and funding is delegated to local government, as opposed to concentrated in central government (Boyne, 1992)?
- **Horizontal fragmentation**: The number of units within a single tier of local government (Goodman, 2019)?
- **Vertical fragmentation**: Are local government services split across many layers of government or provided by a smaller number of consolidated multi-purpose entities (Goodman, 2019)?

Local government entities can be horizontally fragmented but vertically integrated, or vice versa. Figure 1 illustrates a few hypothetical examples, focusing on the provision of transport infrastructure / services and urban planning services. When considering the boundaries and responsibilities of local governments, it is important to consider both horizontal and vertical structure, rather than solely focusing on one aspect.

[1] Recent work in a New Zealand context includes Department of Internal Affairs (2021); Frontier Economics (2019) ; and Water Industry Commission for Scotland (2021). Further international evidence is available from (Saal et al., 2013).

Figure 1: Fragmentation occurs along two dimensions

Distinction between horizontal and vertical fragmentation



Source: Te Waihanga

Previous studies of local government structure have mainly focused on the relationship between fragmentation and the performance of government bodies, rather than examining the pros and cons of centralisation. There are arguments both for and against fragmentation (Goodman, 2019).

On one side, the 'localist' literature has argued that increased fragmentation increases performance while offering few disbenefits. On the other, 'regionalists' argue that consolidation provides opportunities for efficiency gains and overcomes the disbenefits associated with fragmentation (Goodman, 2019; Hall et al., 2018).

The pros and cons of horizontal fragmentation

Table 1 summarises the main theories for and against horizontal fragmentation in local government, which cover five issues: types and quantity of service provision, efficiency of service provision, democratic representation, equity, and spillover effects.

Tiebout's theory of local expenditures (1956) sets the foundation of the localist literature. In the model, fragmentation of local government bodies exerts competitive pressure, reducing overall costs. People have varying preferences for government services and choose to live in areas that match their preferences. This generates efficient outcomes, as the provision of services is well matched to demand for those services, eliminating free rider problems. Brennan & Buchanan (1980) argue that larger local governments have increased scope to act in a monopolistic fashion, while competition from fragmentation reduces monopolistic behaviour and keeps government expenditure in check.

On the opposing side of the debate, regionalists argue that local government consolidation enables economies of scale by reducing duplication of efforts and spreading fixed costs over a wider number of users. Under this view, larger government size increases opportunities for cost sharing and reduces the negative consequences of spillover effects.

Empirical studies, primarily based on UK and US data, have attempted to measure the pros and cons of horizontal fragmentation (Oates, 2005). On balance, the empirical evidence from studies of local

government structure suggests that fragmentation is generally associated with improved efficiency of service provision, while concentration is generally associated with higher spending (Goodman, 2019; Hall et al., 2018).

Table 1: Theories of horizontal structure of local government

Issue	Considerations favouring more smaller entities	Considerations favouring fewer, larger entities
Quality of service provision	Competition for residents between municipalities encourages services to be aligned with demand (Tiebout, 1956). Consolidation increases the scope for local governments to act as monopolists (Brennan & Buchanan, 1980)	Fixed costs can be spread over more users enables more specialised services.
Efficiency of service provision	Competition for residents between municipalities exerts downward pressure on spending (Tiebout, 1956). Consolidation obscures transparency of costs and benefits (Boyne, 1997).	Economies of scale reduce duplication of efforts and spread fixed costs over more users, increasing efficiency (Adams, 1965; Boyne, 1992)
Democratic representation	Smaller governments enable residents to be closer to elected officials and engagement processes (Ostrom, 1972)	Larger governments makes it easier for residents to identify local government bodies and hold them to account (Goodman, 2019)
Equity	Smaller jurisdictions improves minority representation (Zimmerman, 1970) Instead of consolidation, equity is more efficiently achieved through other means, e.g. redistribution by central government (Ostrom, 1983).	Larger government size increases opportunities for cost sharing and cross subsidisation. Fragmentation enables segregation and tax avoidance (Hill, 1974)
Spillover effects	Spillovers can be resolved either through local government cooperation or involving higher levels of government (regulations or transfers) (Oates, 1972; Ostrom, 1972).	With larger jurisdictions, the costs and benefits of services are contained within the region, which results in the socially optimal level of public goods (Adams, 1965; Solé-Ollé, 2006)

The pros and cons of vertical fragmentation

Table 2 summarises the main theories for and against vertical fragmentation in local government, which cover three main issues: democratic representation, efficiency of service provision, and spillover effects.

Similarly to Tiebout, Oates (1972) argues that because there is variation in preferences for government services, provision of services at the local government level can provide levels of services that are well matched with the demands of the residents of their respective jurisdictions. In contrast, consolidation results in a single, uniform level of public output, resulting in either free-rider problems or insufficient provision of services.

There are fewer empirical studies on the pros and cons of vertical fragmentation (Goodman, 2019). However, the available evidence tends to point towards inefficiencies associated with vertical fragmentation, due to the increased difficulty of coordinating between different service providers.

Table 2: Theories of vertical structure of local government

Issue	Favours many single-purpose entities	Favours fewer multi-purpose entities
Democratic representation	Aligning structures with services improves public scrutiny of costs and benefits of service provision (Boyne, 1997)	Fewer layers of government simplifies voting and civic participation, maximises competition for residents (Berry, 2008)
Efficiency	Separation of planning for and provision of services enables efficiencies. Smaller organisations reduce 'bureaucratic congestion' (Boyne, 1992; V. Ostrom et al., 1961)	Fewer layers of government improves efficiency through economies of scope, reduced transaction costs, and greater purchasing power (Grosskopf & Yaisawarng, 1990)
Spillover effects	More layers of government can improve coordination and reduce spillover effects, for example through the creation of special purpose vehicles that span multiple municipalities (Oates, 1972; Ostrom, 1972).	More layers of government can raise issues with revenue collection methods. Distortions can result from the decentralisation of taxation of highly mobile tax bases (Oates, 2005).

Improving the evidence base

The purpose of this Research Insights piece is to improve our understanding of the impact of local government structure on the efficiency of infrastructure and service provision in New Zealand.

Our research focuses primarily on cost efficiencies in provision of infrastructure, which is one of several factors that is relevant for optimal local government structure. We have focused on cost efficiencies for two reasons. Firstly, New Zealand faces a historic infrastructure deficit, and improving efficiency is a key means of responding to the infrastructure challenges we face. Secondly, cost efficiencies have been a main motivating factor behind previous reforms of local government in New Zealand. While we do not directly assess other factors such as democratic representation and quality of infrastructure and service provision, these factors are also important and should be a focus of future research. We focus on the largest types of operational expenditures incurred by Councils, excluding three waters infrastructure as this has recently been addressed by other studies.

First, we provide a descriptive summary of the current structure and responsibilities of local government in New Zealand, as well as a summary of past changes.

Second, we compare New Zealand's local government with local government in other OECD countries. This comparison focuses on the degree to which public infrastructure provision is centralised or decentralised and the degree of local government fragmentation or consolidation. Comparative data allows us to explore whether local government structure and responsibilities are associated with high-level differences in infrastructure quality.

Third, we investigate the impact of horizontal local government fragmentation on cost efficiency for three key services: road maintenance, building consent processing, and council overhead costs for governance and support services. This analysis allows us to test whether larger local governments provide similar services at a lower or higher cost than smaller councils, and whether there are other factors that affect costs.

We conclude by considering the implications of this research for Recommendation 14 in the *Strategy*, discussing the limitations of the findings, and outlining areas for future research. The impacts of local government structure on the efficiency and effectiveness of infrastructure and service provision are complex, reinforcing the need for robust evidence.

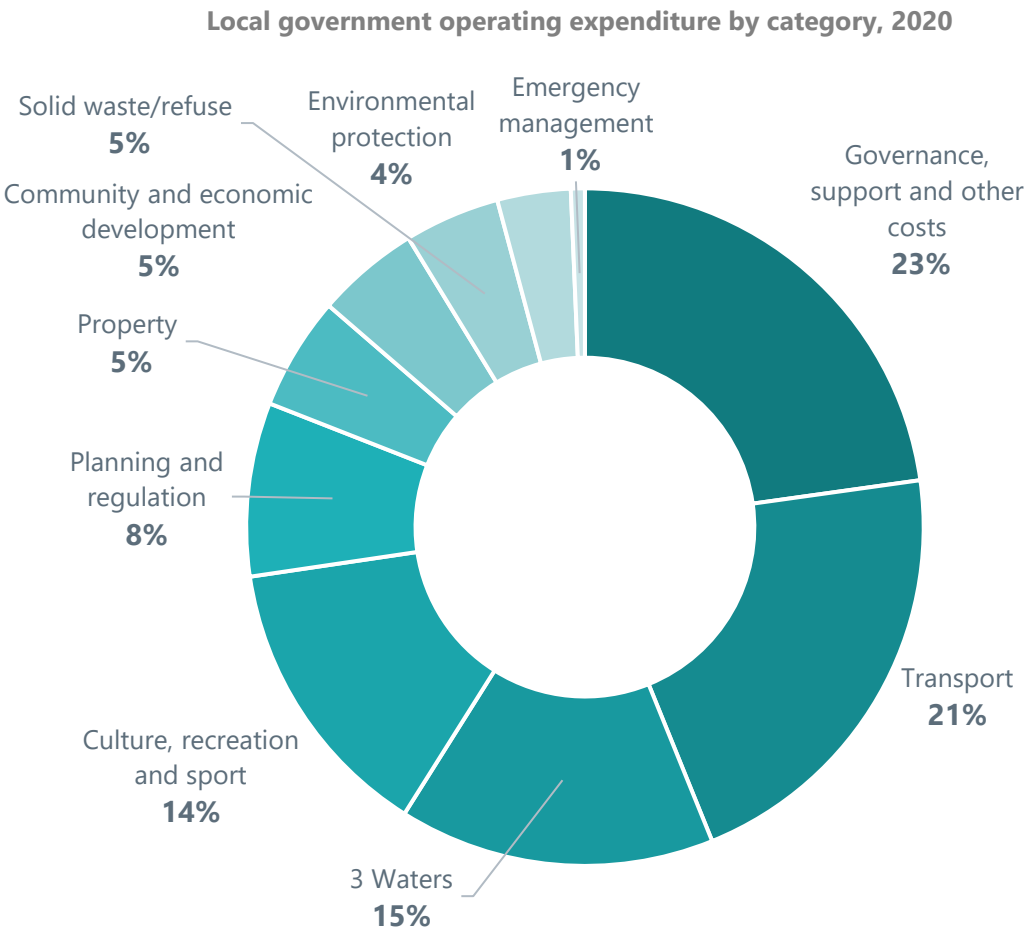
Local government in New Zealand

What local government does

Figure 2 outlines the distribution of total local government operating expenditure across 10 expenditure categories in 2020 (Statistics New Zealand, 2021). Councils provide a variety of services. The largest expenditure category is governance, support, and other costs (23% of expenditure). This category includes 'overhead' costs to run elected Councils and committees, provide finance, IT, and HR functions, prepare strategic plans required under the Local Government Act, and provide other miscellaneous services. The next largest expenditure category is transport (21%), followed by three waters (15%), and culture, recreation, and sport (14% of expenditure).

Local government operates with varying level of autonomy across activity categories. Some powers and responsibilities given to local government are prescriptive and allow councils little or no discretion. These types of activities are often referred to as 'delegated powers' and include enforcement of the Building Act 2004. In other areas, such as sports and recreation, local governments have 'devolved powers' and operate largely autonomously (New Zealand Productivity Commission, 2019). Other activities, such as transport, sit in the middle of these two extremes, allowing for local decision making in the context of national guidance or expectations.

Figure 2: Councils provide a wide variety of services



Source: Statistics New Zealand, 2022a

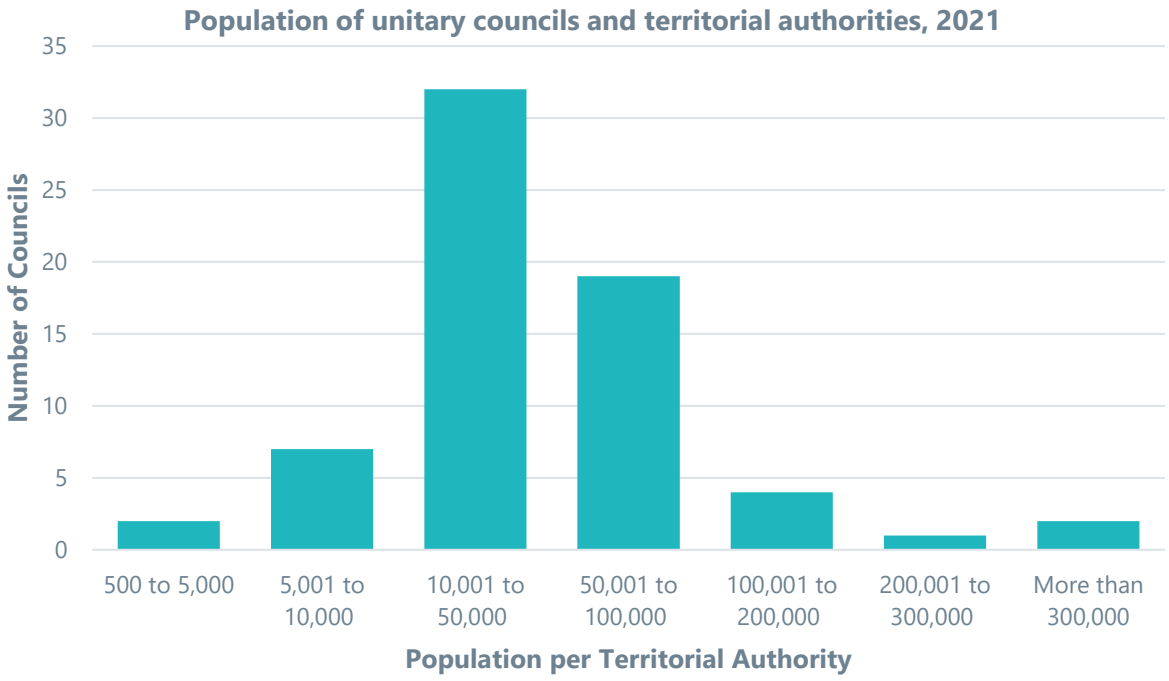
Size and form of local government

There are three types of local, or subnational, government in New Zealand: regional councils, unitary councils, and territorial authorities. There are currently a total of 78 local government bodies: 11 regional councils, 6 unitary councils, and 61 territorial authorities.

At a high level, regional councils are responsible for environmental protection and provide public transport services. Territorial authorities have a much broader mandate, including the provision of local transport infrastructure, three waters infrastructure (drinking water, wastewater, and storm water), land use planning, parks, sports and recreation, regulatory functions such as building consents, and some public health functions such as liquor licensing. Unitary authorities perform the functions of both regional councils and territorial authorities.

Figure 3 outlines the size of New Zealand's 67 unitary councils and territorial authorities in 2021. While the average population per council is about 75,000 people, this is skewed upwards by a few large councils. The most common population per council is much smaller, between 10,001 and 50,000 people (48% of councils). Only 13% of councils are very small, with less than 10,000 people and only 10% of councils are large, with populations more than 100,000 people.

Figure 3: The average council has about 75,000 people



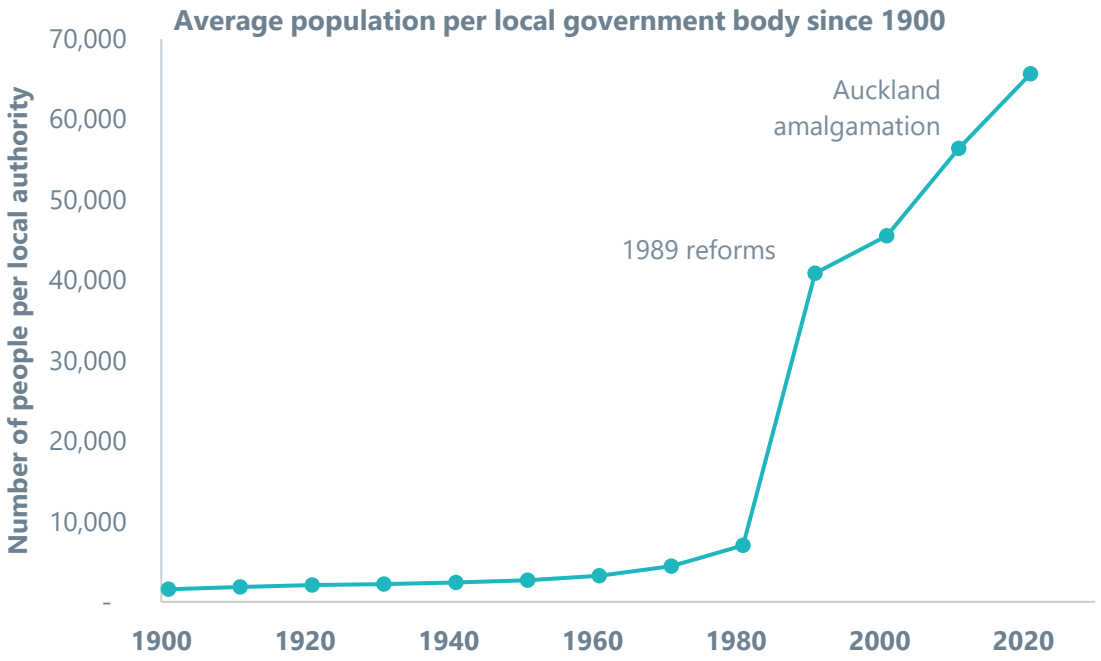
Source: Te Waihanga, with data from Statistics New Zealand, 2022b

Previous local government reforms

In New Zealand, the shape, function, and requirements of local government are set by central government legislation. The Local Government Act (2002), an ordinary statute, forms the basis for local government (Cheyne, 2008). Local government legislation can be updated through acts of Parliament, meaning that the structure and responsibilities of local government has changed significantly over time (Nicholls, 2017).

The function and role of local government in New Zealand has been reshaped through successive central government legislative changes over the past 150 years. These changes have followed a general pattern of consolidation of local government bodies while decreasing the scope of local government (Smith & Crawford, 2020). In 1930, local government represented roughly half (46%) of total government expenditure. By 1975 local government expenditure had dropped to 24%, and by 2019 it had further declined to 11% of total government expenditure (Cookson, 2019). At the same time, local governments have become more consolidated, with an average of 2,225 people per local government body in 1930, to 40,884 in 1991 and 65,674 in 2021 (Figure 4).[2]

Figure 4: Local government is increasingly consolidated



Source: Te Waihanga, with data from Ihimaera-Smiler, 2014; Statistics New Zealand, 2022b

The most substantial local government reform in the last century took place in 1989, when over 400 local government bodies were combined to form 74 territorial authorities. This concurrent horizontal and vertical amalgamation eliminated most single-purpose bodies and consolidated their powers within regional councils and territorial authorities (New Zealand Productivity Commission, 2019). This reform took place within a context of wider public sector reforms intended to improve the performance and accountability of both local and central government (Boston & Douglas, 2011). One of the key motivating factors of the 1989 local government reforms was pursuit of economic efficiency, and it was believed that vertical and horizontal amalgamation would result in economies of scale (Rouse & Putterill, 2005).

In 2010, Auckland's seven territorial authorities and regional council were combined into one unitary council. This amalgamation was largely motivated by the perceived poor performance of Auckland's infrastructure and failure to address strategic infrastructure challenges, in addition to concerns surrounding democratic representation and high costs of service provision. Moving to a unitary council structure was intended to provide improved integration across all levels of government, address the region's strategic infrastructure challenges, and provide improved efficiency (Asquith et al., 2020; Reid, 2009). As a result of this amalgamation, Auckland Council is now by far the biggest council in New Zealand. It is more than four times larger than the next biggest council and was home to a third of the country's population in 2020.

[2] This figure includes territorial authorities, unitary councils, and regional councils.

How we compare to our peers

In this section, we benchmark the structure of New Zealand local government against 37 other OECD countries. We review the vertical structure of local government (the number of layers of government within a country), and its horizontal structure (the average population served by each local government body) (OECD, 2021a; OECD/UCLG, 2016). We then review the degree to which public infrastructure provision is centralised or decentralised. Lastly, we briefly explore the degree to which local government structure and responsibilities are related to the efficiency of infrastructure provision.[3]

How much local government does New Zealand have?

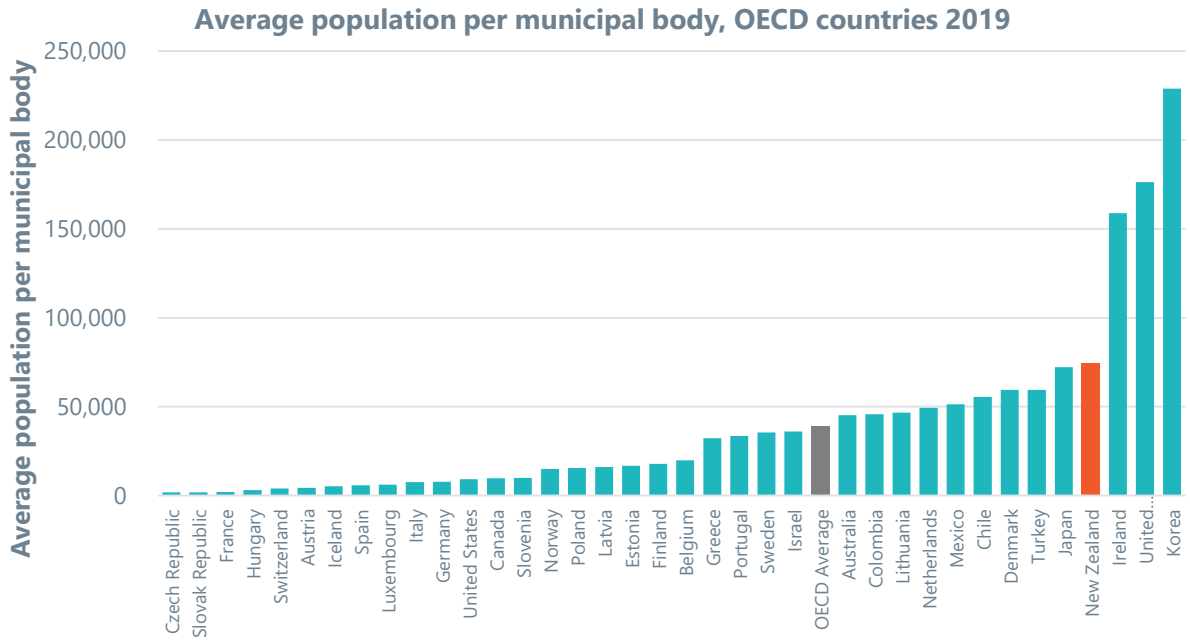
Within the OECD, there is substantial variation in the vertical structure of subnational / local government. Ten member countries have a federal structure, with states or provinces sitting underneath central government, while 27 have a Unitary structure. The number of levels of subnational governments, which includes state and local government, also varies. Among OECD member countries, 21% have one level of subnational government, 58% (including New Zealand) have two levels, and 21% have three or more levels of government.

There is also significant variation in the horizontal structure of local government. Figure 5 provides a simple measure of horizontal fragmentation - the average population per local government municipal body. Some OECD countries have a large number of small local governments, with some countries averaging one local government entity per 2,000 people, while others have over 200,000 people per municipal body. The OECD average was one local government entity per 39,000 people.

As a result of past local government amalgamation, New Zealand already has a relatively consolidated local government sector. With one local government entity per 74,000 people, on average, New Zealand has the fourth highest level of local government consolidation in the OECD. New Zealand local governments are nearly twice as large as the OECD average size.[4]

[3] Drawing upon infrastructure efficiency scores developed in our December 2021 Research Insights paper.
[4] This figure only counts the number of local governments at the lowest layer that exists in each country, excluding state and provincial governments and (in the New Zealand context) regional councils. As noted in the previous section, New Zealand's average population per local government body is around 65,000 if regional councils are also included.

Figure 5: New Zealand's local governments are consolidated



Source: OECD, 2021a

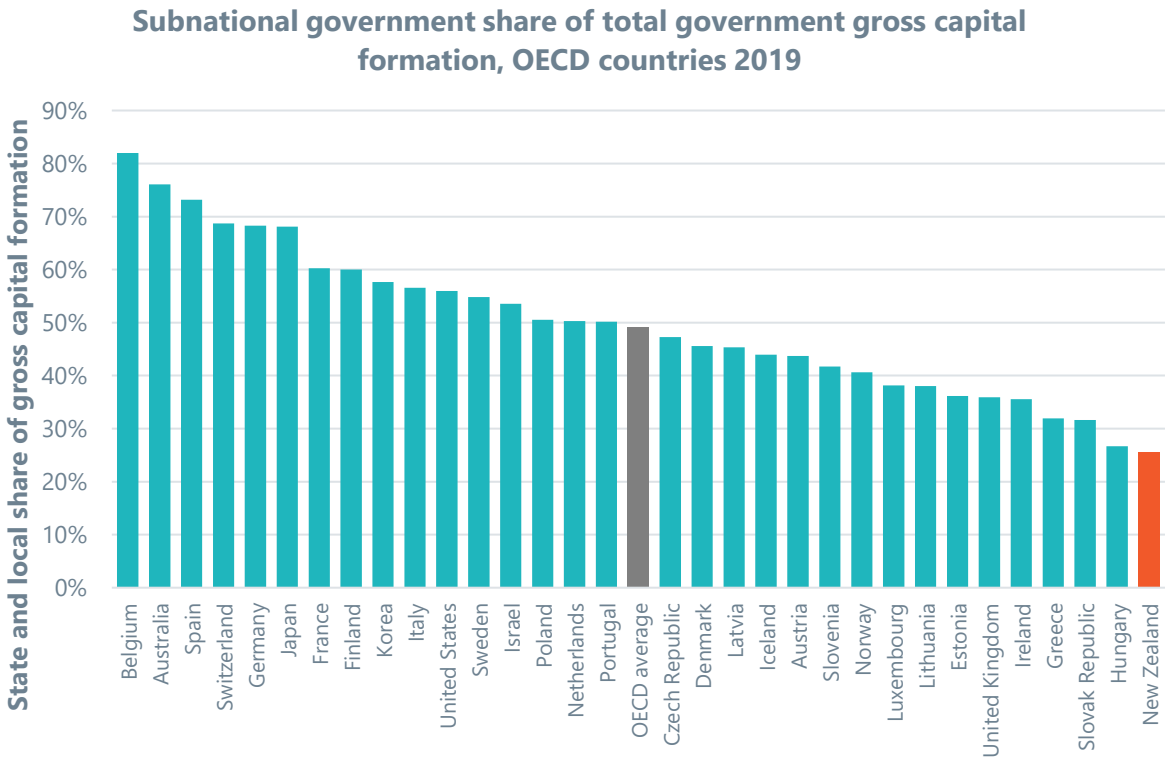
How much does local government do?

While the presence of local government is universal across the OECD, the functions, roles, and powers of subnational governments vary substantially across countries. One measure of the size of local government is its share of total public investment, as measured by local government share of total government gross capital formation.[5] As compared to total expenditure, gross capital formation data provides a closer approximation of expenditure on infrastructure.

In general, state and local governments play a larger role in infrastructure provision relative to their role in providing other government services, like social welfare or education services. On average across the OECD, subnational governments account for 31% of total government expenditure but 49% of total gross capital formation by government.[6]. Figure 6 summarises the subnational government share of total public investment among 32 OECD countries in 2019. There is substantial variation in the scope of central and sub-national governments across OECD countries. Relative to its OECD peers, New Zealand has a very low share of capital formation by subnational government. Local government only accounts for 26% of total government investment in New Zealand: this is around half of the OECD average.

[5] Gross capital formation is defined as the sum value of three non-financial produced assets: fixed assets, inventories, and valuables (Intersecretariat Working Group on National Accounts, 2009).
[6] This general pattern is reflected in New Zealand, where local government represents 11% of total government expenditure and 26% of gross capital formation in 2019 (OECD, 2021a, 2021b).

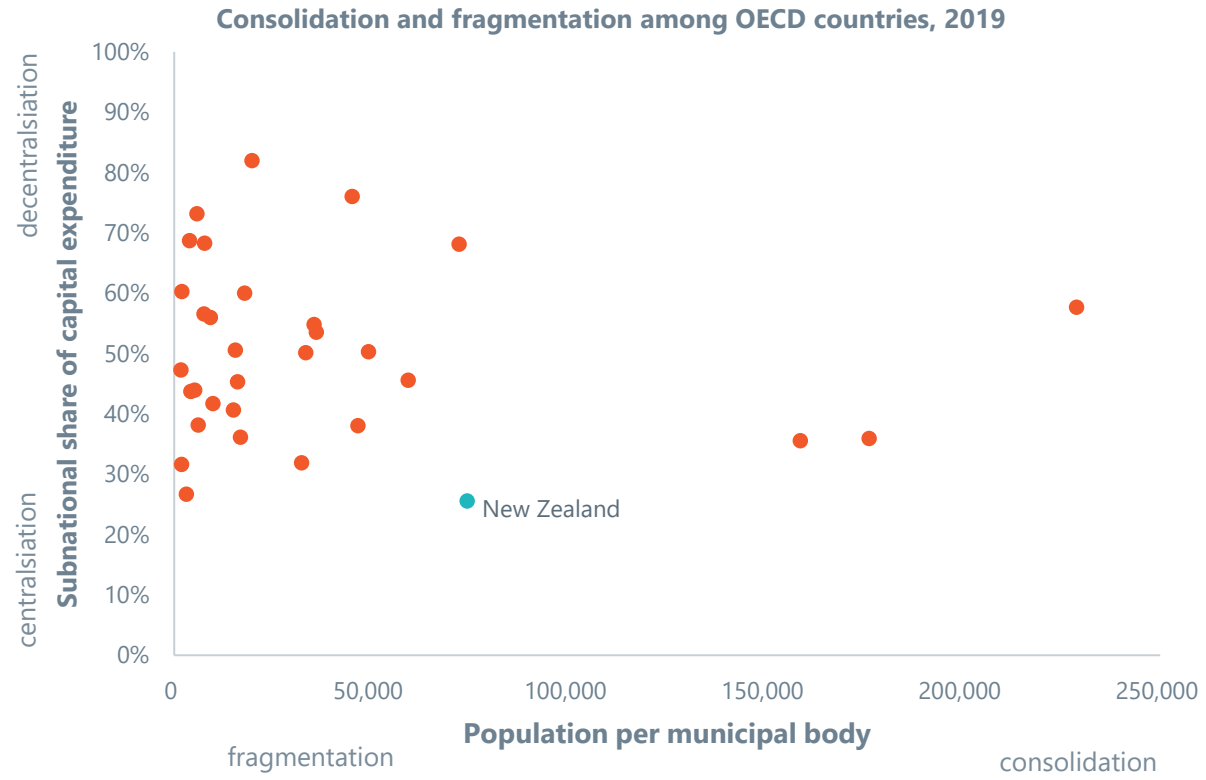
Figure 6: New Zealand has the lowest share of local capital formation in the OECD



Source: OECD, 2021b

Figure 7 shows the relationship between consolidation and fragmentation among OECD countries in 2019. Relative to its OECD peers, New Zealand has highly centralised public infrastructure provision and a low level of local government fragmentation.

Figure 7: New Zealand government is highly centralised and consolidated



Source: OECD, 2021a, 2021b

Does local government size relate to investment efficiency?

It is desirable to understand if there is an observed relationship between local governments' role in infrastructure and the efficiency of infrastructure provision. Table 3 summarises the descriptive statistics used to examine the relationship between infrastructure investment efficiency and the role of local government among OECD countries. Infrastructure investment efficiency is a measure of the quality of public infrastructure achieved for a given level of investment. This efficiency indicator has been estimated for OECD countries using data envelopment analysis; the full methodology for this calculation is outlined in Te Waihanga (2021).

Table 4 summarises a brief regression analysis used to identify factors that are correlated with infrastructure investment efficiency scores. The dependent variable is infrastructure investment efficiency. The explanatory (or independent) variable of interest is local government investment share. Four other independent variables expected to impact investment efficiency (Population, Density, Institutional quality, and Investment volatility) are included in the model so that the impact of local government investment share can be observed while holding these other factors constant. Full data is available for 32 of 38 OECD countries.

Local government share of investment is excluded from Model 1 and included in Model 2. While both models explain most of the variation in infrastructure investment efficiency scores across OECD countries, inclusion of local government investment share appears to improve model fit (R^2 = 0.706 in the Model 1, R^2 = 0.785 in Model 2).

This analysis suggests that:

- **Population size matters**: Countries with larger populations tend to have higher efficiency scores.
- **Density matters**: Countries with higher average population density tend to have higher efficiency scores.
- **Centralisation of infrastructure provision matters**: Countries with a larger local government share of total public investment tend to have higher infrastructure efficiency scores, with an effect that is statistically significant ($p \leq .001$).
- Institutional quality and investment volatility are not statistically significant among a smaller sample of OECD countries, although they are statistically significant among all countries.[7]

Although the analysis draws upon a relatively small dataset, the results indicate that local government share of total infrastructure investment matters for infrastructure efficiency. This relationship between efficiency and local government's share in infrastructure investment holds when other influences on efficiency, including population, density, institutional quality, and investment volatility, are held constant.

[7] Te Waihanga (2021) finds that increased volatility reduces infrastructure efficiency and improved institutional quality improves efficiency. The lack of significance of these two variables here can be explained by the substantially reduced sample size, as small sample sizes reduce the ability to observe small effect sizes due to reduced statistical power.

Table 3: Descriptive statistics of variables used in investment efficiency

Variable	Definition	N	Median	Std. dev.
Infrastructure efficiency	The quality of infrastructure achieved for a given level of spending	38	0.92	0.06
Population	Population in 2019 (log transformed)	38	35 million	59 million
Density	Average population density (pop / area) in 2019 (log transformed)	38	138.8	139.9
Institutional quality	Global Competitiveness Index Institution Score in 2019.	38	81.9	7.1
Investment volatility	Standard deviation of public investment as a share of GDP over 1980-2019 period	38	0.008	0.004
Local government investment share	Local government share of total public capital formation in 2019	32	49%	14%

Table 4: Regression results, investment efficiency model

	Model 1		Model 2	
	Estimate	**SE**	**Estimate**	**SE**
Intercept	0.501***	0.091	0.586***	0.099
Population	0.015***	0.004	0.009**	0.004
Density	0.029***	0.005	0.029***	0.004
Institutional quality	0.001	0.001	-0.001	0.001
Investment volatility	0.012	1.378	0.046	1.514
Local government investment share	-	-	0.140***	0.051
N	32		32	
R^2	0.706		0.785	
AIC	To be added		To be added	

Statistical significance: * p ≤ .05. ** p ≤ .01. *** p ≤ .001

Cost efficiency in New Zealand local government

In this section, we investigate whether council size and shape is related to local government cost efficiency in three areas: road maintenance, building consents, and council overhead costs.[8]

These activities represent approximately half of councils' total operating expenses. On average, transport maintenance represented 21%, planning and regulation represented 8%, and governance and support services (overhead) costs represented 23% of council expenditure in 2020 (Figure 2 above) (Statistics New Zealand, 2022a).

Previous New Zealand research

In spite of New Zealand's history of local government reforms, there has been little empirical research on the impact of local government form and shape on desired outcomes. Studies related to local government form and efficiency are outlined below.

Rouse & Putterill (2005) investigated the impact of the 1989 local government reforms on the efficiency of local road maintenance. While they find a general increase in efficiency from 1982 to 1997, the authors find no evidence that amalgamation contributed to this improvement. Areas that experienced high levels of amalgamation underperformed relative to areas that did not amalgamate, suggesting there may be diseconomies of scale.

Aulich et al., (2014) investigated efficiency from amalgamations using 15 case studies of different forms of consolidation, including amalgamation, across Australia and New Zealand. The authors find little evidence of economies of scale from consolidation but do find some evidence of economies of scope. Kortt et al. (2016) evaluated the potential impact of amalgamation of Hawkes Bay councils on efficiency of service provision, and project that amalgamation would be unlikely to provide efficiencies from economies of scale.

Adams and Chapman (2016) investigated the relationship between urban density and infrastructure costs. They find that per-capita costs for transport and 3 waters infrastructure tend to be lower in denser areas, and that these effects may be more pronounced in faster-growing regions. However, they do not note a relationship between infrastructure costs and total population.

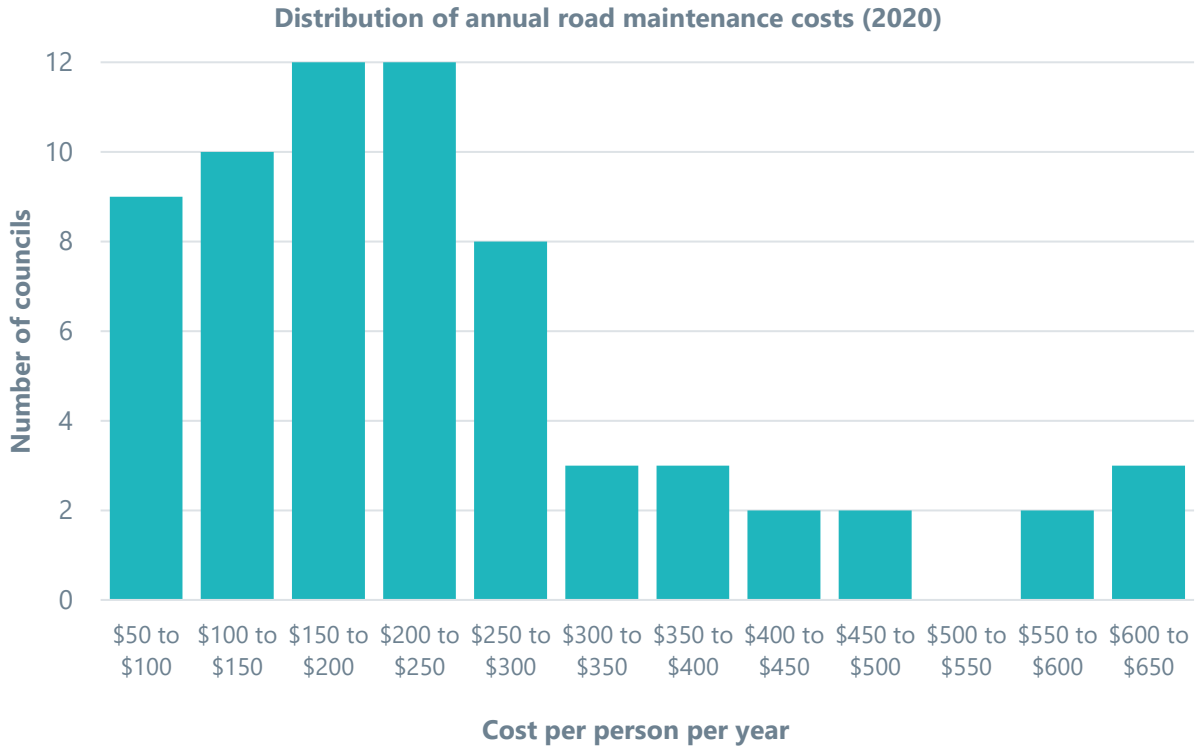
Asquith et al. (2020) qualitatively evaluated the performance of Auckland Council in the first 9 years after amalgamation in terms of three criteria: regional leadership, strategic planning, and democratic input. The authors conclude that amalgamation in Auckland was successful in two of the three areas: the provision of leadership and the setting and pursuit of an effective and appropriate strategic direction. Voter turnout did not appear to be influenced by amalgamation.

[8] While infrastructure efficiency, covered in the previous section, relates to the quality of public infrastructure achieved for a given level of investment, cost efficiency relates to the cost of providing services, while holding other factors constant.

Road maintenance costs

In this section, we investigate the determinants of variation in the maintenance costs of local roads in New Zealand, using Waka Kotahi data (Waka Kotahi NZ Transport Agency, 2022). Figure 8 outlines the distribution of annual road maintenance costs among councils in New Zealand in 2020.[9] We can see that while the median cost is $150 per person per year, there is considerable variation in costs between councils (standard deviation: $160), roughly following a log-normal distribution.

Figure 8: Road maintenance costs vary substantially across councils



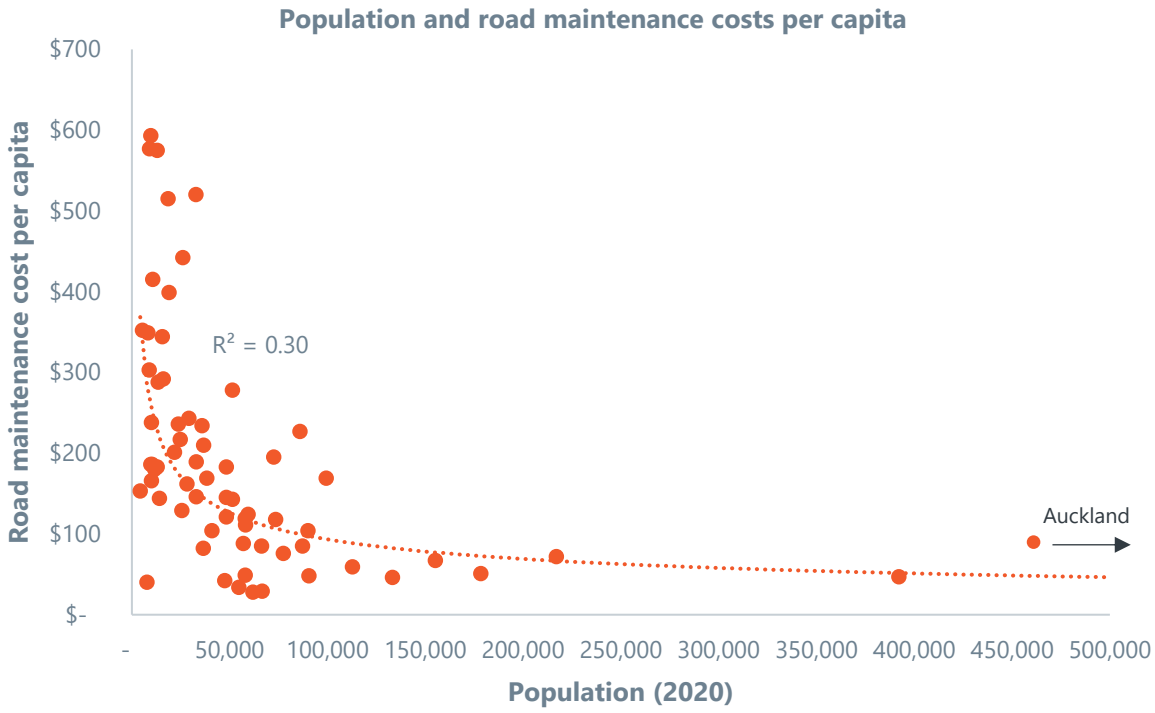
Source: Te Waihanga, using data from Waka Kotahi

Figure 9 shows the relationship between population size and road maintenance costs for 2020.Source: Te Waihanga, using data from Waka Kotahi

Figure 10 shows the relationship between population density and road maintenance costs for the same year. It shows that there is a much stronger relationship between road maintenance costs and density than there is between costs and total population, with councils that have a denser population tending to have lower road maintenance costs per person, a finding that is consistent with a previous study by (Adams & Chapman (2016). Population and density tend to be highly correlated: where local authorities have larger populations, their (urban) areas tend to be denser.

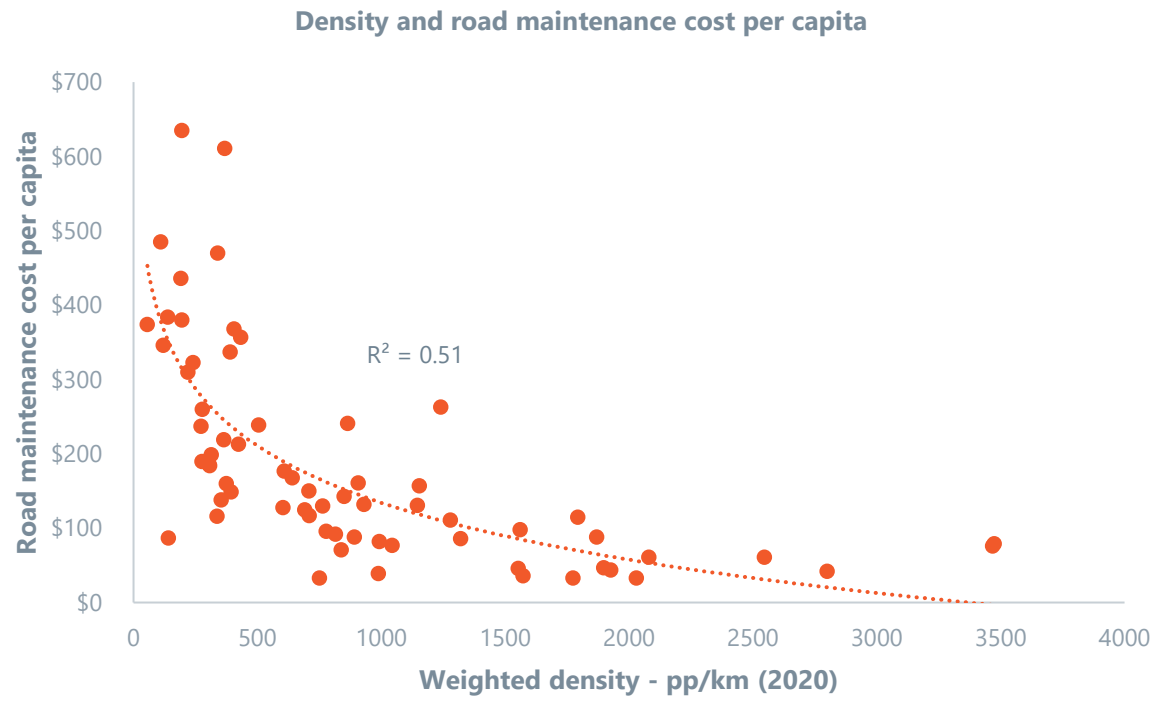
[9] Chatham Islands is excluded from this analysis due to lack of available data.

Figure 9: There is wide variation in road maintenance costs among smaller councils



Source: Te Waihanga, using data from Waka Kotahi

Figure 10: Denser areas have lower road maintenance costs



Source: Te Waihanga, using data from Waka Kotahi

Understanding the causes of the variation in costs across councils may assist in projecting future changes in maintenance costs and enabling opportunities for cost savings. To do this, we use a panel dataset which consists of pavement maintenance costs for 66 councils over 15 years (2006-2020). Table

5 outlines the descriptive statistics for the panel dataset; data is available for all variables for a total of 966 observations. Two independent variables (STE% and Sealed %) are measures of network quality, one independent variable is a measure of network usage (VKT/pp), and three independent variables relate to the shape and form of council providing the networks (Population, Area, and Density)[10].

Table 5: Descriptive statistics of variables used in the road maintenance cost model

Variable	Definition	N	Median	Std. dev.
Cost/pp	Cost per person per year ($/pp)	990	$150.00	$160.45
STE %	Percentage of vehicle kilometres travelled on the network defined as smooth (%)	966	93%	7%
Sealed %	Percentage of the network length that has a sealed surface (%)	990	68%	21%
Population	Estimated resident population in June (log transformed)	990	32,900	190,711
VKT/pp	Vehicle kilometres travelled on the network per person per year (log transformed)	990	4,492	1,823
Area	Council land area in (km^2) (log transformed)	990	2,722	4,304
Density	Population density (council pop / area) (log transformed)	990	10.00	1.31

Figure 11 and Table 6 outlines the regression results for the preferred road maintenance cost model and a sensitivity test with an alternative variable specification. Appendix A presents the methodology for selecting the preferred model form.[11]

In the preferred model, Density has an inverse association with pavement maintenance cost and is highly significant ($p \leq .001$), VKT/pp is also highly significant, understandably. Perceived smoothness of seal is not significant. Population is slightly positive and insignificant ($p=0.67$), and Area is excluded from the model. In the sensitivity test, the density variable is excluded, Population becomes negative and highly significant ($p \leq .001$), and Area is positive and highly significant ($p \leq .001$).

This analysis suggests that:

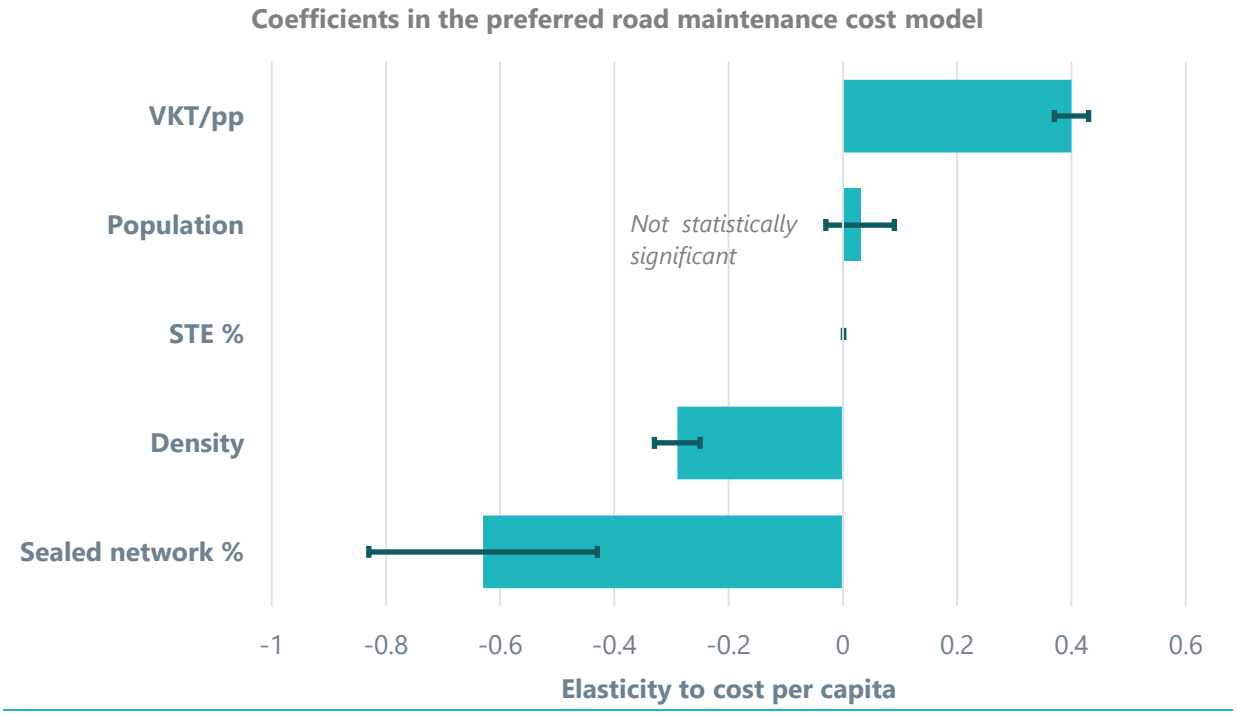
- **Sealing roads reduces maintenance costs:** Seal extensions appear to be an effective means of reducing road maintenance costs. Councils with a higher percent of their network sealed have lower ongoing maintenance costs, although this has to be balanced against higher up-front costs to extend road seal.
- **Density matters:** Councils with higher population density tend to have lower road maintenance costs per person, reflecting the fact that it is more efficient to serve a more spatially concentrated population.
- **Less driving reduces costs:** Councils with lower vehicle kilometres driven per capita tend to have lower road maintenance costs.

[10] On 1 November 2010, seven territorial authorities were amalgamated to become a unified Auckland Council. In the dataset, data for the seven legacy authorities are reported together for the first five years.
[11] A random effects panel model is chosen after diagnostic tests showed that it outperforms fixed-effects and pooled panel models.

- **Size of council doesn't influence cost:** Council population is statistically insignificant: it neither increases nor decreases costs.

The analysis also shows that density and population can be easily conflated with each other. Density and population are closely related: density is a product of population and area, and cities that have high populations also tend to have high densities. Comparison of the preferred model and the sensitivity test shows that when density is excluded from the model, population becomes negative and significant. However, in the sensitivity test Area shows a positive, significant coefficient equal in size to the Population coefficient, suggesting that amalgamating two councils of the same density would have a roughly neutral impact on road maintenance costs.

Figure 11: Population does not predict road maintenance costs



Source: Te Waihanga analysis

Table 6: Preferred road maintenance cost model

	Preferred model		Sensitivity test	
	Estimate	SE	Estimate	SE
Intercept	2.08**	0.67	2.08**	0.68
STE %	>0.00*	0.00	0.01*	0.00
Sealed %	-0.63**	0.20	-0.69***	0.20
Population	0.03	0.06	-0.26***	0.05
Density	-0.29***	0.04	-	-
VKT/pp	0.40***	0.03	0.41***	0.03
Area	-	-	0.27***	0.04
Council effects	Random		Random	
Time effects	-		-	
N	966		966	
R^2	0.290		0.284	

*Statistical significance indicators: * $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$*

Building consent processing

Building consents are a delegated power: Councils must process building consents under the Building Act 2004 but do not receive financial assistance from central government to undertake this required activity (New Zealand Productivity Commission, 2019). Alongside the allocation of regulatory responsibilities, councils are allocated the risk in the case of regulatory failure as building consent authorities (New Zealand Productivity Commission, 2013).

Councils have discretion on the extent to which consents are funded from fees or rates but are prohibited from charging more than the reasonable costs incurred to process the consent (Building Act 2004, 2022). Building consents provide a useful case study of cost efficiency for regulatory service provision because they allow a like-for-like comparison, holding other factors constant. All councils are providing essentially the same service.

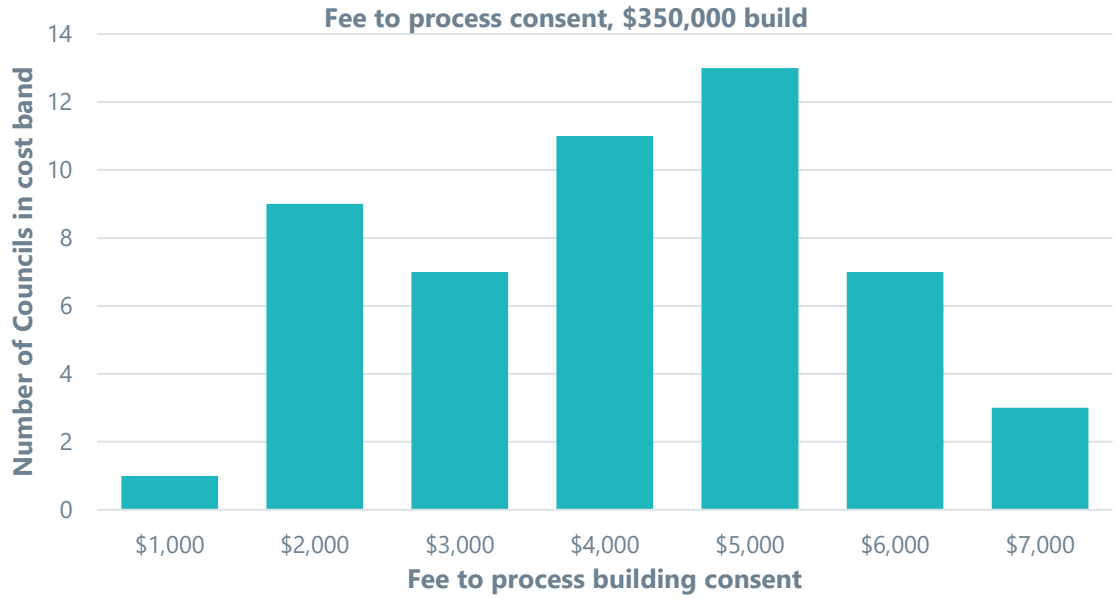
Figure 12 outlines the distribution of fees to process a building consent for a $350,000 new build residential dwelling among councils in New Zealand in 2022.[12] Data was sourced from council websites and was available for 51 of 67 councils. While the median fee to process a consent for a $350,000 build is $3,780, there is considerable variation in costs between councils (standard deviation: $1,540). For a $350,000 build, this variation represents a range from a minimum of 0.3% to a maximum of 2.0% of build cost among the 51 observed councils. Fees for a more expensive $750,000 build follow a similar pattern, with a median fee of $4,376 and a standard deviation of $2,024.[13]

Figure 13 shows the relationship between size of council and the fee to process a building consent for a $350,000 new build. Although fees vary, there does not appear to be a clear relationship between council size and building consent fees. An ordinary least squares regression model is constructed to further investigate the contributing factors to the variation in building consent costs across councils.

[12] This dwelling was defined as a single storey home, 150 m^2 in size, and constructed of wood, with a $350,000 build cost.
[13] This dwelling was defined as a two-storey home, 250 m^2 in size, and constructed of wood, with a $750,000 build cost.

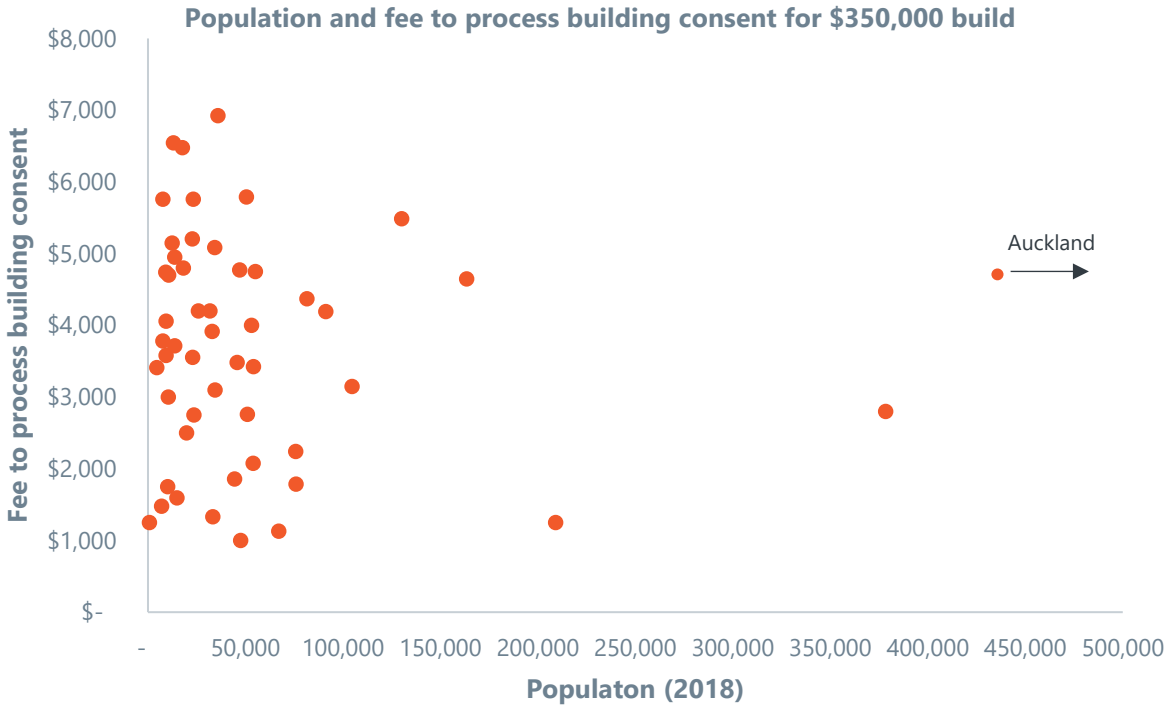
Table 7 outlines the descriptive statistics of the variables used in the building consent cost model. Data is available for all variables for a total of 50 councils.

Figure 12: There is substantial variation in building consent costs



Source: Te Waihanga, based on data gathered from council websites

Figure 13: Variation in fees is not clearly related to size of council



Source: Te Waihanga, based on data gathered from council websites

Two different outcome variables are tested: fees to process a building consent for a $350,000 or $750,000 new build residential dwelling. One explanatory variable relates to the physical characteristics of the council providing consents (Population). Six other explanatory variables which could potentially impact building consent fees (labour costs, consent volume, employee cost share, income from fees, and

a proxy variable for spatial competition facing councils) are included in the model so that the impact of local government size can be observed while holding these other factors constant.

Table 8 outlines the regression results for the building consent cost model. The variation in fees to process building consents is not well predicted by the variables included in the models. Over 80% of the variation in building consent costs between councils remains unexplained (R^2 = 0.147 for the Fee $350,000 build, R^2 = 0.158 for Fee $750,000 build).

Council (local government) size does not have a statistically and practically significant impact on building consent fees, suggesting that there is little evidence of economies of scale in building consent processing.

None of the other potential factors tested were statistically significant. The data suggests that variations in building consent processing costs cannot be explained by local wages, quantity of consenting activity, local population density, or council policies and processes (including degree of outsourcing and degree of cost recovery for regulatory services). Building consent costs also appear to be unaffected by the degree of spatial competition that councils face, which we proxy using Census data on the share of council residents commuting to jobs in other councils.[14]

While all explanatory variables were statistically insignificant, point estimates of coefficients representing the influence on consent costs of the share of council consenting costs funded by fees and the degree of spatial competition facing councils were large and had the expected sign.

[14] In areas where there are several Councils within a functional labour market, people face fewer barriers to moving from one Council to another, and thus more choice about which Council districts to build a new property in. Competition between Councils for development may or may not exert a downward pressure on building consent fees.

Table 7: Descriptive statistics of variables used in building consent cost model

	Definition	N	Median	Std. dev.
Fee, $350,000 build (2022)	Stated fee to process building consent (log transformed)	51	$3706	$1540
Fee, $750,000 build (2022)	Stated fee to process building consent (log transformed)	50	$4596	$2,024
Population	Estimated resident population in June 2018 (log transformed)	67	71,539	195,216
Labour costs	Mean quarterly earnings of continuing jobs in 2021 (log transformed)	66	$15,561	$1,495
Consent volume	Dwelling consents per 1000 population in 2021	67	8	5
Density	Population weighted density (pp/km) (log transformed)	66	908	778
Employee cost share	Share of council consenting costs are employee costs in 2020	67	52%	23%
Income from fees	Share of council consenting costs funded by fees and charges in 2020	67	51%	16%
Spatial competition proxy	Spatial competition facing councils is proxied using Census data on the share of council residents that commute to jobs in other districts[15].	67	10%	12%

Table 8: Regression results, building consent cost model

	Fee, $350,000 build		Fee, $750,000 build	
	Estimate	**SE**	**Estimate**	**SE**
Intercept	10.930*	6.093	10.936*	6.198
Population	-0.020	0.114	0.020	0.122
Labour costs	-0.279	0.665	-0.315	0.666
Consent volume	0.011	0.160	0.074	0.173
Density	-0.073	0.124	-0.080	0.140
Employee cost share	0.234	0.317	0.378	0.338
Income from fees	0.933	0.826	0.950	0.880
Spatial competition proxy	-0.786	0.557	-0.909	0.604
N	50		49	
R^2	0.147		0.158	

*Statistical significance indicators: * $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$*

[15] The more residents commute externally, the easier it is for council residents to 'vote with their feet' to avoid high Council costs.

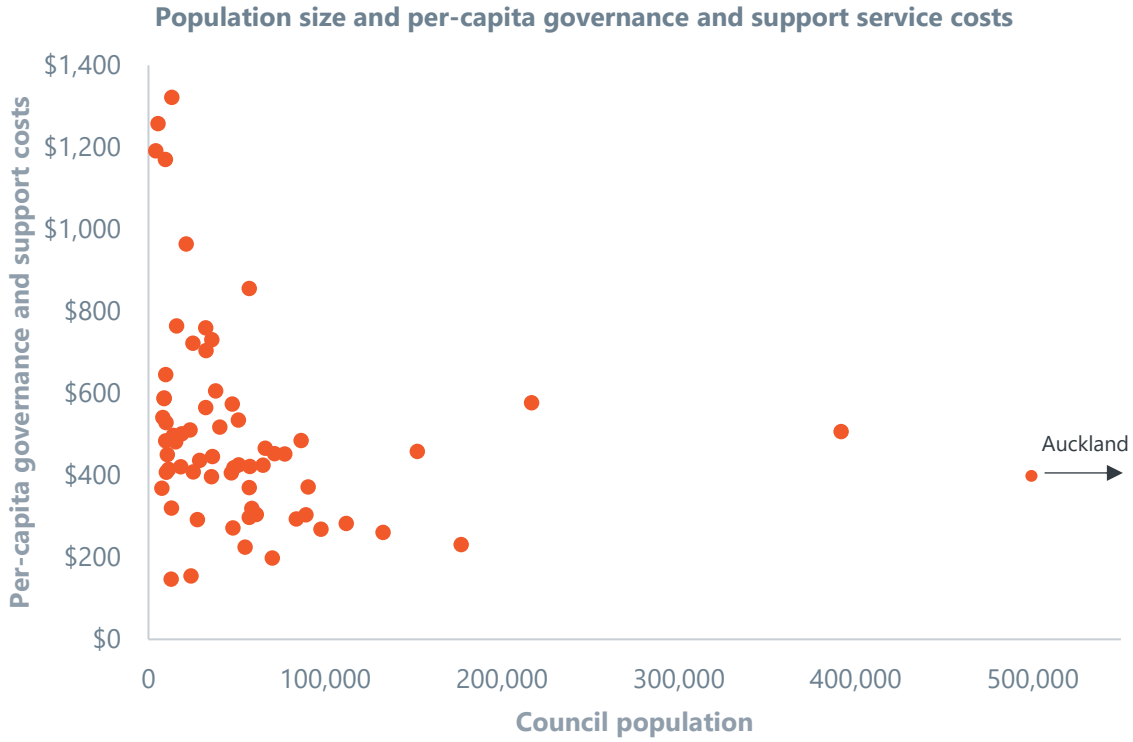
Governance and support service costs

Council overheads include costs of governance, elections, and council support services, and represented 23% of council operational expenditure in 2021 (Statistics New Zealand, 2022).

Local government amalgamations often seek to reduce overhead costs associated with council operations. Some analysts have argued that economies of scale can be realised by spreading fixed costs over more users (Adams, 1965; Boyne, 1992).

Figure 14 shows that New Zealand councils with the highest per-person overhead costs tend to have small populations. However, the councils with the lowest per-person overhead costs *also* tend to be small. It is therefore unclear whether council size has a significant impact on overhead costs.

Figure 14: It is unclear whether council size has a significant impact on overhead costs



Source: Te Waihanga, based on data from Statistics New Zealand, 2022a

To better understand this issue, we use Statistics New Zealand's Local Government Financial Statistics to analyse whether larger local government population was related to council overhead costs for 67 councils over 19 years (2003-2021).[16] We use this data, plus annual estimates of council population, to calculate per-capita governance and support service costs for each council over this time period.[17]

[16] To obtain a balanced panel of councils across all years, data is combined for predecessor Councils of the pre-amalgamation Auckland Council (merged from predecessor councils in 2010) and pre-amalgamation Christchurch City Council (merged with Banks Peninsula District Council in 2006).

[17] We measure governance and support service costs using the following expenditure items: "Governance", "Council support services", "Other activities", and "All other activities". These categories include 'overhead' costs to run elected Councils and committees, provide finance, IT, and HR functions, prepare strategic plans required under the Local Government Act, and provide other miscellaneous services. Reporting categories changed slightly in 2009 (when "Council support services" and "Other activities" were split out from "Governance") and 2020 (when "Council support services" and "Other activities" were combined into "All other activities").

We do not directly measure the quality of governance and support services provided by different councils. However, the Local Government Act 2002 requires all councils to meet a similar set of requirements around holding elections, preparing annual and long-term plans, and undertaking consultation on plans, which are accounted for as governance costs. To deliver services, councils must also provide a similar set of support functions like finance, information technology, and human resources, although they have flexibility about how to provide these services.

Table 9 outlines the descriptive statistics for the panel dataset; data is available for all variables for a total of 1273 observations (67 councils multiplied by 19 years).

In addition to council population, we control for three other variables that may affect overhead costs:

- Non-overhead operating costs per capita (which is a proxy variable for the scope of services that councils provide, which may affect overhead costs)
- population density (which could in theory also affect overhead costs), and
- annual population growth rate (as faster growing councils may incur additional overhead costs to plan for growth).

In addition, in our preferred model specification we include council and year fixed effects, which control for other unmeasured council characteristics that may affect overhead costs and broad trends that may affect overhead costs for the entire country, like changing legislative requirements.

Table 9: Descriptive statistics of variables used in the overhead cost model

Variable	Definition	N	Mean	Std. dev.
Overhead cost/pp	Governance and support cost per person per year ($/pp). Deflated to real 2021 NZD using Consumer Price Index.	1273	$413	$353
Population per council	Estimated resident population in June, divided by number of councils[18] (log transformed)	1273	59,236	152,776
Non-overhead operating cost/pp	Operating cost per person per year, excluding governance and support costs ($/pp). Deflated to real 2021 NZD using Consumer Price Index.	1273	$1572	$925
Population density	Population weighted density (Pop / square km) (log transformed)	1273	841	736
Population growth rate	Annual percentage growth in estimated residential population to June year	1273	1.12%	1.36%

Table 10 outlines the regression results for the preferred overhead cost model and a sensitivity test that excludes Auckland Council and its predecessors from the analysis. Appendix B presents the methodology for selecting the preferred model form.[19]

[18] This allows us to account for the fact that some councils were amalgamated during the 2003-2021 period.
[19] A fixed effects panel model is chosen after diagnostic tests showed that it outperforms random effects and pooled panel models. Diagnostic tests also indicated that time fixed effects should be included in the model.

We find that population size has a small and statistically insignificant impact on per-capita overhead costs, after controlling for factors like the broad quantity of services that councils provide and country-level time trends that may affect overhead costs. This effect is statistically indistinguishable from zero whether Auckland is included or excluded in the analysis. This suggests that size of council doesn't influence overhead costs.

Table 10: Preferred governance, support, and overhead costs model

	Preferred model		Sensitivity test (excluding Auckland)	
	Estimate	SE	Estimate	SE
Intercept	-		9.065***	1.959
ln (Population per council)	0.061	0.086	0.056	0.167
ln (non-overhead opex per capita)	-1.439**	0.096	-0.311	0.197
Population density	0.104	0.156	-0.263*	0.149
Population growth rate	-0.256	1.539	6.731**	3.334
Council effects	Fixed		Random	
Time effects	Fixed		Random	
R^2	0.162		0.096	

*Statistical significance indicators: * $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$*

Several councils were amalgamated during the 2003-2021 period covered by this analysis. In principle, these amalgamations could be studied to assess whether creating larger councils resulted in lower overhead costs.

Reducing overhead costs was a key desired outcome of Auckland's 2010 amalgamation (Asquith et al., 2020). The Royal Commission on Auckland Governance projected that Auckland's amalgamation would result in estimated efficiency gains of between $76 million to $113 million per year, equivalent to 2.5% to 3.5% of the legacy Auckland councils total expenditure for 2008/09 (Bazley et al., 2009).[20] These efficiency gains were expected to come primarily from reduced council overhead costs.

While the Department for Internal Affairs proposed to undertake a post-implementation review of Auckland Council amalgamation to understand the impacts and outcomes of the reforms over the short, medium and longer-term, no such review has been published. It is therefore difficult to establish whether the proposed efficiency gains were realised in practice (Department of Internal Affairs, 2010a, 2010b).

[20] Other desired benefits included increased democratic participation and improved quality of infrastructure and services.

Conclusion

Local government plays an important role in infrastructure planning and provision in New Zealand. Addressing New Zealand's infrastructure challenge will require local government to provide infrastructure and services efficiently and effectively.

This Research Insights piece has investigated the impact of local government structure on infrastructure service delivery and performance in New Zealand. This analysis highlights some important considerations for Recommendation 14 in the *Infrastructure Strategy*, which outlines a need to review the boundaries and responsibilities of local governments to achieve benefits of better coordination between local governments in growing urban areas.

The key findings from this analysis are as follows.

New Zealand is already highly centralised and consolidated

Previous local government reforms have already significantly reduced horizontal and vertical fragmentation of local government bodies in New Zealand. Over the last century, New Zealand has gone from having roughly one local government body for every 2000 people to having one for every 65,000 people, primarily due to large-scale consolidation in the 1989 local government review.

Relative to other OECD countries, New Zealand has comparatively large local government bodies and a comparatively small role for local government in provision of public infrastructure and public services. New Zealand has the lowest local government proportion of public investment in the OECD, and the fourth-highest average local government size in the OECD.

OECD countries where local governments play a larger role in public infrastructure provision tend to provide infrastructure more efficiently. However, the average size of local government does not appear to be related to infrastructure efficiency in OECD countries.

There is little evidence of cost efficiencies from larger local governments

We investigate whether local government size and structure affects the cost of providing three types of local government services: road maintenance, building consents, and council overhead costs. These activities account for a large share of councils' operating expenses. In 2020, transport maintenance represented 21% of total operating costs, planning and regulation represented 8%, and governance and support services (overhead) costs represented 23%.

Our analysis suggests that population size neither decreases nor increases the cost to provide these three services. After controlling for other factors that affect costs, we find no evidence of cost economies of scale.

In the case of road maintenance cost, we find that other factors have a statistically significant impact on per-person road maintenance costs. Councils with higher population density, or lower per-person vehicle kilometres travelled, tend to have lower road maintenance costs. As our analysis is based on data from almost all councils over a 15-year period, we are able to control for unobserved sources of variation between councils, giving us a high degree of confidence in the results.

In the case of building consent costs, where all councils are legally required to provide a similar service and are prohibited from charging more than the cost of providing the service, we cannot identify any variables that explain differences in costs. However, consenting costs do vary significantly across councils. More work is needed to understand why some councils process building consents at a significantly lower cost than others.

In the case of council overhead costs, we examine the impact of council population size on per-capita governance, support, and other costs over the 2003-2021 period. This reflects 'overhead' costs to service elected members, prepare annual and long-term plans, and provide back-office services like IT and human resources. We find that council size neither increases nor decreases overhead costs.

These findings could be improved by studying the impact of past local government amalgamations, such as the 2006 merger of Christchurch City Council and Banks Peninsula District Council or the 2010 Auckland Council amalgamation. Completing and publishing post-implementation reviews of these mergers could improve our understanding of the impact of local government structure on cost efficiency and other outcomes.

Other factors are also relevant for local government structure

The empirical analysis in this Research Insights piece focuses primarily on assessing cost efficiencies related to the size of local governments. While this is an important consideration for local government structure, it is not the only consideration.

The broader literature on local government structure identifies a number of other relevant factors that should be considered, including impacts of local government structure on the quality of infrastructure and services, impacts on the ability of local government bodies to manage 'spillover' effects, impacts on democratic representation, and equity impacts. The findings of this Research Insights piece suggest that future analysis of the benefits and disbenefits of alternative local government structures should focus more on these issues than on cost efficiencies.

Recommendation 14 in the *Infrastructure Strategy* identifies coordination of regional infrastructure and regional planning as key considerations. Coordination can be important for ensuring consistent service quality for regional infrastructure and for ensuring that various social, environmental, and economic spillovers are managed efficiently.

In many cases, local decisions about infrastructure and urban planning can have regional or national impacts that local governments may not have the right incentives or capability to address. For instance, Hsieh and Moretti (2019) and Ganong and Shoag (2017) show that local policies that limit housing supply in some US cities have reduced economic growth and slowed convergence in incomes between different regions.[21] Internationally, there is some evidence that local government structure can affect other outcomes, such as travel patterns and local economic growth (Bartolini, 2015; Egger et al., 2022; Loumeau, 2020). Further research is needed to understand these issues in the New Zealand context.

[21] Nunns (2021) finds that regional housing supply constraints also affect regional and trans-Tasman migration and national economic output in New Zealand.

Appendix A. Road Maintenance Costs

To determine what independent variables related to the shape and form of councils are most appropriate to use, we test four alternative model specifications. In the base specification, we use population and density; in Sensitivity test 1, we use population, density, and area; in Sensitivity test 2, we use population and area.

Table 11, Table 12, and Table 13 outline three potential model forms for each of the model specifications: a pooled model, a fixed effects model, and random effects model. A pooled model is a traditional ordinary least squared approach, which ignores the longitudinal nature of the data and treats each observation as unique. Fixed effects models and random effects models provide two alternative approaches of controlling for unobserved heterogeneity in data by using longitudinal datasets. Fixed effects models can offer advantages over a pooled OLS approach because individual specific effects and unobserved variables are removed by using time de-meaned variables. However, under a fixed-effects approach the variables must not be correlated with the error term and time-invariant variables cannot be used. Like fixed effects models, random-effects models also control for individual specific effects and unobserved variables, but they also eliminate heteroscedasticity and allow for the inclusion of time-invariant variables. Under a random effects model, unobserved heterogeneity between individuals must be uncorrelated with the independent variables.

Three statistical tests were used to determine whether a pooled OLS model, a fixed-effects model, or a random effects model was the most appropriate model form for the dataset. First, an F test is used to compare model fit between the pooled model and the fixed-effects model. Results are significant in all three cases, lending more support for a fixed effect model over a pooled model (F=52.47, p-value <.0001 in the base specification, F=53.06, p-value <.0001 in Sensitivity Test 1, F=52.25, p-value <.0001 in Sensitivity Test 2, F=63.91, p-value <.0001 in Sensitivity Test 3). A Lagrange multiplier (LM) test is used to test for panel effects within the dataset and determines whether a pooled model and a random-effects model is more appropriate. Results are significant in all three cases, lending more support for a random effects model over a pooled model (F=63.07, p-value <.0001 in the base specification, F=62.65, p-value <.0001 in Sensitivity Test 1, F=62.79, p-value <.0001 in Sensitivity Test 2, F=43.47, p-value <.0001 in Sensitivity Test 3).

Hausman tests were run to determine whether a fixed or random effects model would be more suitable for the dataset. Hausman tests performed yielded statistically insignificant results in three model specifications ($\chi 2$ =2.2, p-value = 0.82 in the base specification, $\chi 2$ =1.66, p-value =0.89 in Sensitivity Test 1, and $\chi 2$ =0.70, p-value=0.95 in Sensitivity Test 2). The Hausman test yielded a statistically significant result in Sensitivity Test 3 ($\chi 2$ =25.39, p-value = <.0001). This suggests that for three of four specifications, a random-effects model provides a more efficient model specification than a fixed-effects model while also providing consistent results.

We now turn to comparing the base model with Sensitivity Test 1, 2, and 3 to determine the preferred independent variables related to the shape and form of councils providing the road networks. When comparing the preferred random effects model form across specifications, we see that the three models produce very similar estimates for STE %, Sealed %, and VKT/pp variables, but yield differing results for the population, density, and area variables. Additionally, these three variables are closely related: density is derived from population and area, and density and population are highly correlated with each other (R^2 = 0.751).

In the base model (outlined in Table 11), density is negative and highly significant ($p \leq .001$), population is slightly positive and insignificant (p=0.67), and area is excluded from the model.

In Sensitivity Test 1 (outlined in Table 12), area is negative but not statistically significant and does not improve model fit (R^2 = 0.290 for the base model and Sensitivity Test 1), while population is still positive

and insignificant (p=0.26) and density is still negative and highly significant ($p \leq .001$). Additionally, the standard error for density rises from 0.04 in the base specification to 0.12 and the standard error for population rises from 0.06 in the base specification to 0.13, suggesting reduced goodness of fit for these variables.

In Sensitivity test 2 (outlined in Table 13), the density variable is excluded, Population becomes negative and highly significant ($p \leq .001$), and Area becomes positive and highly significant ($p \leq .001$). However, model fit is reduced as compared to the base model ($R^2 = 0.290$ in the base model, $R^2 = 0.284$ in Sensitivity Test 2). In this specification population and area have opposite signs of roughly equal magnitude, suggesting that increasing population and area in equal measures has a neutral impact on costs; this specification provides little insight into the impact of local government population on costs while holding other factors constant.

In Sensitivity test 3 (outlined in Table 14), the density and areas variable are excluded, Population is negative and highly significant ($p \leq .001$). Model fit is reduced compared to all other models presented ($R^2 = 0.235$). This demonstrates that omission of area and density variables leads to omitted variable bias, with the negative sign from density misattributed to population.

We therefore conclude that density is the primary council attribute that predicts pavement costs, and the base is the preferred model specification.

Table 11: Base specification of road maintenance cost model

	Pooled model		Fixed effects model		Random effects model	
	Estimate	**SE**	**Estimate**	**SE**	**Estimate**	**SE**
Intercept	1.35**	0.45	-	-	2.08**	0.67
STE %	0.01**	0.00	>0.00*	>0.00	>0.00*	0.00
Sealed %	-0.75 ***	0.11	-0.61*	0.23	-0.63**	0.20
Population	-0.01	0.02	0.17**	0.15	0.03	0.06
Density	-0.25***	0.02	-0.43	0.12	-0.29***	0.04
VKT/pp	0.50***	0.04	0.39***	0.04	0.40***	0.03
Council effects	-		Fixed		Random	
Time effects	-		-		-	
R^2	0.721		0.161		0.290	

Statistical significance: * $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$

Table 12: Sensitivity test 1 of road maintenance cost model

	Pooled model		Fixed effects model		Random effects model	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	1.30**	0.45	-	-	2.25**	0.69
STE %	0.01**	0.00	>0.00*	>0.00	0.00*	0.00
Sealed %	-0.75***	0.11	-0.61**	0.23	-0.65**	0.20
Population	-0.36^	0.19	0.17	0.15	0.14	0.13
Density	0.10	0.19	-0.43***	0.12	-0.41***	0.12
VKT/pp	0.50***	0.04	0.39***	0.04	0.40***	0.03
Area	0.35^	0.20	-	-	-0.13	0.13
Council effects	-		Fixed		Random	
Time effects	-		-		-	
R^2	0.722		0.161		0.290	

Statistical significance: * p ≤ .05. ** p ≤ .01. *** p ≤ .001

Table 13: Sensitivity test 2 of road maintenance cost model

	Pooled model		Fixed effects model		Random effects model	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	1.32**	0.45			2.08**	0.68
STE %	0.01**	0.00	0.01*	0.00	0.01*	0.00
Sealed %	-0.75***	0.11	-0.68**	0.23	-0.69***	0.20
Population	-0.26***	0.02	-0.24*	0.10	-0.26***	0.05
VKT/pp	0.50***	0.04	0.40***	0.04	0.41***	0.03
Area	0.25***	0.02			0.27***	0.04
Council effects	-		Fixed		Random	
Time effects	-		-		-	
R^2	0.722		0.149		0.284	

Statistical significance: * p ≤ .05. ** p ≤ .01. *** p ≤ .001

Table 14: Sensitivity test 3 of road maintenance cost model

	Pooled model		Fixed effects model		Random effects model	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	2.52***	0.65			9.68***	0.81
STE %	0.01***	0.00	-0.00	0.00	0.00	0.00
Sealed %	-1.90***	0.11	-1.51***	0.42	-2.06***	0.25
Population	-0.19***	0.02	-0.36**	0.12	-0.22***	0.05
VKT/pp	0.54***	0.08	-0.23***	0.07	-0.13*	0.07
Council effects	-		Fixed		Random	
Time effects	-		-		-	
R^2	0.63		0.075		0.235	

Statistical significance: * p ≤ .05. ** p ≤ .01. *** p ≤ .001

Appendix B. Governance and support costs

We followed a similar process for testing panel regression models for per-capita council overhead costs and selecting a preferred model type.

Table 15, Table 16, and Table 17 outline three potential model forms for each of the model specifications: a pooled model, a fixed effects model, and random effects model. A pooled model is a traditional ordinary least squared approach, which ignores the longitudinal nature of the data and treats each observation as unique. Fixed effects models and random effects models provide two alternative approaches of controlling for unobserved heterogeneity in data by using longitudinal datasets. Fixed effects models can offer advantages over a pooled OLS approach because individual specific effects and unobserved variables are removed by using time de-meaned variables. However, under a fixed-effects approach the variables must not be correlated with the error term and time-invariant variables cannot be used. Like fixed effects models, random-effects models also control for individual specific effects and unobserved variables, but they also eliminate heteroscedasticity and allow for the inclusion of time-invariant variables. Under a random effects model, unobserved heterogeneity between individuals must be uncorrelated with the independent variables.

Three statistical tests were used to determine whether a pooled OLS model, a fixed-effects model, or a random effects model was the most appropriate model form for the dataset. First, an F test is used to compare model fit between the pooled model and the fixed-effects model. Results are significant in all three cases, lending more support for a fixed effect model over a pooled model ($F=21.79$, p-value <.0001 in the base specification, $F=21.69$, p-value <.0001 in Sensitivity Test 1, $F=23.34$, p-value <.0001 in Sensitivity Test 2). A Lagrange multiplier (LM) test is used to test for panel effects within the dataset and determines whether a pooled model or a random-effects model is more appropriate. Results are significant in all three cases, lending more support for a random effects model over a pooled model ($\chi2=930.53$, p-value <.0001 in the base specification, $\chi2=923.7$, p-value <.0001 in Sensitivity Test 1, $\chi2=981.26$, p-value <.0001 in Sensitivity Test 2).

Hausman tests were run to determine whether a fixed or random effects model would be more suitable for the dataset. Hausman tests performed yielded statistically significant results for all three model specifications ($\chi2=37.72$, p-value <.0001 in the base specification, $\chi2 =0.32$, p-value =0.99 in Sensitivity Test 1, and $\chi2 =111.61$, p-value<.0001 in Sensitivity Test 2). The Hausman test yielded a statistically significant result in the base model and Sensitivity Test 2, indicating that a fixed effects model is preferred for these two specifications. For Sensitivity Test 1, a random-effects model provides a more efficient model specification than a fixed-effects model while also providing consistent results.

The fixed and random effects model specifications presented below all include time effects in addition to council effects. Inclusion of time effects allowed us to control for broad national factors that may affect council overhead costs over time, like legislative changes or broad cost inflation trends. We tested for the presence of time effects in fixed effects models using an F test ($F=33.48$, p-value <.0001 in the base specification, $F=29.90$, p-value <.0001 in Sensitivity Test 1, $F=40.30$, p-value <.0001 in Sensitivity Test 2). We tested for the presence of time effects in random effects models using a Hausman test ($\chi2=11.82$, p-value = 0.019 in the base specification, $\chi2=12.25$, p-value = 0.016 in Sensitivity Test 1, $\chi2=17.12$, p-value <.0001 in Sensitivity Test 2). These tests allowed us to reject the null hypothesis of no time effects at the 5% confidence level or better for all model specifications.

Our conclusion that council population does not have a significant effect on per-capita overhead costs is consistent across all model specifications and is robust to inclusion or exclusion of specific councils and control variables for population growth and population density.

Table 15: Base specification of per-capita overhead costs model (including Auckland)

	Pooled model		Fixed effects model		Random effects model	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	3.491***	0.522	-		8.576***	1.792
ln (Population per council)	0.025	0.026	0.061	0.086	0.104	0.132
ln (non-overhead opex per capita)	0.423***	0.060	-1.439***	0.096	-0.290	0.195
Population density	-0.169***	0.026	0.104	0.156	-0.287**	0.135
Population growth rate	3.089**	1.279	-0.256	1.539	6.588**	3.295
Council effects	-		Fixed		Random	
Time effects	-		Fixed		Random	
R^2	0.200		0.162		0.091	

Statistical significance: *p<0.1; **p<0.05; ***p<0.01

Table 16: Sensitivity test 1 of per-capita overhead costs model (excluding Auckland)

	Pooled model		Fixed effects model		Random effects model	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	3.764***	0.552	-		9.065***	1.959
ln (Population per council)	0.007	0.028	-0.210	0.212	0.056	0.167
ln (non-overhead opex per capita)	0.406***	0.062	-1.429***	0.097	-0.311	0.197
Population density	-0.163***	0.026	0.220	0.179	-0.263*	0.149
Population growth rate	3.357***	1.292	-0.334	1.556	6.731**	3.334
Council effects	-		Fixed		Random	
Time effects	-		Fixed		Random	
R^2	0.202		0.162		0.096	

Statistical significance: *p<0.1; **p<0.05; ***p<0.01

Table 17: Sensitivity test 1 of per-capita overhead costs model (excluding some variables)

	Pooled model		Fixed effects model		Random effects model	
	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	2.177***	0.500	-		8.842***	1.820
ln (Population per council)	-0.085***	0.017	0.080	0.081	-0.102	0.094
ln (non-overhead opex per capita)	0.620***	0.054	-1.444***	0.096	-0.273	0.191
Council effects	-		Fixed		Random	
Time effects	-		Fixed		Random	
R^2	0.166		0.162		0.002	

Statistical significance: *p<0.1; **p<0.05; ***p<0.01

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