NEW ZEALAND
INFRASTRUCTURE
COMMISSION
Te Waihanga

Benchmarking our infrastructure

Technical Report

Tewaihanga.govt.nz

New Zealand Infrastructure Commission / Te Waihanga

The New Zealand Infrastructure Commission, 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.

We are an autonomous Crown entity, listed under the Crown Entities Act 2004, with an independent board. We were established by the New Zealand Infrastructure Commission/Te Waihanga Act 2019 on 25 September 2019. Information on the Commission is available at www.tewaihanga.govt.nz/

How to cite this document

New Zealand Infrastructure Commission. (2025). *Benchmarking our infrastructure: Technical report*. Wellington: New Zealand Infrastructure Commission / Te Waihanga.

Contact

Peter Nunns
General Manager, Strategy
Email: peter.nunns@tewaihanga.govt.nz
Website: tewaihanga.govt.nz
LinkedIn: tewaihanga

Acknowledgements

This report was written by **Ezra Barson-McLean**, with additional analysis contributed by **Graham Campbell**, **Philip Stevens**, and **Peter Nunns**. We are grateful for formal review of these documents by **Stuart Donovan** at Motu Research. We are also grateful to the many organisations who provided feedback on this work, formally or informally.

Cover photo credit: Nikola Johnny Mirkovic/Unsplash.

Contents

1. Introduction

1.1. What is the Infrastructure Needs Analysis?

The Infrastructure Needs Analysis (INA) seeks to identify and quantify long term infrastructure needs due to various drivers of demand.

The INA consists of three themes, each with a separate output:

- **Where and how should we invest in the future?** This theme explores what has driven investment in infrastructure in the past, and how might those factors change in the future. The key output of this theme is a quantitative forecast model of infrastructure spending based upon these drivers of demand.
- **What is the current state of our networks?** This theme explores whether there are clear gaps in our infrastructure networks relative to peer countries across investment levels, quantities, usage and quality measures. The key output of this theme is a comprehensive international benchmarking study as a comparison to our quantitative model above.
- **What are we willing to spend on infrastructure?** This theme provides insight into the trade-offs we should expect to make when meeting our needs. Identifying infrastructure needs requires prioritisation that is not possible without knowledge of a constraint. The key output of this theme is a series of analyses showing potential budget envelopes for infrastructure and opportunities for expanding our budgets.

Identifying needs can involve many different approaches. Our approach for the INA is to study the question of infrastructure needs in a holistic way. The core output is our quantitative forecasting model, supported by parallel work on international infrastructure needs and separate analyses of potential infrastructure needs budgets.

1.2. Why did we do international benchmarking?

The INA aims to take a comprehensive view of infrastructure needs. The main output of the INA is a forecast model that lays out the Commission's forward guidance for infrastructure investment to meet long run demands.

We consider the international benchmarking complementary to this analysis in two ways:

1) Another way of defining needs is to compare New Zealand's infrastructure performance to similar countries. Notwithstanding whether these countries have the optimal or efficient approach to infrastructure, it gives us an understanding of network performance.

2) It allows us to confirm or reconsider the results produced by our investment forecast. For instance, if our investment forecast shows an increase in investment required for the health sector to address a historical underinvestment, we might expect that international benchmarking may show New Zealand is comparatively behind its peers in terms of the quality of its infrastructure.

1.3. Purpose of this document

The purpose of this document is to detail the sources, methods, and metrics used to benchmark infrastructure networks across countries. It will also lay out the various assumptions used in the weighting of various metrics.

2. Broad approach and method

2.1. Our approach, at a high level

Our approach involves collecting information across four key parameters for each infrastructure sector:

- investment levels
- quantities of physical infrastructure
- usage of the network
- quality of the network or outcome measures.

Our approach for each infrastructure sector is as follows:

1. Create a subset of comparable countries using a set of control variables, such as population, terrain ruggedness, and other measures.
2. Gather information on investment levels, quantities of infrastructure, usage of the network, and quality of the network for various countries.
3. Standardise our results to make high-level comparisons across the key parameters.

Our approach has implicit assumptions and drawbacks. The first thing to note is that we are not implying that other countries have the efficient mix or amount of infrastructure. We are only seeing how New Zealand compares to them. New Zealand may have a more (or less) efficient approach than other countries.

Our international benchmarking work is only as good as the data we could find. Where possible we have used datasets with standardised, high-quality collection methods. In many cases, these datasets come from the OECD.

2.2. Creating a comparable country subset

Central to our benchmarking approach is the idea that country's existing infrastructure quantity, investment, and quality levels are, in large part, explained by high-level factors. These include a country's population, size, topography, urbanisation, and incomes. This position has been informed by previous Commission research, which has found that population, demographics, and income can explain country-by-country differences in infrastructure stocks.[1]

Understanding these factors is important because it allows us to determine what countries we should be comparing ourselves to. Different countries face different challenges when it comes to delivering infrastructure. Our goal is to find countries which face similar challenges to New Zealand in each infrastructure sector.

This exercise does not attempt to control for *all* factors that could explain infrastructure networks across countries. Our approach relies on high-level factors that could explain variations between countries. For example, for electricity networks, we know that New Zealand relies heavily on hydroelectric dams for generation, which are located a great distance away from the demand centres where power is used. We control for population density of a countries, but not for geographic distance between generation sources and demand centres.

The process for identifying similar countries requires first identifying a limited set of control variables (typically between 5 and 10) and then developing a 'similarity score'.

[1] https://media.umbraco.io/te-waihanga-30-year-strategy/43ikcme0/paying-it-forward-understanding-our-long-term-infrastructure-needs.pdf

2.2.1. Determining control variables for similar countries

As noted, for most sectors, we relied on previous Commission research explaining infrastructure quantity and investment between countries.

For most sectors, there are a key set of variables we use:

- **Geographic characteristics:** measures included a country's land area, topography, and coastal areas.
- **Population characteristics:** measures included the overall population, population density, or demographic characteristics (such as the share of the population over 65). We also considered where these populations lived to be important, so we typically include population density and urbanisation metrics.
- **Economic characteristics:** measures included a country's industrial composition and natural resources.

Because our benchmarking focuses on OECD countries, we are also controlling for average incomes. All OECD countries are developed countries, and for the most part, the comparator countries we use for all sectors have GDP per capita between $40,000 and $65,000 USD, compared to New Zealand's GDP per capita of $44,000 USD. In our comparisons, we list per capita incomes for reader reference.

We further refined or added these control variables by speaking to sector experts. This often led to the inclusion of other variables that are not directly related to the three above. For instance, in health, it was determined that institutional arrangements to be particularly it important, so we included a measure for the share of health services provided publicly or privately.

2.2.2. Creating a similarity score

To create our similar country-subset, we calculate a similarity score for each country. In effect, this measure is designed to show us which countries are most like New Zealand across the chosen control variables.

To create this score, each control variable is standardised to have a mean of zero and a standard deviation of one. Each variable then has the value for New Zealand subtracted from it:

$$\hat{x}_{ij} = \frac{x_{ij} - x_i^{NZ}}{\sigma_i}$$

Where x_{ij} is the value for variable i and country j. Each value then shows how many standard deviations away from the New Zealand value each country is for each variable. The root mean square error of these values is then taken to get the similarity score for each country:

$$s_j = \sqrt{\frac{1}{I}\sum_i \hat{x}_{ij}^2}$$

Each similarity score is then the root mean square of how many standard deviations a country's variables are away from the New Zealand values. New Zealand's similarity score is then necessarily zero, with a higher value indicating a country is less comparable to New Zealand. The eight or so most similar countries are then chosen as the benchmark set. Some countries are removed from the benchmark set later in the benchmarking due to data constraints. To demonstrate how this work, we lay out an example for road network below.

Road infrastructure example

To create the similarity score for roads, we use four variables: population density, terrain ruggedness, log of total population, and the share of population living in urban areas. Based upon our similarity score, the country that is most like us across these variables is Norway, and the country that is least like us is the Netherlands.

Table 1 below shows the road demographic variables for New Zealand, Norway, and the Netherlands. Norway is very similar to New Zealand across all measures. Norway, like New Zealand, is sparsely populated, has a very rugged terrain, and has a small but moderately urbanised population. The Netherlands on the other hand, is very unlike New Zealand. The Netherlands is very densely populated, very flat, with a larger, more urbanised population.

Table 1: Road infrastructure demographic variables for New Zealand, Norway, and the Netherlands

Country	Population density	Terrain ruggedness	Population (2023)	Urban population
New Zealand	20	2.04	5,223,100	87%
Norway	15	2.41	5,519,594	84%
Netherlands	531	0.04	17,879,488	93%

Source: World Bank World Development Indicators, Nathan Nunn & Diego Puga (2012)

Table 2 shows how many standard deviations Norway and the Netherland's values are away from New Zealand's. The similarity score is then the root mean square (or the average of the absolute values) of these standard deviations. New Zealand's demographics are naturally all 0 standard deviations away from its own values. Norway's values are all low, giving it a similarity score of 0.17. This implies that the demographic variables are on average 0.17 standard deviations away from the New Zealand values. The Netherlands, on the other hand, has a similarity score of 1.71. This implies that the demographic variables are on average 1.71 standard deviations away from the New Zealand values, making it the country that is the least like New Zealand.

Table 2: Road infrastructure similarity scores for New Zealand, Norway, and the Netherlands

Country	Population density	Terrain ruggedness	Population (2023)	Urban population	Similarity score (RMSE)
New Zealand	0.00	0.00	0.00	0.00	0.00
Norway	-0.03	0.34	0.04	-0.27	0.17
Netherlands	3.61	-1.84	0.82	0.57	1.71

Source: World Bank World Development Indicators, Nathan Nunn & Diego Puga (2012)

This is done for every country in the OECD for each infrastructure sector. For each infrastructure sector, we then choose the eight or so countries with the lowest similarity scores to be the benchmark countries. Some countries would then be removed from the benchmark set due to having insufficient data.

2.3. Data collection

The key to a robust international benchmarking exercise is the quality of data used. It is critical to have data that utilise a standardised methodology for collection and definitions. Otherwise, international comparisons will be comparing 'apples to oranges'.

Our work puts high value on data from standardised international data sets from organisations such as the OECD, United Nations Statistics Division, Eurostat, and the World Bank. Data from these sources is already either standardised or has any inconsistencies detailed.

If there are no standardised data sets available, we look for data from national data sets. These are primarily from national infrastructure bodies, national statistical organisations, and some academic

articles. National-level data collection is prioritised for benchmark countries. Where this data was used, we ensured that definitions and collection methods were similar across countries.

2.4. Key benchmarking parameters

Our approach to benchmarking countries infrastructure is to compare across four different measures:

- **Investment:** This is usually measured as gross fixed capital formation in each network over the last 5 to 10 years. These measures capture capital investment in new assets and capital investment to replace and renew assets. These measures shouldn't include operational expenditure such as maintenance on existing assets.
- **Quantity:** Here we look for measures of stock expressed as physical units (kilometres of road, transmission lines, etc.). These are often expressed in normalised terms (per capita, per square kilometre of land area, etc.).
- **Usage:** Infrastructure networks provide or enable services. These measures capture how intensely these services are utilised. For example, electricity infrastructure provides electricity to households and businesses, therefore we collect data on the amount of electricity used in each country.
- **Quality:** This is a broad suite of measures that attempts to measure outcomes of the network. These measures are often bespoke for each sector. We do not make judgements about the relative importance of the measures we find.

For flow variables, such as investment, we use the annual average over the last 5 to 10 years of available data. For stock variables such as quantity of infrastructure or number of students, we use the value from the last available year. An OECD or sample average for each variable is then taken by calculating the simple, unweighted average across each country.

2.5. Summarising our results

To display the benchmarking results for each sector across the four categories we create 'whisker' graphs. These are box and whisker graphs showing the investment, quantity, usage, and quality measures for each sector, except without the boxes. These are designed to create a straightforward way to observe New Zealand's position relative to other countries.

Creating these results requires aggregating multiple measures into a single measure for comparison purposes. For instance, for quality measures for roads, we have metrics on congestion, road safety, road smoothness, and access. For our summary charts, we need to aggregate these into a single metric of quality.

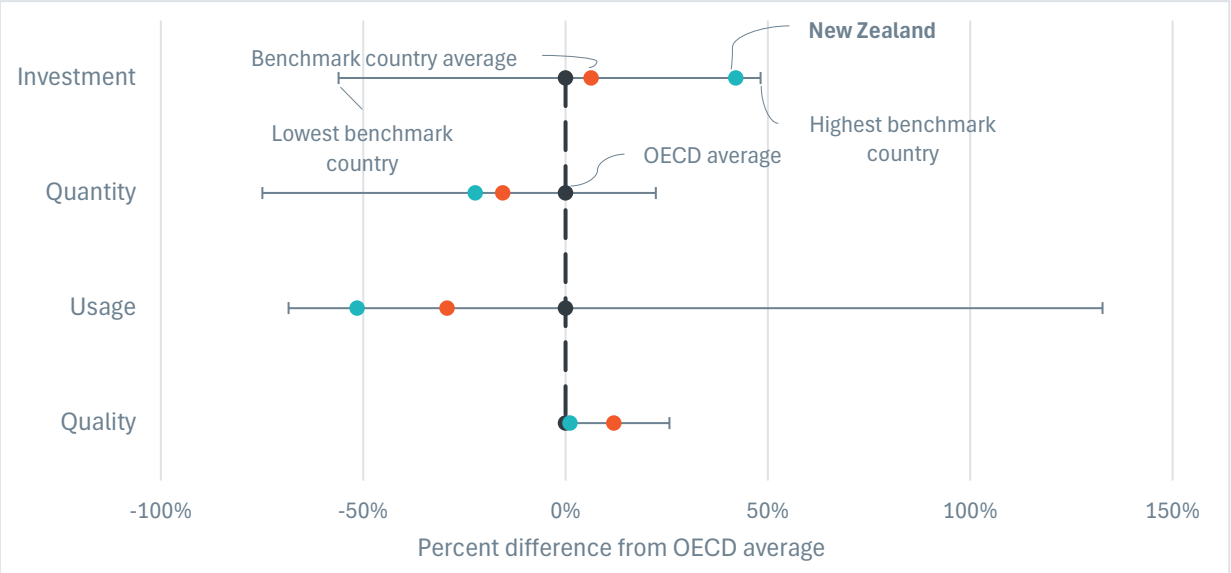
To do this for investment, quantity, usage, and quality measures, the following process is undertaken for each sector:

1. Every value for each variable for each country is normalised to be the difference from the OECD average for that variable.
2. Variables are aggregated across each country as a simple average, once similar variables have been aggregated.
3. The values for New Zealand, the benchmark country average, and the lowest and highest benchmark country are plotted on a whisker graph.

Appendix B describes the process behind this, its assumptions and pitfalls in more detail.

As an example, Figure 1 shows the results for road networks.

Figure 1: Whisker graph showing benchmarking results for road infrastructure



The blue and orange points on the graph represent New Zealand and its comparator country average, respectively. The ends of each whisker represent the lowest and highest of the comparator countries. The OECD average is at 0%, represented by the dashed black line.

For example, the key points from Figure 1 for investment are then:

- New Zealand's investment in road infrastructure is 42% above the OECD average.
- New Zealand's benchmark countries invest on average 6% above the OECD average.
- New Zealand's benchmark countries investment ranges between -56% and +48% of the OECD average.

Where there are multiple measures combined into one (such as quality, where we have multiple different measures), this can be interpreted as 'New Zealand's road quality measures are on average 1% above the OECD average'.

We create these graphs for each sector, but we also examine each parameter to see where the variation comes from.

2.6. Caveats with our comparative results

We present our results so that multiple metrics can be distilled into a relatively easily interpretable result. However, there are drawbacks to this approach.

Principal among these drawbacks is that we weight the value of our metrics equally for each parameter. For instance, when creating a comparative statistic for road quantity, we weight the importance of the metric for lane kilometres per capita and lane kilometres per 100 square kilometres equally. This implies that it is equally important to have a road network that serves people but also allows access to areas of the country (even if they are uninhabited).

A further discussion of the advantages and drawbacks of this approach can be found in Appendix B. We scenario tested our results to determine how robust they were across the sectors we benchmarked. In general, we found:

- For sectors where we had more measures, our approach was robust to applying different weights to different measures. That is, our simple comparative statistic was sensitive to weighting changes. This was the case with roads, electricity, health, education. For rail, the relatively low number of metrics made the results more sensitive to the weights.
- For networks that could plausibly be split into subsectors, the weights placed on those subsectors matter.
    - In telecommunications, our approach averages performance across fixed and mobile broadband networks. However, New Zealand's quantity of fixed broadband is much higher than its mobile broadband network. If we weighted mobile broadband metrics higher, New Zealand performs relatively poorly.
    - In rail, freight and passenger networks could plausibly be benchmarked separately. New Zealand rail usage for freight is about average for its comparator countries but well below for passengers. An equal weight across both leads to an overall statistic that is skewed towards below average.

A discussion of this scenario testing can also be found in Appendix B.

Future research using the data collected as part of this project will be utilised to produce analysis that uses more technical weighting approaches.

3. Overall results

3.1. High level results across all sectors

Our overall results across all sectors and parameters are listed in *Table* 3. In general, we find that in many sectors, New Zealand's investment in many infrastructure sectors is higher than that in benchmark countries. However, this is not necessarily resulting in higher quality infrastructure. This could be indicative of efficiency/effectiveness issues with our investment, or a reflection of a different point in the infrastructure investment cycle.

Table 3: *Overall results of international benchmarking of infrastructure networks*

	NZ difference from benchmark country average					
Sector	Investment	Quantity	Usage	Quality	Benchmark countries	Notes
Roads	+34%	-13%	-33%	-13%	CZE, CAN, FIN, SWE, ISL, NOR	High investment levels, low usage, high amount of fatalities on the network
Rail	-64%	-43%	-23%	-90%	CHL, GRC, JPN, ESP, FIN, SWE, ISL, NOR	Low investment levels, low usage (both passengers and freight), high emissions
Electricity	-3%	+29%	-46%	-12%	COL, CRI, CHL, CAN, FIN, SWE, ISL, NOR	Large transmission network, relatively high frequency and length of outages
Water	+70%	-3%	+99%	+9%	CHL, GRC, ESP, CZE, CAN, FIN, SWE, ISL, NOR	High levels of investment, very high usage, average levels of leakage
Telecom	+28%	-12%	+3%	-4%	COL, CRI, CHI, CAN, FIN, SWE, ISL, NOR	High investment levels, developed fixed broadband but underdeveloped mobile broadband
Health	-25%	-10%	-2%	-13%	UK, AUS, SWE, DEN, ISL, NOR	Low amounts of some medical equipment, some higher wait times, and older hospitals
Education	+1%	-10%	+6%	+4%	CHL, FIN, AUS, ISL, NOR, USA, IRL	No clear deficits or shortages

Differences from benchmark country average is based upon a simple weighted average of multiple measures. See Appendix A for the full list of variables.

Usage measures vary by sector. Usage of road infrastructure is below the benchmark country average. Usage of telecommunications infrastructure is close to the benchmark country average. Usage of water infrastructure is well above the benchmark country average.

4. Road infrastructure benchmarking

4.1. Road infrastructure controls

Table below outlines the controls that we use to determine benchmark countries for road infrastructure.

Table 4: Controls for road infrastructure

Sector name	Control variables	Definition	Source
Roads	Population density	Total population divided by the land area of the country, people per km^2.	World Bank World Development Indicators
	Terrain ruggedness	Average of the Terrain Ruggedness Index for the area of the country.[2]	Nathan Nunn & Diego Puga (2012)
	Population	Natural log of the country's total population in 2023.	World Bank World Development Indicators
	Urban population	Share of population living in urban areas as defined by national statistical offices.	World Bank World Development Indicators

Based on these controls, the countries we have determined as benchmarks to New Zealand for road infrastructure are listed in *Table 5* below. The cells are colour coded relative to the OECD average, with red indicating that the value is below the OECD average, and green indicating that it is above.

Table 5: New Zealand's benchmark countries for road infrastructure

Country	GDP per capita (2017 PPP USD)	Population density	Terrain ruggedness	Population (2023)	Urban population (% of total population)	Similarity score (RMSE)
Spain	42,003	97	1.69	48,373,336	82%	0.71
New Zealand	43,744	20	2.04	5,223,100	87%	
Czechia	44,176	141	0.88	10,873,689	75%	0.89
Canada	49,771	5	0.78	40,097,761	82%	0.77
OECD Average	50,706	141	1.36	36,447,517	77%	
Finland	51,965	18	0.33	5,584,264	86%	0.44
Sweden	57,466	26	0.72	10,536,632	89%	0.47
Iceland	63,217	4	1.47	393,600	94%	0.75
Norway	88,792	15	2.41	5,519,594	84%	0.17

Source: World Bank World Development Indicators, Nathan Nunn & Diego Puga (2012).

Our benchmark countries have, in general, very low population density and have very rugged terrain. They also generally have a smaller total population and a higher share of the population living in urban areas compared to the OECD average.

[2] Refer to Nathan Nunn & Diego Puga (2012) and https://diegopuga.org/data/rugged/ for more detail.

4.2. Road infrastructure variables

The following table outlines the measures we found for road infrastructure for each category of benchmarking.

Table 6: Variables for road infrastructure

			No. countries with data	
Category	Variable	Source	OECD	Benchmark
Investment	Road investment as a share of GDP[3]	OECD-ITF	36	8
	Road investment per km of road[4]	CIA World Factbook, OECD-ITF, UNECE	36	8
Quantity	Road km per 100 sq. km	CIA World Factbook, OECD-ITF, UNECE, World Bank World Development Indicators	36	8
	Road km per 100 people	CIA World Factbook, OECD-ITF, UNECE, World Bank World Development Indicators	36	8
Usage	Annual road freight tonne-km per capita	OECD-ITF, World Bank World Development Indicators	35	8
	Annual road passenger-kilometres travelled per capita	OECD-ITF, World Bank World Development Indicators	29	8
	Millions of freight tonne-km per km of road	CIA World Factbook, OECD-ITF, UNECE	35	8
	Millions of passenger-kilometres per km of road	CIA World Factbook, OECD-ITF, UNECE	26	7
Quality	Paved roads ratio	Bureau of Infrastructure and Transport Research Economics, NZTA, World Bank World Development Indicators	30	6
	Perceived quality of road infrastructure	World Economic Forum Executive Opinion Survey	38	8
	Road fatalities per 100 million passenger-kilometres travelled	OECD-ITF	29	8
	Road fatalities per 100,000 people	OECD-ITF, World Bank World Development Indicators	36	8
	Rural access index	Rural Access Index Measurement Tool, World Bank	38	8
	Adjusted mean speed score	International Monetary Fund	37	8
	Hours lost in traffic per year	INRIX	25	7

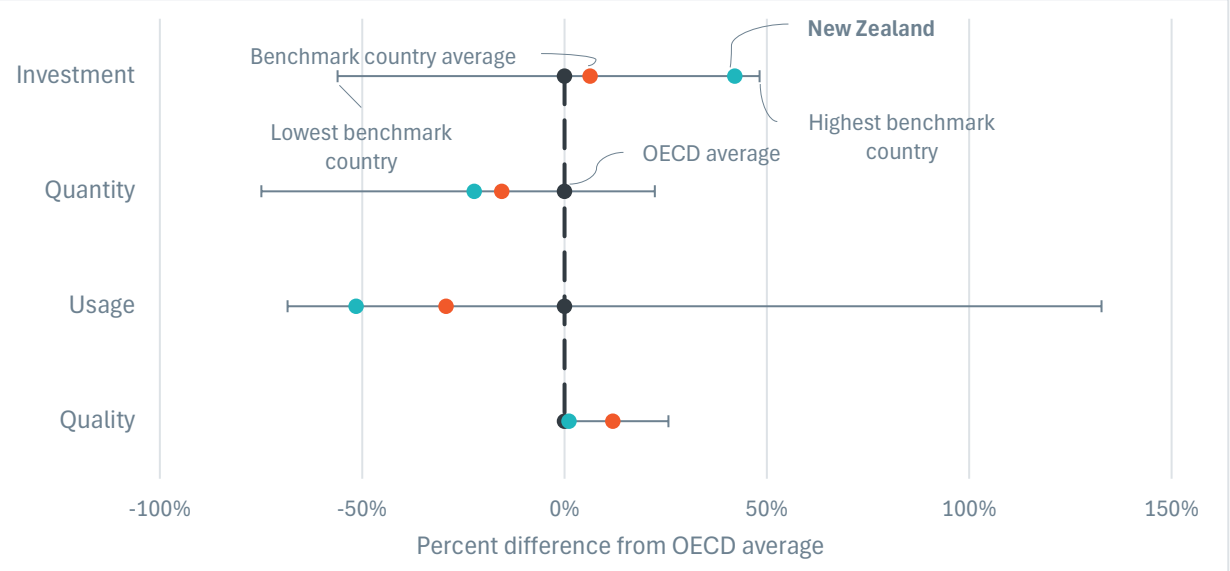
[3] For road investment the OECD collects both capital and non-capital expenditure on roads. We have combined the two to get more internationally comparable data as some countries appear to be classifying renewals as non-capital expenditure.
[4] Same as above.

International roughness index	Various sources including the Australian Department of Infrastructure, Dutch Rijkswaterstaat, Government and Municipalities of Quebec, Government of Alberta, NZTA, Transport Scotland, UK Office of Rail and Road, US Federal Highway Administration, Welsh Government	N/A	N/A
Road transport greenhouse emissions per capita	Emissions Database for Global Atmospheric Research Community Greenhouse gas Database, World Bank World Development Indicators	38	8

4.3. Road infrastructure benchmarking results

Figure 2 below shows the benchmarking results for road infrastructure. New Zealand's spending on roads is very high and our road usage is very low, even compared to our peers. The amount of roads we have and the overall quality of our roads is generally on par with comparator countries.

Figure 2: Benchmarking results for road infrastructure

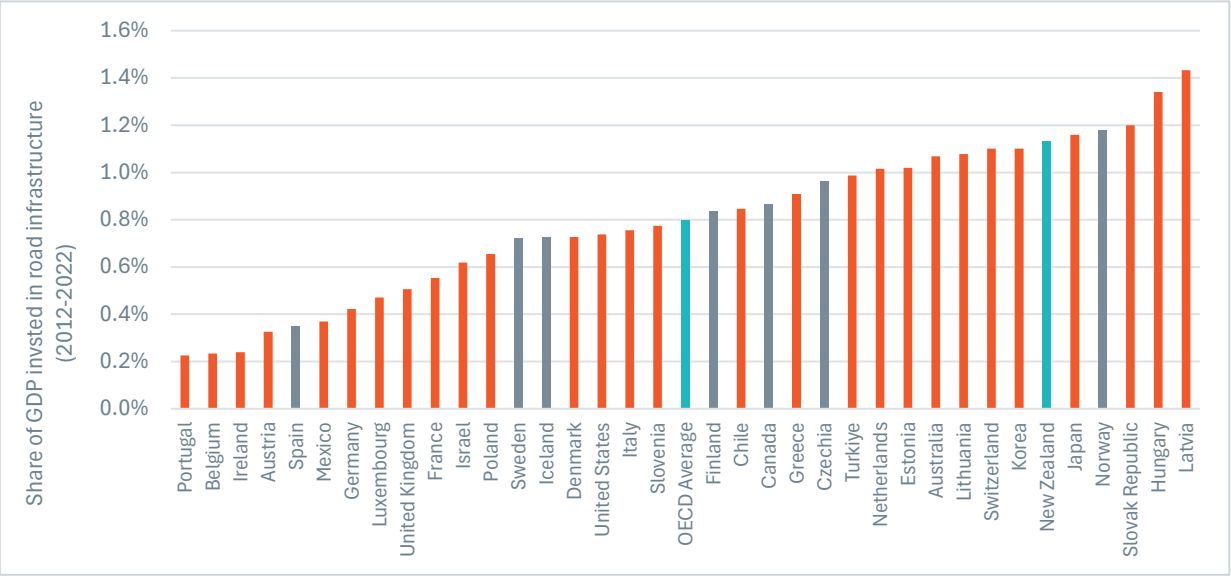


4.3.1. Road infrastructure investment

From 2012 to 2022, New Zealand invested an average of 1.13% of GDP per year on roads. The OECD average over this period is 0.80% per year. Investment in benchmark countries over this period averages 0.81% of GDP. New Zealand's investment in road infrastructure is higher than the OECD average and higher than most benchmark countries, as we see in *Figure 3* below.

New Zealand's investment in road infrastructure is amongst the highest in the OECD

Figure 3: Share of GDP invested in road infrastructure in OECD countries



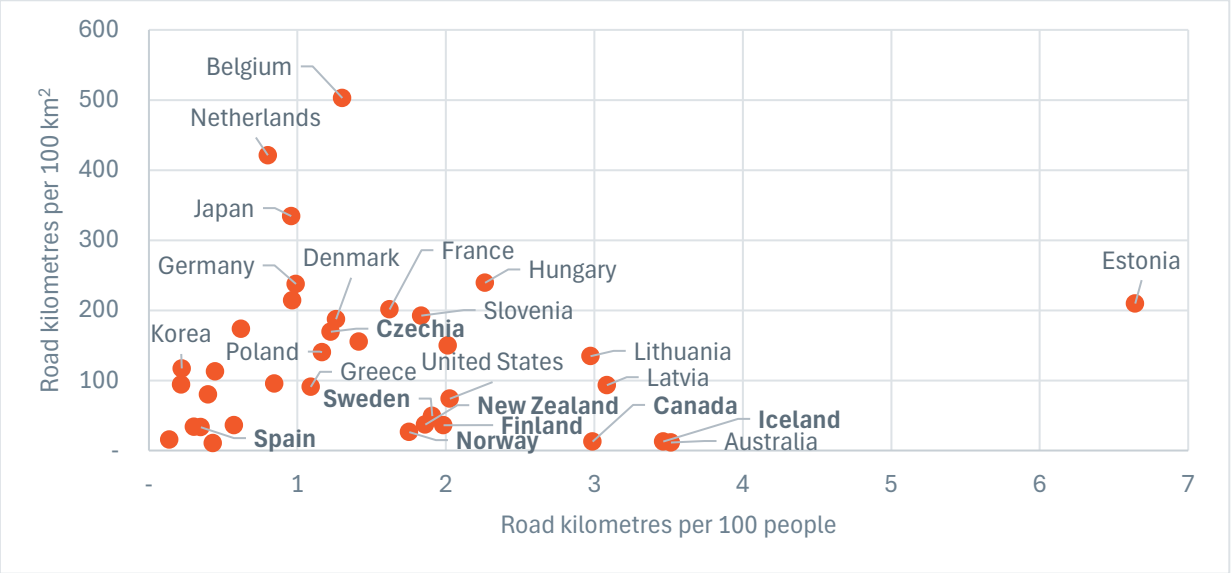
Source: OECD-ITF.

4.3.2. Road infrastructure quantity

New Zealand's quantity of roads is small compared to our land area but is slightly above average for the number of people we have. New Zealand has 1.8 kilometres of roads per 100 people and 37 kilometres of roads per 100 square kilometres of land area. However, this pattern is very similar to our benchmark countries, as shown in **Error! Reference source not found.** with our benchmark countries in bold.

New Zealand's length of roads on a per person and land area basis is similar to our benchmark countries

Figure 4: Road length on a per person and land area basis in OECD countries



Source: UNECE, OECD-ITF, CIA World Factbook, national transport bodies.

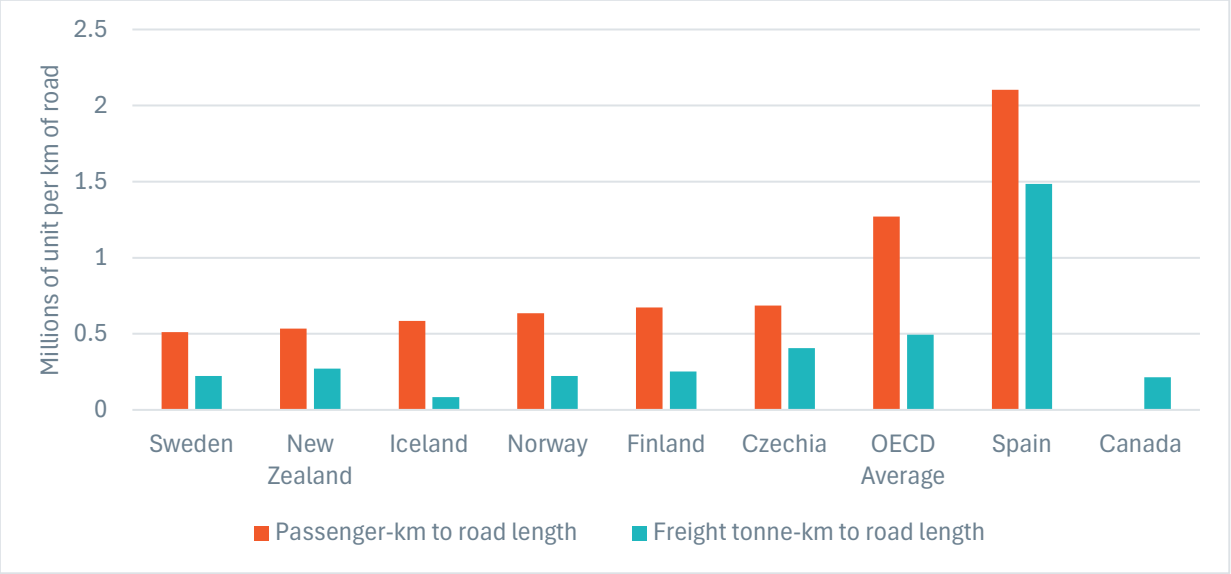
4.3.3. Road infrastructure usage

New Zealand's roads are sparsely used, overall, for both freight and passenger travel. On a per kilometre of road basis, passenger volumes in New Zealand are almost a third of the average OECD country, and freight volumes are about half.

However, this is also largely the case with our benchmark countries as shown in *Figure 5* below.

Road traffic density in New Zealand is very low, but similar to our benchmark countries

Figure 5: Road traffic density in New Zealand and benchmark countries



Source: UNECE, OECD-ITF, CIA World Factbook, national transport bodies.

4.3.4. Road infrastructure quality

Our assessment of the quality of New Zealand's road quality relied on a variety of different measures.

Table 7 below shows the quality indicators that we have collected for road infrastructure. New Zealand generally does not appear an outlier in any of these measures, except for road safety, where we have a high fatality rate.

Table 7: Road quality measures for New Zealand and benchmark countries

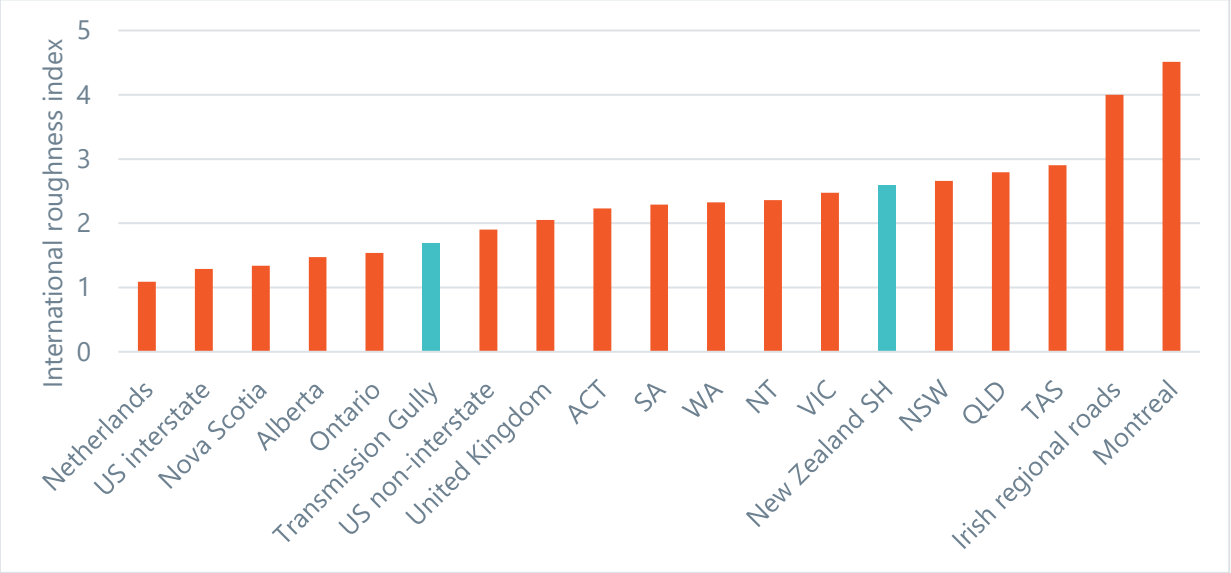
Country	Paved roads ratio	Perceived quality (1-7)	Fatalities per 100m passenger-km	Fatalities per 100,000 people	Rural access index	Adjusted mean speed score	Hours lost in traffic per year
New Zealand	67.7%	4.46	0.84	13.3	82.8%	95	48.4
OECD	72.0%	4.90	1.54	11.0	90.1%	99	54.6
Spain		5.70	1.78	10.6	89.7%	115	33.3
Czechia		3.91	1.43	10.2	99.7%	109	55.0
Canada	43.4%	5.03	0.59	10.4	81.9%	119	50.1
Finland	64.9%	5.26	0.71	8.1	86.7%	89	23.0
Sweden		5.32	0.51	6.0	91.0%	102	38.4
Iceland	45.8%	4.12	0.40	6.9	76.1%	97	
Norway	84.7%	4.55	0.54	5.9	77.6%	88	31.3

Paved roads ratio: the share of roads paved, source: BITRE, NZTA, World Bank World Development Indicators; perceived quality: survey question about the quality of road infrastructure, source: WEF Executive Opinion Survey; fatalities per 100m passenger-km: the amount of people dying in road crashes per 100 million passenger-kilometres, source: OECD-ITF; fatalities per 100,000 people: the amount of people dying in road crashed divided by total population, source: OECD-ITF, World Bank World Development Indicators; rural access index: the share of the rural population living within 2 kilometres of an all-season road, source: Rural Access Index Measurement Tool, World Bank; adjusted mean speed score: a measure of how quickly you can travel on a country's roads, adjusted for geography, source: IMF; hours lost in traffic per year: hours per person lost in congestion in peak commute times compared to off-peak, source: INRIX.

We also attempted to gather information about the conditions of our roads. *Figure 6* below shows the international roughness index for countries, cities, and areas that we could find data for. The International Roughness Index is the accumulated suspension displacement of a vehicle as it travels over a road surface, calculated using a quarter-car mathematical model of a vehicle's suspension. A higher index means a vehicles suspension is moving more, which would indicate a rougher road. Therefore, lower is better for the international roughness index.

New Zealand's roads are about as rough as Australian roads, and better than Ireland's

Figure 6: International roughness index for various countries, cities, and territories



Source: various sources including the Australian Department of Infrastructure, NZTA, Government and Municipalities of Quebec, Government of Alberta, UK Office of Rail and Road, Transport Scotland, Welsh Government, Dutch Rijkswaterstaat, US Federal Highway Administration.

New Zealand's state highways seem to have similar roughness scores to highways in Australia. Roads in the Netherlands have the lowest reported IRI at only 1.09, whereas Irish regional roads and Montreal have the highest at 4 and 4.51 respectively. The IRI data is of poor quality, however. There are sample selection issues within each data point and potentially comparability issues. Australia and New Zealand measure road roughness in NAASRA which must be then converted into IRI.

5. Rail infrastructure

5.1. Rail infrastructure controls

Table 8 below outlines the controls that we use to determine benchmark countries for rail infrastructure.

Table 8: Controls for rail infrastructure

Sector name	Control variables	Definition	Source
Rail	Coast to area ratio	Metres of coastline length derived from World Vector Shoreline at 1:250,000 scale divided by square kilometres of land area.	World Resources Institute
	Terrain ruggedness	Average of Terrain Ruggedness Index for area of the country.	Nathan Nunn & Diego Puga (2012)
	Log(population)	Natural log of the country's total population in 2023.	World Bank World Development Indicators
	Urban population	Share of population living in urban areas as defined by national statistical offices.	World Bank World Development Indicators
	Coal production	Kilograms of coal production per capita.	United States Energy Information Administration
	Usable iron ore production	Kilograms of usable iron ore production per capita.	United States Geological Survey
	Primary cereals production	Kilograms of primary cereals production per capita.	Food and Agricultural Organisation of the United Nations

We used standard controls for population, density, and terrain. However, we also added some unique controls for rail.

The coast to area ratio shows how many metres of coastline correspond to every square kilometre of land area. A high ratio indicates that is easy to access the coast of a country from every point in its interior. This is important because rail is just one option by which freight can be moved around a country. A country with easy access to its coastline may find it more economically feasible to move its freight by road to a close port and then use ships.

Lastly, we consider that rail is most suitable for transporting heavy, bulky goods from a single point to a single point, whereas road transport is more suitable for transporting goods that involve many points. Goods such as coal, iron ore, and cereals fit this definition, so we consider countries that produce these items extensively to have more developed rail networks.

Based on these controls, the countries we have determined as benchmarks to New Zealand for rail infrastructure are listed in Table 9 below. The cells are colour coded relative to the OECD average, with red indicating that the value is below the OECD average, and green indicating that it is above.

Table 9: New Zealand's benchmark countries for rail infrastructure

Country	GDP per capita (2017 PPP USD)	Coast / area ratio	Terrain ruggedness	Population (2023)	Urban population	Coal production	Usable iron ore	Cereals, primary	Similarity score (RMSE)
Chile	27,110	106.0	2.48	19,629,590	88%	6	899	127	0.47
Greece	33,597	116.0	3.10	10,361,295	81%	1010	92	329	0.66
Japan	40,280	79.6	2.13	124,516,650	92%	5	0	92	0.63
Spain	42,003	14.6	1.69	48,373,336	82%	0	0	247	0.71
New Zealand	43,744	65.1	2.04	5,223,100	87%	498	758	184	
OECD Average	50,706	42.1	1.36	36,447,517	79%	815	1122	571	
Finland	51,965	102.0	0.33	5,584,264	86%	0	0	538	0.57
Sweden	57,466	64.3	0.72	10,536,632	89%	0	2669	411	0.43
Iceland	63,217	84.8	1.47	393,600	94%	0	0	20	0.70
Norway	88,792	175.0	2.41	5,519,594	84%	22	297	142	0.63

Source: World Bank World Development Indicators, Nathan Nunn & Diego Puga (2012), FAOSTAT, USGS.

New Zealand's rail benchmark countries generally have a long coastline, are very rugged, small, urbanised, and produce a reasonable amount of bulk goods for their population.

5.2. Rail infrastructure variables

The following table identifies the measures we found for each category of benchmarking.

Table 10: Variables for rail infrastructure

			No. countries with data	
Category	Variable	Source	OECD	Benchmark
Investment	Rail investment as a share of GDP[5]	OECD-ITF	34	8
Quantity	Rail length per 100,000 people	OECD-ITF	33	8
	Rail length per 100 square kilometres	OECD-ITF, World Bank World Development Indicators	33	8
	Share of track electrified	OECD-ITF	26	5
Use	Annual rail goods tonne-kilometres per capita	OECD-ITF, World Bank World Development Indicators	35	8
	Annual rail passenger-kilometres per capita	OECD-ITF, World Bank World Development Indicators	35	8
	Millions of annual rail goods tonne-kilometres per kilometre of track	OECD-ITF	32	8
	Millions of annual rail passenger-kilometres per kilometre of track	OECD-ITF	33	8

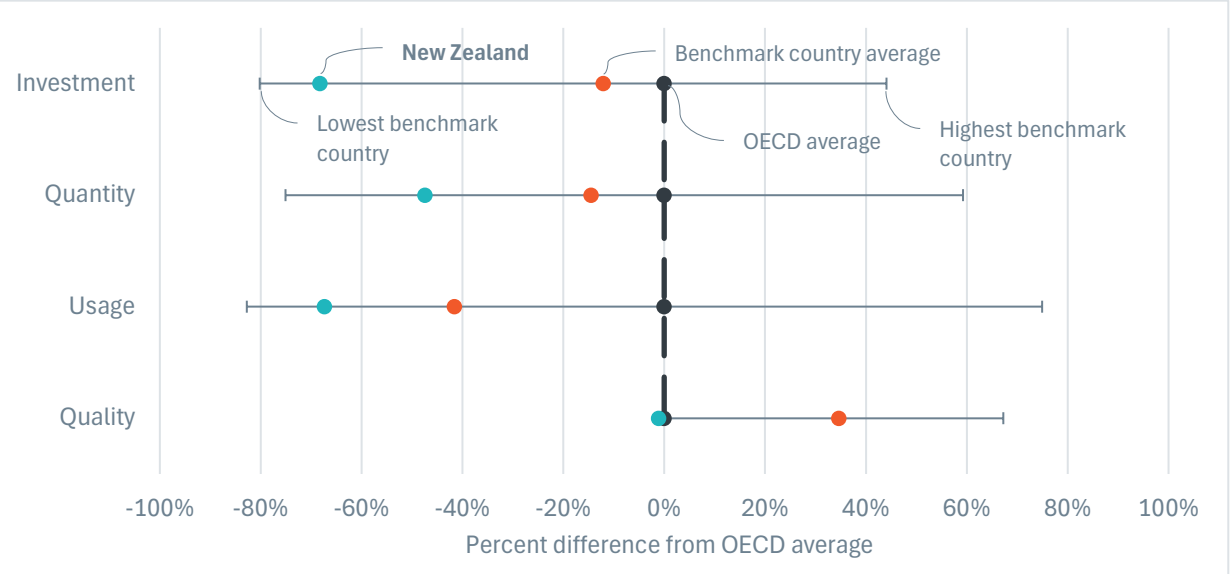
[5] For rail investment the OECD collects both capital and non-capital expenditure on roads. We have combined the two for to get more internationally comparable data as some countries appear to be classifying renewals as non-capital expenditure.

Quality	Railway greenhouse gas emissions per capita	Emissions Database for Global Atmospheric Research Community Greenhouse gas Database, World Bank Development Indicators	37	9
	Perceived efficiency of train services	World Economic Forum Executive Opinion Survey	38	9

5.3. Rail infrastructure results

Figure 7 below shows the benchmarking results for rail infrastructure. New Zealand's investment in rail infrastructure is well below the OECD average and well below the benchmark country average. New Zealand's quantity and use of its rail infrastructure is also well below the OECD average and benchmark countries. The quality of New Zealand's rail infrastructure is around the OECD average, but worst amongst benchmark countries.

Figure 7: Benchmark results for rail infrastructure



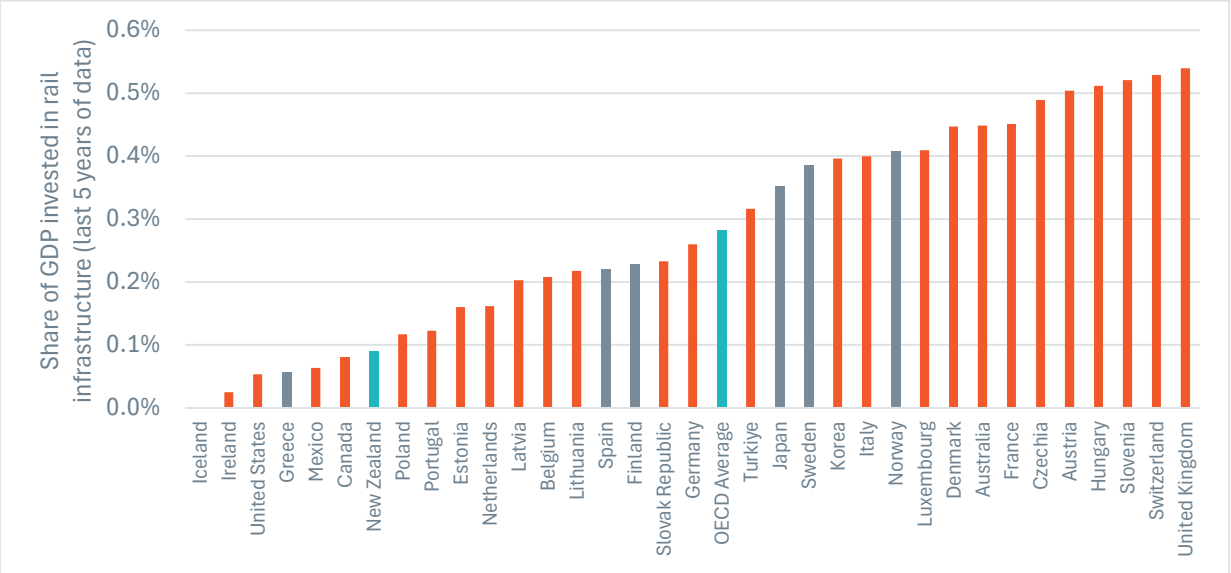
We performed our benchmarking on the rail network as a whole, rather than subsets of the rail network (freight versus metro versus passenger rail). This was largely due to the availability of data. An option for future work is to explore public transport benchmarking, which would delineate metro rail from overall rail services.

5.3.1. Rail infrastructure investment

New Zealand's investment in rail infrastructure is very low. Between 2018 and 2022, New Zealand invested only 0.09% of GDP per year on rail infrastructure. This is well below the OECD average of 0.28% per year. It is also well below all benchmark countries apart from Greece and Iceland, who maintain a very small and no rail network respectively (Figure 8).

New Zealand's investment in rail infrastructure is amongst the lowest in the OECD

Figure 8: Share of GDP invested in rail infrastructure in OECD countries



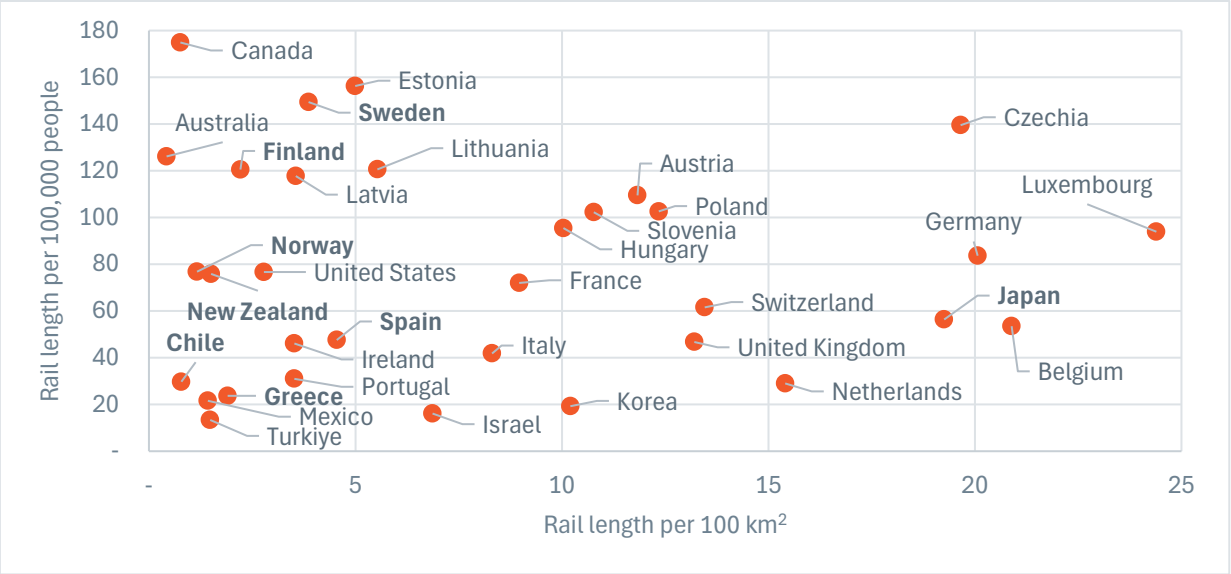
Source: OECD-ITF.

5.3.2. Rail infrastructure quantity

New Zealand's rail network is small, but not necessarily much smaller than its benchmark countries, on a per capita and per kilometre of track basis. Our benchmark countries have a range of rail infrastructure quantity, ranging from a lot to a little, but our rail network is roughly the same as Norway (*Figure 9*).

New Zealand has a relatively normal amount of rail infrastructure quantity compared to benchmark countries

Figure 9: Rail length on a per person and land area basis in OECD countries



Source: OECD-ITF, World Bank World Development Indicators.

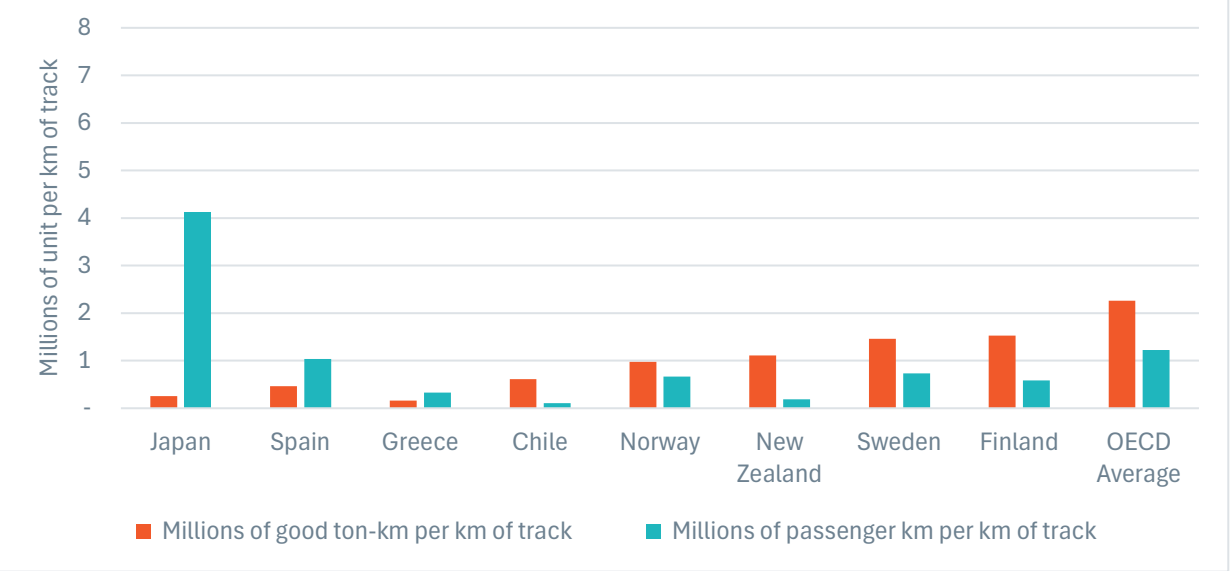
Electrification of rail networks appears to be a goal of most OECD countries and our benchmark countries. However, only 20% of New Zealand's railway tracks are electrified, below the OECD average of 55% and below benchmark countries. Benchmark countries range from Greece at 53% to Sweden at 78%.

5.3.3. Rail infrastructure usage

New Zealand's rail network is characterised by very low levels of usage, particularly by passengers. This statement is true on a per capita or per-kilometre of track basis (Figure 10).

New Zealand has low freight usage on its rail network, and very low passenger usage

Figure 10: Rail traffic density in New Zealand and benchmark countries



Source: OECD-ITF, Japanese Trains, BITRE.

New Zealand moves 1.11 million good tonne-kilometres per kilometre of rail track and only 0.19 million passenger-kilometres per kilometre of rail track. This is well below the OECD averages of 2.26 million and 1.22 million respectively. New Zealand's passenger usage is especially low. New Zealand has the same amount of rail infrastructure as Norway, and uses it a similar amount for goods transport, but New Zealand uses it far less for passengers.

5.3.4. Rail infrastructure quality

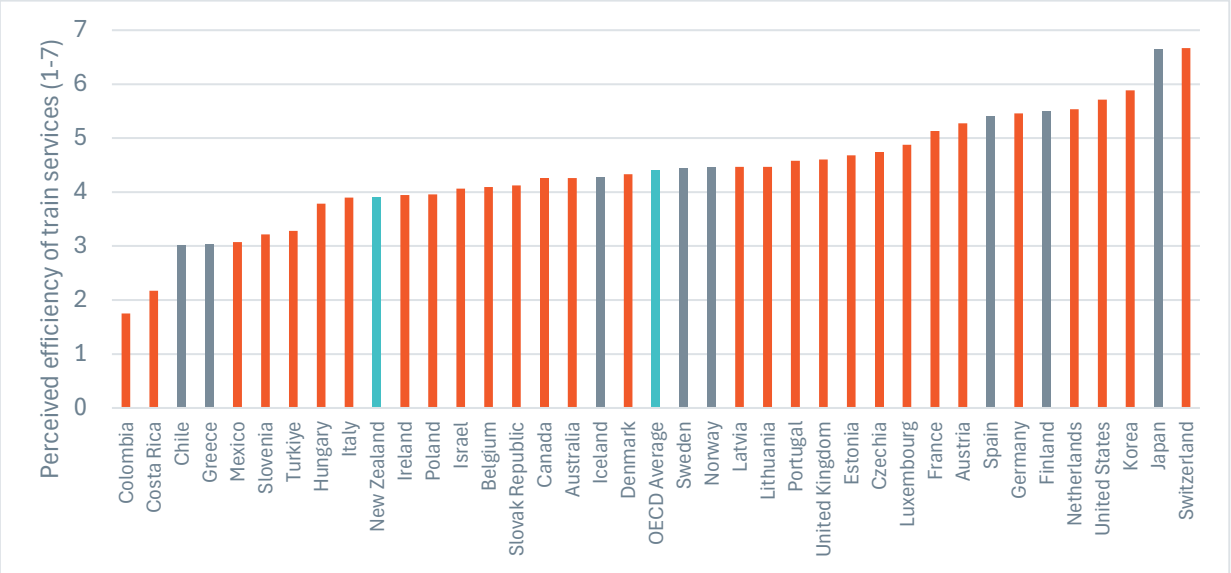
Standardised measures of rail quality were difficult to find. What we did find, however, indicates a network of below average quality compared to our peers.

New Zealand's railways emit 5.1 grams of greenhouse gases per tonne-kilometre and passenger-kilometre (total) above the OECD average of 3.0 grams per person. This is despite New Zealand's per capita usage being very low.

The perceived efficiency of New Zealand's trail services is low, rated at 3.9 out of 7, compared to the OECD average of 4.4. This is shown in Figure 11 below.

The perceived efficiency of New Zealand's train services is amongst the lowest in the OECD

Figure 11: Perceived efficiency of train services in OECD countries



Source: WEF Executive Opinion Survey.

6. Electricity generation and transmission / distribution infrastructure

6.1. Electricity infrastructure controls

Table 11 outlines the controls we use to determine benchmark countries for electricity infrastructure.

Table 11: Controls for electricity infrastructure

Sector name	Control variables	Definition	Source
Electricity generation and distribution / transmission	Population density	Total population divided by the land area of the country, people per km^2.	World Bank World Development Indicators
	Terrain ruggedness	Average of Terrain Ruggedness Index for area of the country.	Nathan Nunn & Diego Puga (2012)
	Log(population)	Natural log of the country's total population in 2023.	World Bank World Development Indicators
	Urban population	Share of population living in urban areas as defined by national statistical offices.	World Bank World Development Indicators
	Electricity trade balance per 1,000 people	The amount of electricity that has left a country's political borders minus the amount of electricity that has entered, measured in kilowatt-hours per 1,000 people.	International Energy Agency
	Manufacturing gross value added as a share of GDP	The value of goods and services produced by manufacturing, after deducting the costs of intermediate consumption, as a share of GDP.	United Nations Statistics Division
	Composition of electricity generation sources	The share of a country's electricity production that comes from different sources.	International Energy Agency

We used standard controls for population, density, and terrain. However, we also added some unique controls for electricity.

The first is electricity trade balance per capita. This measure indicates how much electricity a country is exporting or importing. New Zealand's electricity network is not connected to any other countries and is therefore not able to export or import any electricity. Countries that can export and import electricity may build more generation if they plan to export their power, or less if they plan to import.

We also added the gross value added from manufacturing as a share of GDP. This measures how significant manufacturing is to a country's economy. Manufacturing can be energy intensive. Countries with access to a source of cheap electricity may therefore have a large manufacturing industry, or conversely, countries with significant manufacturing may require significant electricity capacity.

Finally, we consider the composition of electricity generation sources. New Zealand's electricity mostly comes from hydro and geothermal.

Based on these controls, the countries we have determined as benchmarks to New Zealand for electricity infrastructure are listed in *Table 12* below. The cells are colour coded relative to the OECD average, with red indicating that the value is below the OECD average, and green indicating that it is above.

Table 12: New Zealand's benchmark countries for electricity infrastructure

Country	GDP per capita (2017 PPP USD)	Population density	Terrain ruggedness	Population	Urban population (% of total population)	Electricity trade balance per 1,000 people	GVA manufacturing (% GDP)	Similarity score (RMSE)
Colombia	18,038	46.9	0.89	52,085,168	82.4%	-1.2	11.2%	0.60
Costa Rica	21,986	102.1	2.11	5,212,173	82.6%	157.2	14.1%	0.33
Chile	27,110	26.4	2.48	19,629,590	88.0%	0.0	9.5%	0.26
New Zealand	43,744	19.8	2.04	5,223,100	87.0%	0.0	8.8%	
Canada	49,771	4.6	0.78	40,097,761	81.9%	1,202.7	9.0%	0.65
OECD Average	50,706	141.4	1.36	36,447,517	79.2%	-336.2	14.7%	
Finland	51,965	18.4	0.33	5,584,264	85.8%	-2,427.2	15.6%	0.71
Sweden	57,466	25.9	0.72	10,536,632	88.7%	2,663.4	13.5%	0.70
Iceland	63,217	3.9	1.47	393,600	94.0%	0.0	10.1%	0.54
Norway	88,792	15.2	2.41	5,519,594	84.0%	2,511.6	4.9%	0.47

Source: World Bank World Development Indicators, Nathan Nunn & Diego Puga (2012), International Energy Administration.

New Zealand's benchmark countries for electricity infrastructure are generally sparsely populated, very rugged, have a small but urbanised population, and manufacturing makes up smaller than average share of their economies.

6.2. Electricity infrastructure variables

The following table identifies the measures we found for each category of benchmarking.

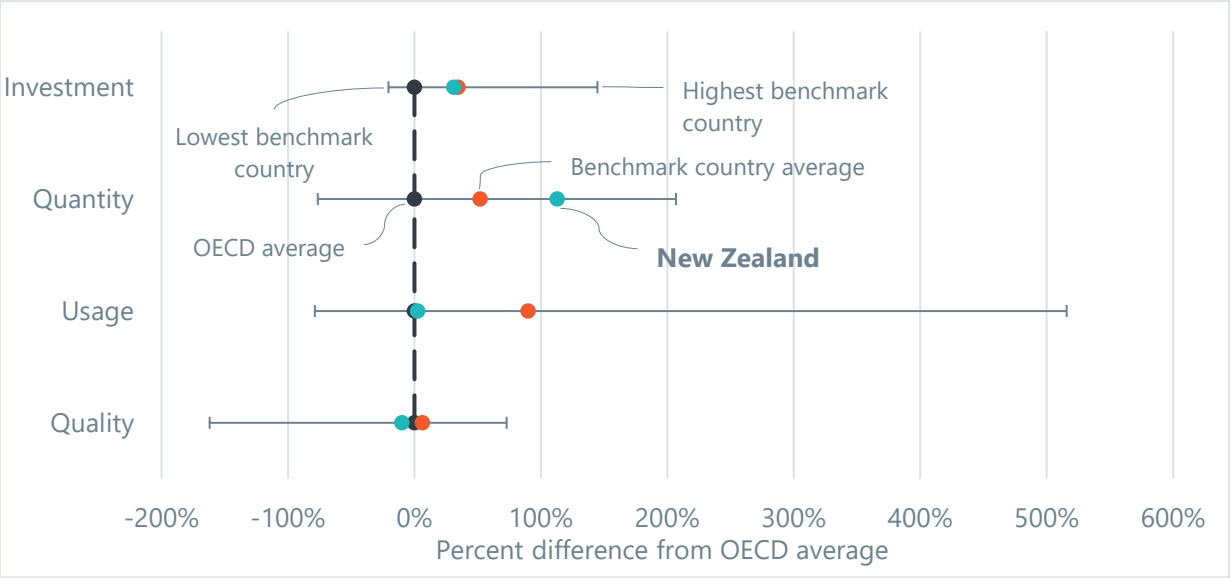
Table 13: Variables for electricity infrastructure

			No. countries with data	
Category	Variable	Source	OECD	Benchmark
Investment	Electricity and gas gross fixed capital formation as a share of GDP	Stats NZ, United Nations Statistics Division	32	8
Quantity	Distribution circuit-kilometres per capita	Kalt, G., Thunshirn, P., & Haberl, H. (2021)	38	9
	Transmission circuit-kilometres per capita	Kalt, G., Thunshirn, P., & Haberl, H. (2021)	38	9
	Electricity installed capacity	US Energy Information Administration, World Bank World Development Indicators	38	9
Usage	Net electricity production per capita	International Energy Agency	37	9
Quality	Share of produced electricity lost in distribution	International Energy Agency	37	9
	System average interruption frequency index	World Bank Doing Business, New Zealand Commerce Commission	36	8
	System average interruption duration index	World Bank Doing Business, New Zealand Commerce Commission	36	8
	Grams of greenhouse gas emissions per kWh of electricity production	International Energy Agency	37	9

6.3. Electricity infrastructure results

Figure 12 below shows the benchmark results for electricity infrastructure. Generally, New Zealand's electricity networks do not stand out relative to peer countries. The only exception is around the amount of transmission infrastructure. We also do appear to have a relatively high frequency and length of electricity outages, which are counterbalanced by quality measures indicating low emissions in electricity production.

Figure 12: Benchmark results for electricity infrastructure

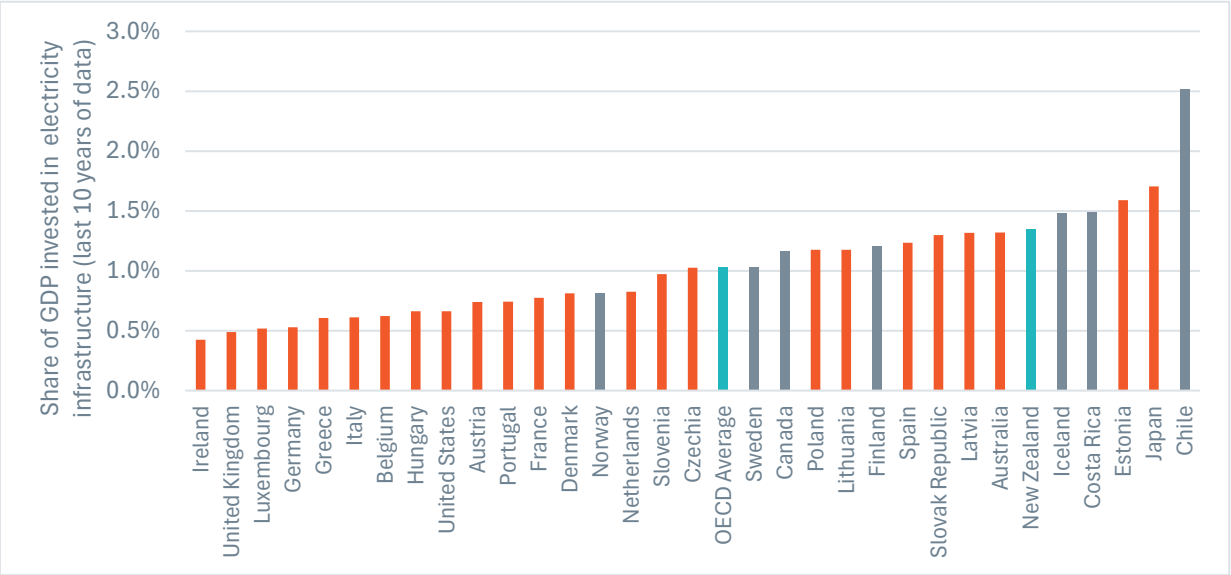


6.3.1. Electricity infrastructure investment

Capital investment on electricity and gas infrastructure is high in New Zealand relative to the average OECD country, although in line with our benchmark countries. *Figure 13* below shows investment in electricity infrastructure in OECD countries. Over the past 10 years of data, New Zealand invested 1.35% of GDP. This is above the OECD average of 1.03%, but close to the benchmark country average of 1.38%.

New Zealand's investment in electricity infrastructure is above the OECD average, but similar to our benchmark countries

Figure 13: Share of GDP invested in electricity infrastructure in OECD countries



Source: UNSD, Stats NZ, 'electricity, gas, steam and air conditioning supply' gross fixed capital formation.

6.3.2. Electricity infrastructure quantity

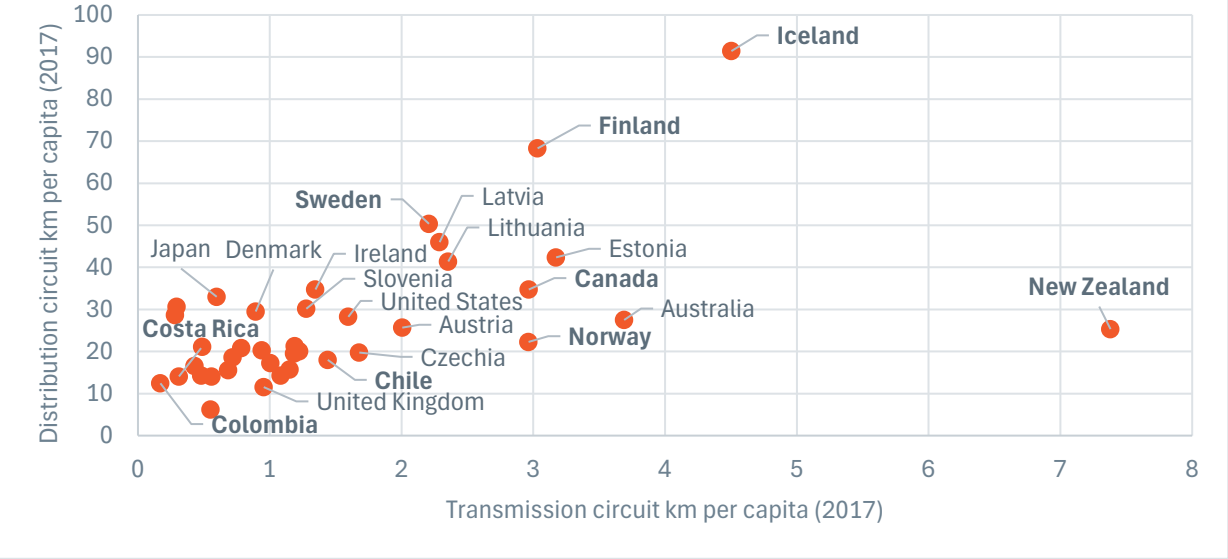
Within electricity networks, transmission networks carry electricity from where it is generated over long distances at high voltage. Distribution networks are those that take this electricity and connect homes and businesses and are at lower voltage levels.

New Zealand's electricity network is characterised by a very large transmission network, but an average distribution network. This means that where we generate electricity is very far from where we use it. But within the areas where we use it, the length of wires is relatively normal.

Figure 14 below shows the amount of electricity transmission and distribution infrastructure per capita.

New Zealand has a vast transmission network, but a normal size distribution network

Figure 14: Distribution circuit kilometres and transmission circuit kilometres per capita in OECD countries



Source: Kalt, G., Thunshirn, P., & Haberl, H. (2021), World Bank World Development Indicators.

We also considered the stock that generates electricity, as measured by installed generation capacity. In this measure New Zealand is slightly below the OECD average and below our benchmark countries. New Zealand has 2.03 kilowatts per person of installed electricity generation capacity, compared to the OECD average of 2.67 kilowatts. New Zealand is below its benchmark countries who average 3.75 kilowatts per person of installed electricity generation capacity. This is because New Zealand cannot export electricity and does not have much energy intensive industry.

6.3.3. Electricity infrastructure usage

In 2023 New Zealand consumed 7,801 kilowatt hours of electricity per person for use. This is slightly above the OECD average of 7,778 kilowatt hours per person, but well below our benchmark countries who average 14,390 kilowatt hours per person. This is largely because these other countries export power.

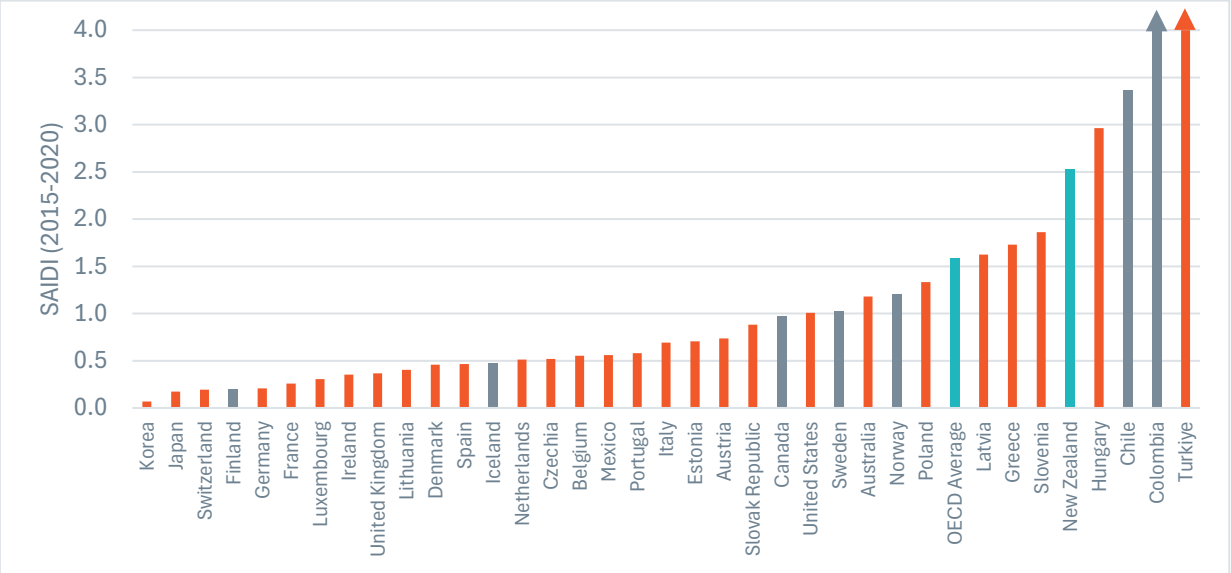
Iceland, another benchmark country, is not connected to any other country's electricity grid (like New Zealand) but instead has a very large aluminium smelting industry for its population. Aluminium smelting is highly energy intensive, so this explains the high consumption statistics we observe.

6.3.4. Electricity infrastructure quality

Figure 15 below shows the system average interruption duration index (SAIDI) for each country from 2015 to 2020. SAIDI shows the average total duration in hours of power outages over the course of a year for each customer served.

New Zealand electricity consumers experience higher-than-average length of electricity outages

Figure 15: System average interruption index (SAIDI) for OECD countries



Source: World Bank Doing Business (collected from distribution utility companies and national regulators).

New Zealand's SAIDI of 2.53 means that the average customer experiences two and a half hours of power outages each year. This is well above the OECD average of 1.59 and above the benchmark country average of 1.95 hours.

Similarly, the system average interruption frequency index (SAIFI) shows the average number of electricity interruptions experienced over the course of a year by each customer. Here New Zealand performs worse than average as well. The average customer in New Zealand experiences 1.57 electricity outages a year, above the OECD average of 1.13 but close to the benchmark country average of 1.63.

Other measures of quality offset poor performance in the SAIDI and SAIFI:

- Electricity lost in transport and distribution, where New Zealand's loss rate of 7% is about average for the OECD and benchmark countries.
- Carbon intensity, for which New Zealand performs well due to its high reliance on renewable energy sources.

7. Water infrastructure

7.1. Water infrastructure controls

Table 14 below outlines the controls that we use to determine benchmark countries for water infrastructure.

Table 14: Controls for water infrastructure

Sector name	Control variables	Definition	Source
Water	Population density	Total population divided by the land area of the country, people per km^2.	World Bank World Development Indicators
	Terrain ruggedness	Average of Terrain Ruggedness Index for area of the country.	Nathan Nunn & Diego Puga (2012)
	Log(population)	Natural log of the country's total population in 2023.	World Bank World Development Indicators
	Urban population	Share of population living in urban areas as defined by national statistical offices.	World Bank World Development Indicators

We used standard controls for population, density, and terrain. We explored other potential controls related to standards but were unable to locate a database on the various standards used for drinking and wastewater across countries and jurisdictions.

Based on these controls, the countries we have determined as benchmarks to New Zealand for water infrastructure are listed in *Table 15* below. The cells are colour coded relative to the OECD average, with red indicating that the value is below the OECD average, and green indicating that it is above.

Table 15: New Zealand's benchmark countries for water infrastructure

Country	GDP per capita (2017 PPP USD)	Population density	Terrain ruggedness	Population (2023)	Urban population	Similarity score (RMSE)
Chile	27,110	26.4	2.48	19,629,590	88.0%	0.49
Greece	33,597	80.4	3.10	10,361,295	80.7%	0.65
Spain	42,003	96.8	1.69	48,373,336	81.6%	0.84
New Zealand	43,744	19.8	2.04	5,223,100	87.0%	
Czechia	44,176	140.9	0.88	10,873,689	74.6%	0.92
Canada	49,771	4.6	0.78	40,097,761	81.9%	0.93
OECD Average	50,706	141.4	1.36	36,447,517	79.2%	
Finland	51,965	18.4	0.33	5,584,264	85.8%	0.79
Sweden	57,466	25.9	0.72	10,536,632	88.7%	0.66
Iceland	63,217	3.9	1.47	393,600	94.0%	0.96
Norway	88,792	15.2	2.41	5,519,594	84.0%	0.22

Source: World Bank World Bank Development Indicators, Nathan Nunn & Diego Puga (2012).

In general, New Zealand's benchmark countries for water infrastructure are sparsely populated, rugged, with a small but urbanised population.

7.2. Water infrastructure variables

The following table identifies the measures we found for each category of benchmarking.

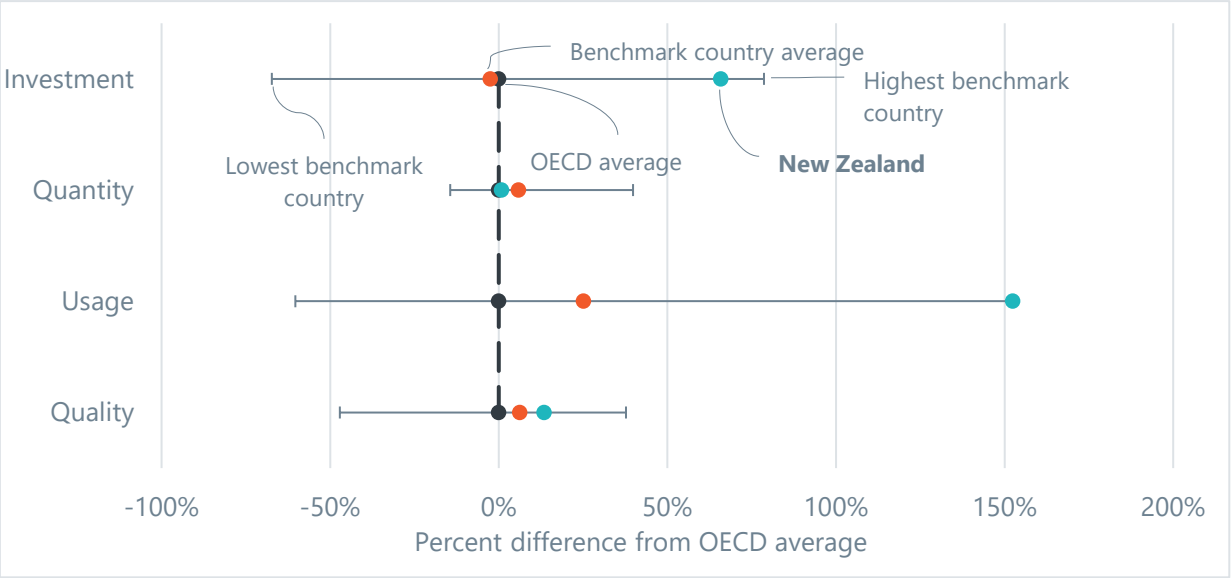
Table 16: Variables for water infrastructure

			No. countries with data	
Category	Variable	Source	OECD	Benchmark
Investment	Water supply; sewerage, waste management and remediation activities gross fixed capital formation as a share of GDP	Eurostat, Statistics Canada, Stats NZ, United Nations Statistics Division	30	9
Quantity	Drinking water network kilometres per 1,000 people	European Federation of National Associations of Water Services, Statistics Canada, Water New Zealand	23	8
	Wastewater network kilometres per 1,000 people	European Federation of National Associations of Water Services, Statistics Canada, Water New Zealand	22	8
	Share of population connected to public water supply	Eurostat, Water New Zealand	23	7
	Share of population connected to public sewerage	Eurostat, Water New Zealand	38	10
Use	Gross freshwater abstractions m^3 per capita	OECD	36	9
	Public water supply m^3 per capita	OECD	38	10
Quality	Perceived reliability of water supply	World Economic Forum Executive Opinion Survey	38	10
	Mortality rate attributed to exposure unsafe water, sanitation and hygiene (WASH) services	World Health Organisation	38	10
	Rate of non-revenue water	European Federation of National Associations of Water Services, Taumata Arowai	21	7

7.3. Water infrastructure results

Figure 16 below shows the benchmarking results for water infrastructure. New Zealand's investment in water infrastructure is well above the OECD average and well above benchmark countries. This is despite New Zealand having a similar quantity of water infrastructure to the OECD average and the benchmark country average. New Zealand's water usage is amongst the highest in the OECD and the highest amongst benchmark countries. The quality of New Zealand's water infrastructure is slightly above the OECD average and slightly above the benchmark country average.

Figure 16: Benchmarking results for water infrastructure



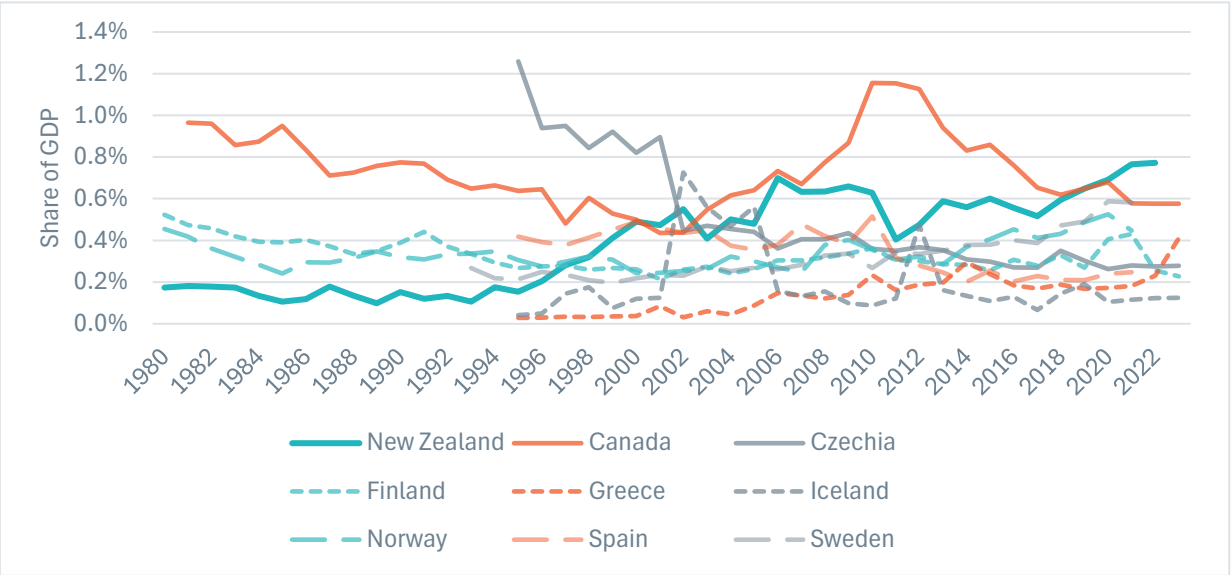
7.3.1. Water infrastructure investment

New Zealand's capital investment in water infrastructure is one of the highest in the world, after a period of very low spending.

Figure 17 below shows gross fixed capital formation in water fixed assets as a share of GDP between 1980 and 2023. Over the last ten years, only Canada and Israel have invested more in water infrastructure than New Zealand.

New Zealand's investment in water infrastructure is amongst the highest in the world over the past 20 years

Figure 17: Share of GDP invested in water infrastructure over time in New Zealand and benchmark countries



Source: UNSD, Stats NZ, Eurostat, Statistics Canada, 'water supply, sewerage and drainage services' gross fixed capital formation.

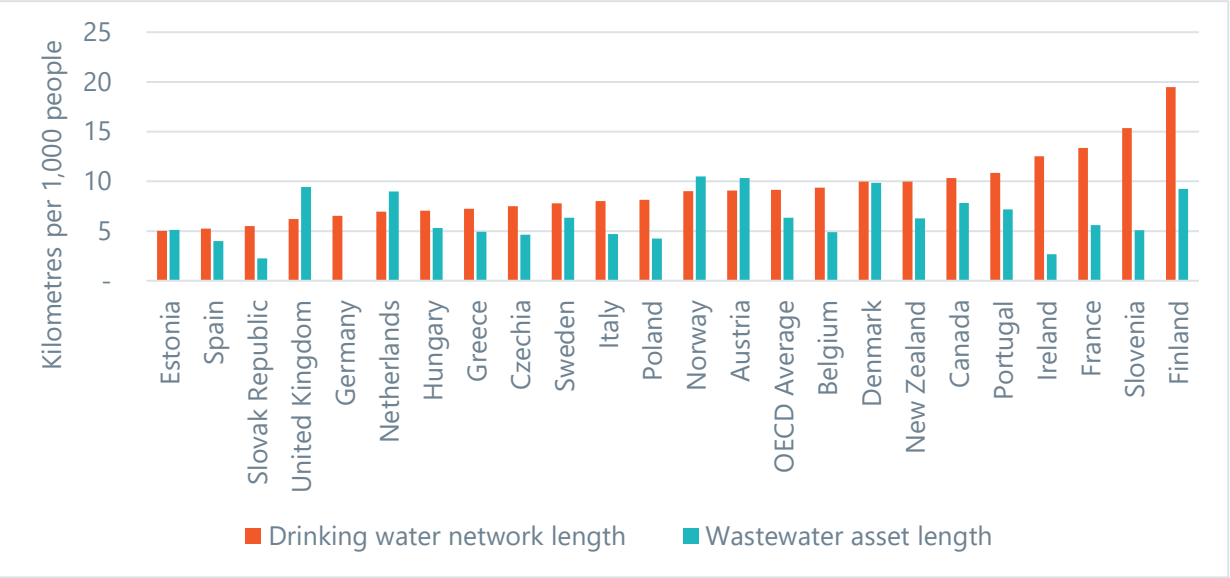
7.3.2. Water infrastructure quantity

New Zealand's quantity of water infrastructure is characterised by average network length on a per capita basis, but a relatively low share of the population connected to public water supplies.

New Zealand has an average drinking water network length and an average sewer network length for its population. We have about 10.0 kilometres of drinking water pipes and 6.3 kilometres of wastewater network per 1,000. Both are about the in the middle of OECD countries and our benchmark countries.

New Zealand has an average amount of drinking water and wastewater network for its population

Figure 18: Drinking water network and wastewater network length per capita in OECD countries



Source: European Federation of National Associations of Water Services, Water New Zealand, Statistics Canada, World Bank World Development Indicators.

However, a relatively low share of New Zealand's population is connected to public water supplies and sewerage. Only 88.0% of New Zealand's population is connected to the public water supply, below the OECD average of 93.8%, and lower than our benchmark countries. 85.8% of New Zealand's population is connected to public wastewater treatment, close to the OECD average of 84.7%, but towards the lower end of our benchmark countries.

7.3.3. Water infrastructure use

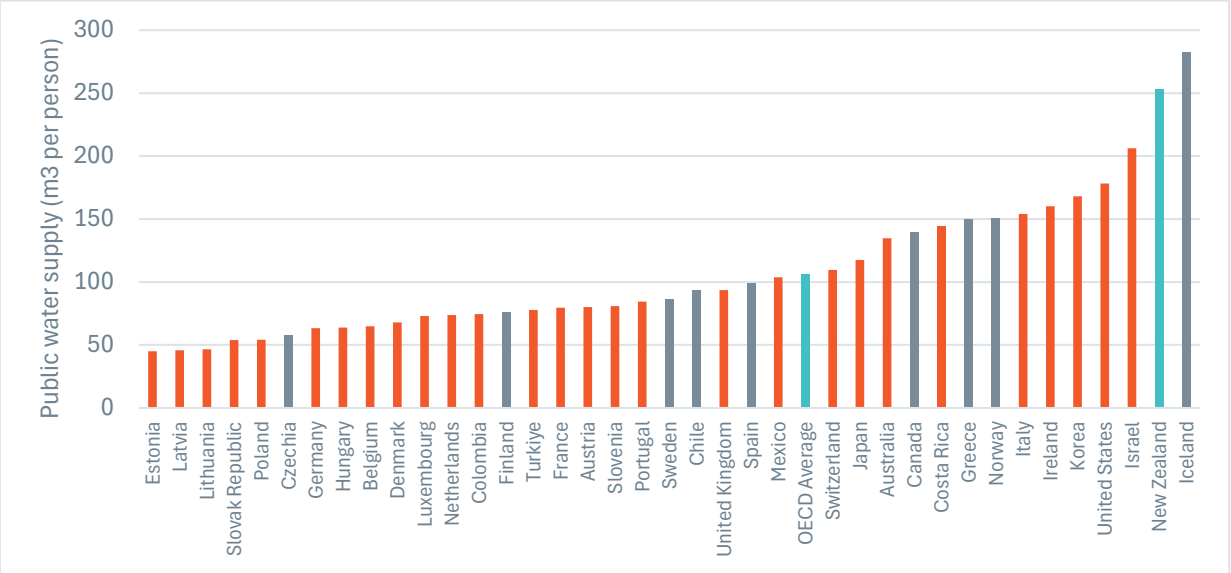
New Zealand's water usage is high, even when accounting for irrigation needs.

Total gross freshwater abstractions in New Zealand equals 1,518 m^3 per person per year, well above the OECD average of 542 m^3. This is also well above all benchmark countries, who average 705 m^3 per person per year.

Freshwater abstractions show the total amount of water used, including irrigation. **Error! Reference source not found.** below shows cubic metres of public water supply, which excludes irrigation, use per person per year.

New Zealand's public water usage is amongst the highest in the world

Figure 19: Public water supply use per capita in OECD countries



Source: OECD, World Bank World Development Indicators.

New Zealand uses 253 m^3 per person per year, also well above the OECD average of 106 m^3. Only one country, Iceland, who is also a benchmark country, uses more for public water supply at 282m^3 per person.

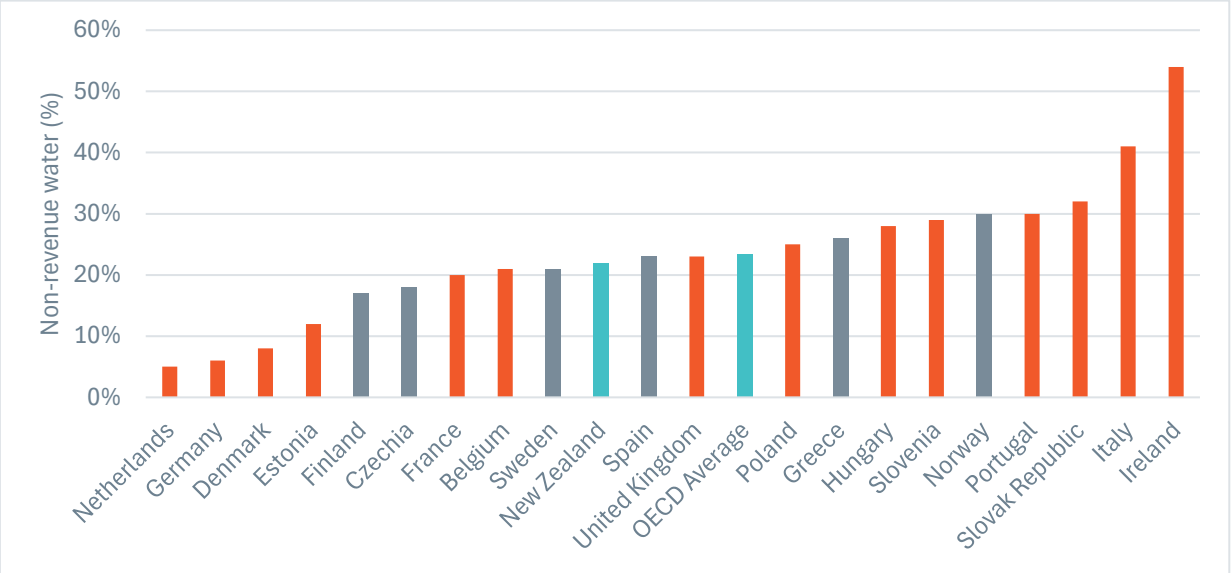
7.3.4. Water infrastructure quality

Like roads, we found data on a number of different quality indicators for water infrastructure.

Water loss (leaks) is a measure of quality of a water network because it shows the condition of assets, but also networks with fewer leaks are less likely to be susceptible to contamination of the supply. *Figure 20* below shows the rate of non-revenue water in New Zealand and European OECD countries. Non-revenue water is water that is pumped and then unaccounted for before it reaches customers. This can be due to leaks, theft, inaccurate water meters, and other factors.

Water loss rates in New Zealand are about average compared to benchmark countries

Figure 20: Non-revenue water rate in OECD countries



Source: European Federation of National Associations of Water Services, Taumata Arowai.

New Zealand has an average rate of non-revenue water at 22%, meaning 22% of water is pumped, and then unaccounted for before it reaches customers. This is in line with the average for European OECD countries of 23% and benchmark countries.

Another measure of quality is the water-related mortality rates. New Zealand has a low mortality rate attributed to unsafe water, sanitation and hygiene services (WASH). 2.1 deaths per 100,000 people are attribute to unsafe WASH services in New Zealand. This is below the OECD average of 3.4 deaths per 100,000 people and below the benchmark country average of 3.1 deaths.

Finally, New Zealanders rated the reliability of water supply 6.0 out of 7. This is modestly below the OECD average of 6.3. and the benchmark country average of 6.5.

8. Telecommunications infrastructure

8.1. Telecommunications infrastructure controls

Table 17 below outlines the controls that we use to determine benchmark countries for telecommunications infrastructure. We used standard controls for population, density, and terrain.

Table 17: Controls for telecommunications infrastructure

Sector name	Control variables	Definition	Source
Telecommunications	Population density	Total population divided by the land area of the country, people per km^2.	World Bank World Development Indicators
	Terrain ruggedness	Average of Terrain Ruggedness Index for area of the country.	Nathan Nunn & Diego Puga (2012)
	Log(population)	Natural log of the country's total population in 2023.	World Bank World Development Indicators
	Urban population	Share of population living in urban areas as defined by national statistical offices.	World Bank World Development Indicators

We note that within telecommunications, there are several subnetworks. For instance, broadband networks, which in turn have fixed and mobile components. It also includes fixed and mobile telephone networks. These control variables may have more of an effect on investment and network configurations that others.

Based on these controls, the countries we have determined as benchmarks to New Zealand for telecommunications infrastructure are listed in Table 18 below. The cells are colour coded relative to the OECD average, with red indicating that the value is below the OECD average, and green indicating that it is above.

Table 18: New Zealand's benchmark countries for telecommunications infrastructure

Country	GDP per capita (2017 PPP USD)	Population density	Terrain ruggedness	Population	Urban population (% of total population)	Similarity score (RMSE)
Colombia	18,038	46.9	0.89	52,085,168	82.4%	0.38
Costa Rica	21,986	102.1	2.11	5,212,173	82.6%	0.14
Chile	27,110	26.4	2.48	19,629,590	88.0%	0.20
New Zealand	43,744	19.8	2.04	5,223,100	87.0%	
Canada	49,771	4.6	0.78	40,097,761	81.9%	0.37
OECD Average	50,706	141.4	1.36	36,447,517	79.2%	
Finland	51,965	18.4	0.33	5,584,264	85.8%	0.32
Sweden	57,466	25.9	0.72	10,536,632	88.7%	0.26
Iceland	63,217	3.9	1.47	393,600	94.0%	0.38
Norway	88,792	15.2	2.41	5,519,594	84.0%	0.09

Source: World Bank World Development Indicators, Nathan Nunn and Diego Puga (2012).

In general, New Zealand's benchmark countries for telecommunications infrastructure are sparsely populated, rugged, with a small but urbanised population.

8.2. Telecommunications infrastructure variables

The following table identifies the measures we found for each category of benchmarking.

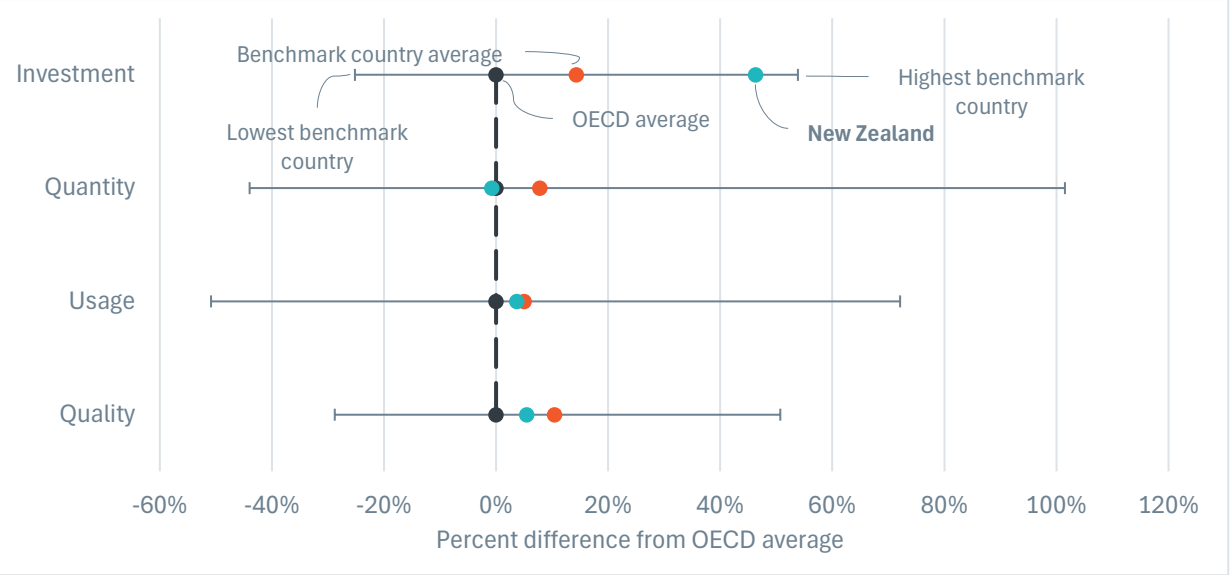
Table 19: Variables for telecommunications infrastructure

			No. countries with data	
Category	Variable	Source	OECD	Benchmark
Investment	Total investment in fixed, cellular mobile, and other wireless as a share of GDP	OECD	37	8
Quantity	Number of fixed broadband subscriptions per 100 people	OECD	38	9
	Share of fixed broadband subscriptions that are fibre	OECD	38	9
	Number of fixed broadband subscriptions per 100 people	World Bank World Development Indicators	38	9
	Number of mobile broadband subscriptions per 100 people	OECD	38	9
	Number of mobile cellular subscriptions per 100 people	World Bank World Development Indicators	38	9
	Number of fixed telephone subscriptions per 100 people	World Bank World Development Indicators	38	9
	Share of population covered by at least 4G	International Telecommunication Union	38	9
	Share of population covered by 5G	International Telecommunication Union	38	9
Use	Fixed broadband traffic per subscription	International Telecommunication Union	29	7
	Mobile broadband traffic per subscription	International Telecommunication Union	38	9
	Annual SMS per person	International Telecommunication Union	36	9
	Annual domestic mobile traffic per person	International Telecommunication Union	37	9
Quality	Fixed broadband down speed	Speedtest Global Index	36	8
	Fixed broadband up speed	Speedtest Global Index	36	8
	Mobile broadband down speed	Speedtest Global Index	37	8
	Mobile broadband up speed	Speedtest Global Index	37	8

8.3. Telecommunications infrastructure results

Figure 21 below shows the benchmarking results for telecommunications infrastructure. New Zealand's investment in telecommunications infrastructure is well above the OECD average and the benchmark country average. This is despite New Zealand's quantity, usage, and quality of telecommunications infrastructure being close to the OECD average and the benchmark country average.

Figure 21: Benchmarking results for telecommunications infrastructure



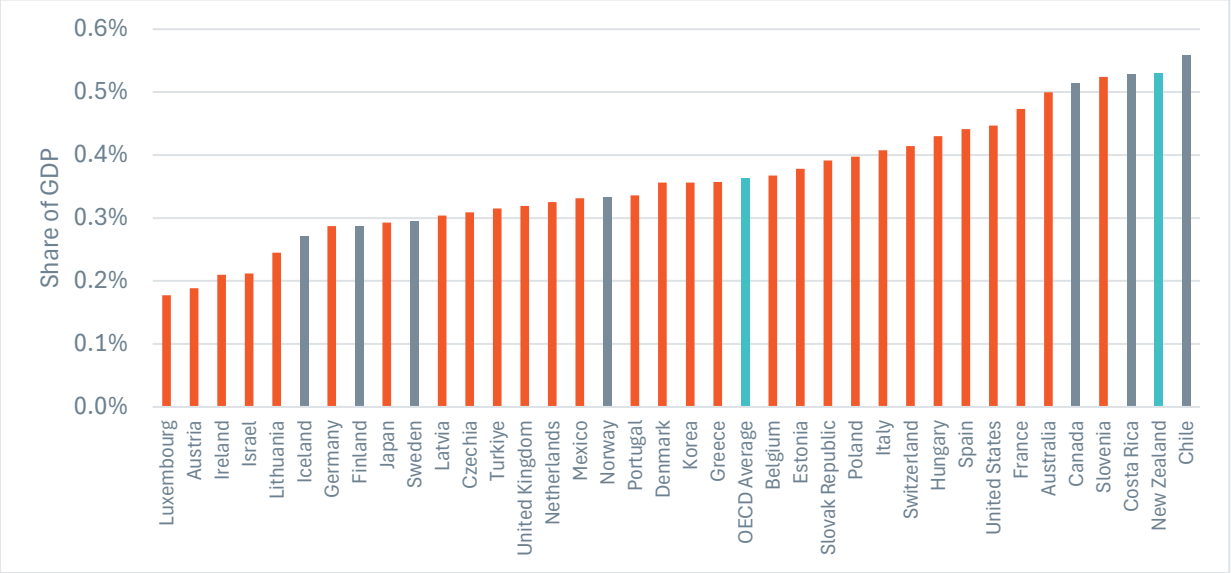
We do, however, note some within network nuance. For instance, it appears as though New Zealand's mobile broadband networks lag their peers, while our fixed broadband networks are about average.

8.3.1. Telecommunications infrastructure investment

New Zealand invests a comparable high amount on telecommunications networks, about 0.53% of GDP. This is above the OECD average of 0.36% and above most benchmark countries.

New Zealand's investment in telecommunications infrastructure is amongst the highest in the OECD

Figure 22: New Zealand's investment in telecommunications infrastructure is amongst the highest in the OECD



Source: OECD.

8.3.2. Telecommunications infrastructure quantity

As mentioned previously, the telecommunications network can be decomposed into several subnetworks. We review all aspects, including fixed and mobile broadband and telephone networks.

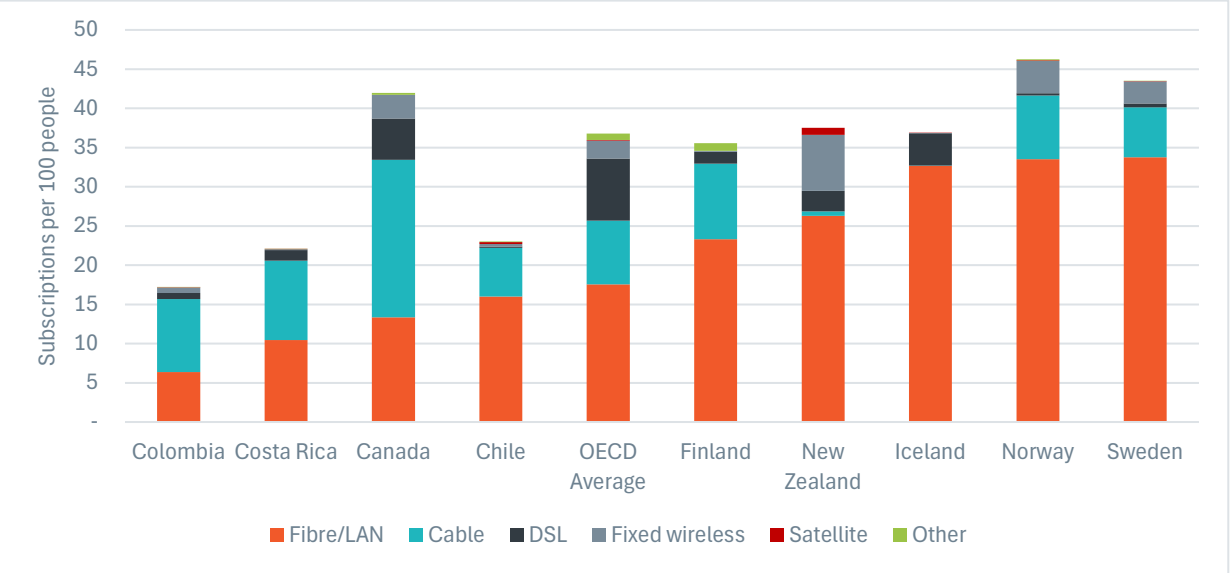
Broadband infrastructure

New Zealand's quantity of broadband infrastructure is well-developed for fixed networks but underdeveloped for mobile networks.

Beginning with fixed broadband, most fixed broadband subscriptions are fibre. This compares favourably to peer countries, and the OECD (Figure 23). Fibre is generally considered capable of the fastest and most reliable internet speeds, so this is an area New Zealand performs well.

Most of New Zealand's fixed broadband connections are fibre

Figure 23: Fixed broadband subscriptions per capita by type in New Zealand and benchmark countries



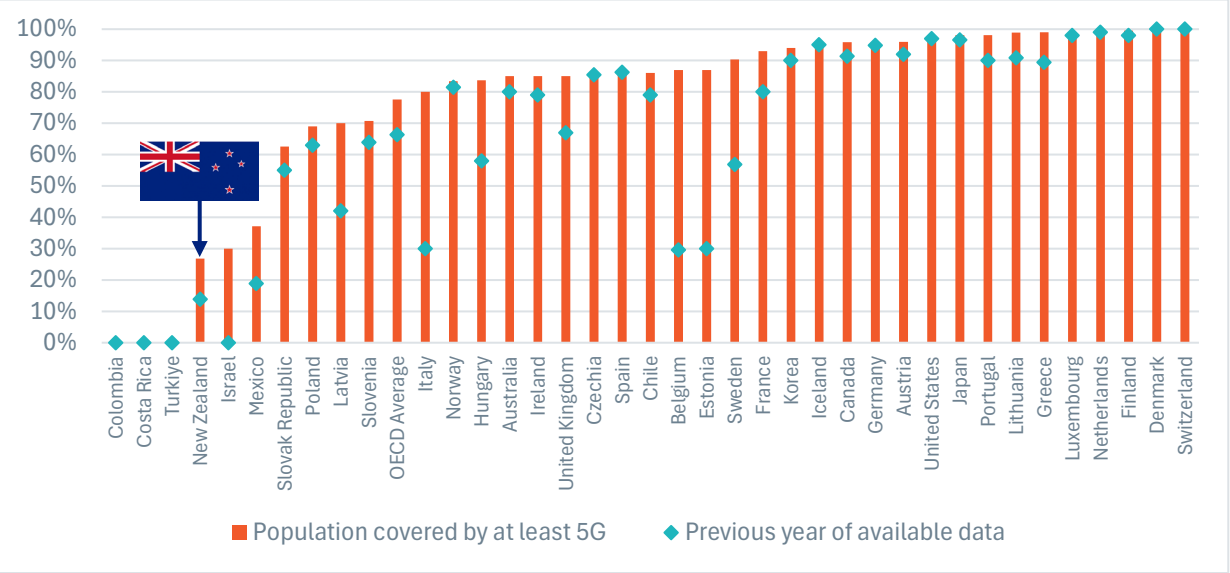
Source: OECD.

For mobile broadband, it is a different story. While 97.7% of New Zealand's population is covered by at least 4G cellular network, this is below the OECD average of 99.0% and below most of our benchmark countries. The only benchmark countries below New Zealand are Costa Rica at 95.0% and Chile at 96.0%, both of whom have lower incomes than New Zealand.

New Zealand's 5G rollout seems to be well behind other countries. Figure 24 below shows the share of each country's population covered by mobile 5G. The bars show the latest year of data for each country, and the diamonds show the previous year to give an idea of the speed of 5G rollout.

New Zealand's 5G rollout is one the worst in the OECD

Figure 24: Share of the population covered by 5G mobile networks in OECD countries



Source: ITU.

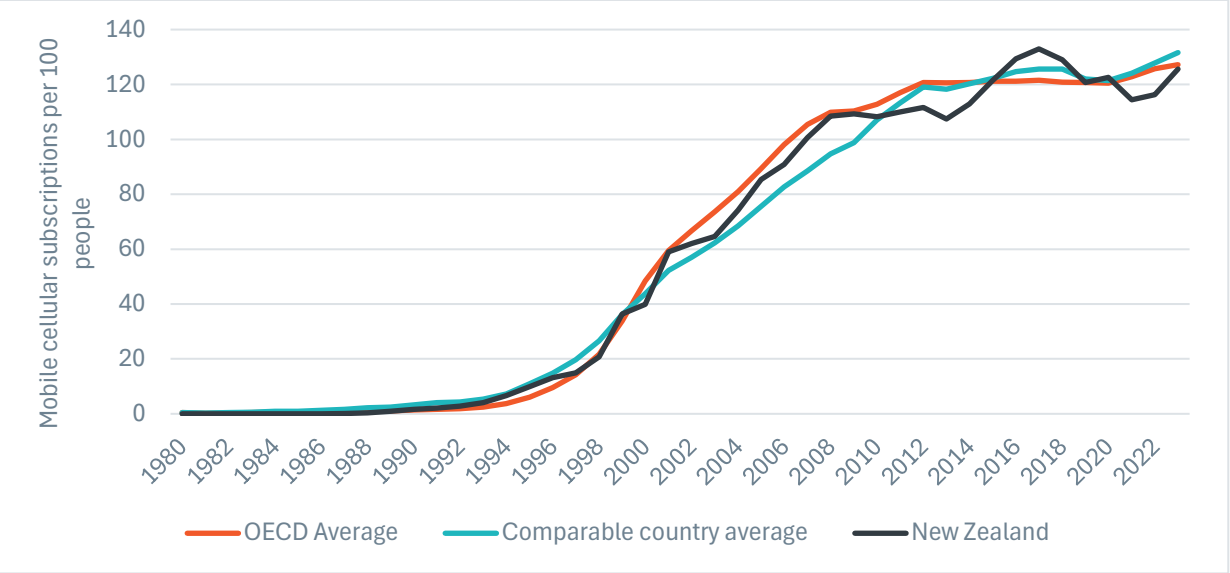
Only 26.8% of New Zealand's population was covered by 5G in 2023, up from 13.9% in 2022. The only countries with lower coverage are Colombia, Costa Rica, and Türkiye, who all have no coverage. The OECD average coverage is 77.6%. Other benchmark countries average 91.7% coverage.

Telephone networks

Mobile telephone networks seem to be fully developed in New Zealand, and in the OECD. Since the early 2010s the number of mobile cellular subscriptions per 100 people has hovered around 120 in New Zealand, benchmark countries, and on average (Figure 25).

The number of mobile cellular subscriptions appears to have saturated across the OECD, including in New Zealand

Figure 25: Mobile cellular subscriptions per capita over time



Source: World Bank.

This has coincided with a rapid decline in fixed telephone networks. The number of fixed telephone subscriptions is declining quickly in New Zealand and across the OECD. The number of subscriptions peaked around the year 2000 at around 50 subscriptions per 100 people. In 2023 New Zealand and benchmark countries had around 13 fixed telephone subscriptions per 100 people, below the OECD average of 25.

Overall, across all sets of networks, we judge having developed broadband networks is critical in the modern economy. New Zealand's relatively poor performance on mobile broadband stands out relative to its peers. This may be a decision by providers and consumers to rely more on fixed broadband, but we note that several of our benchmark countries have developed fixed broadband and very developed 5G network.

8.3.3. Telecommunications infrastructure use

We consider telecommunications infrastructure usage to be two components. First, is the degree of access to the network. The second is how intensively that network is used.

Broadband use

On measures of access, New Zealand's subscriptions to mobile and fixed broadband networks are comparable to its benchmark countries. New Zealand has 110 mobile broadband subscriptions per 100 people, slightly below the OECD average of 118 and the benchmark country average of 112. New

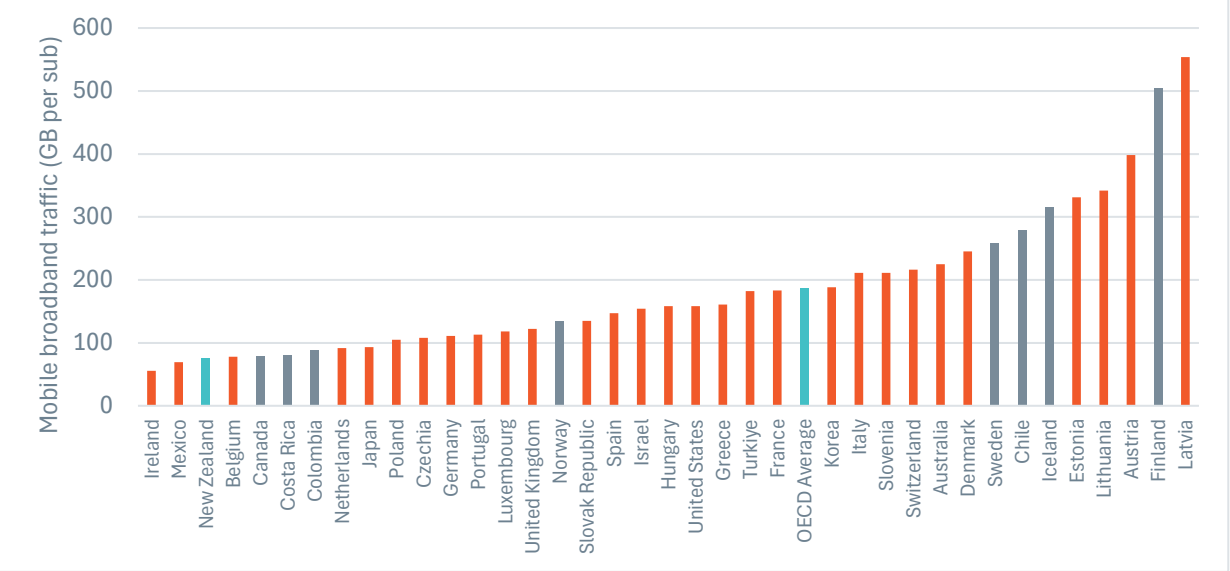
Zealand has 38 fixed broadband subscriptions per 100 people, slightly more than the OECD average of 36 and the benchmark country average of 34.

On measures of usage intensity for broadband networks, the same pattern observed in quantity of infrastructure is observed. New Zealand's fixed broadband traffic per subscription is 4,700 gigabytes, above the OECD average of 3,839 gigabytes per subscription, and above the benchmark country average of 4,069 gigabytes.

Mobile broadband traffic in New Zealand, on the other hand, is amongst the lowest in the OECD and lowest amongst benchmark countries. New Zealand uses 75 gigabytes per mobile broadband subscription. This is well below the OECD average of 186 gigabytes per subscription and the lowest among our benchmark countries (Figure 26). Again, this could be reflecting a substitutability between fixed and mobile broadband in New Zealand, that we don't necessarily observe in other countries.

New Zealand's mobile broadband traffic is one of the lowest in the OECD

Figure 26: Mobile broadband traffic per subscription in OECD countries



Source: ITU.

Telephone use

For telephone usage, New Zealand has around average mobile usage, although New Zealanders seem to prefer sending text messages over calling. New Zealanders send 1,193 SMS texts per person per year, above the OECD and benchmark country average of 667 and 623 respectively. Domestic mobile traffic minutes in New Zealand averages 1,996 minutes per person per year. This is below the OECD average of 2,697 minutes per person per year and below the benchmark country average of 3,051 minutes.

8.3.4. Telecommunications infrastructure quality

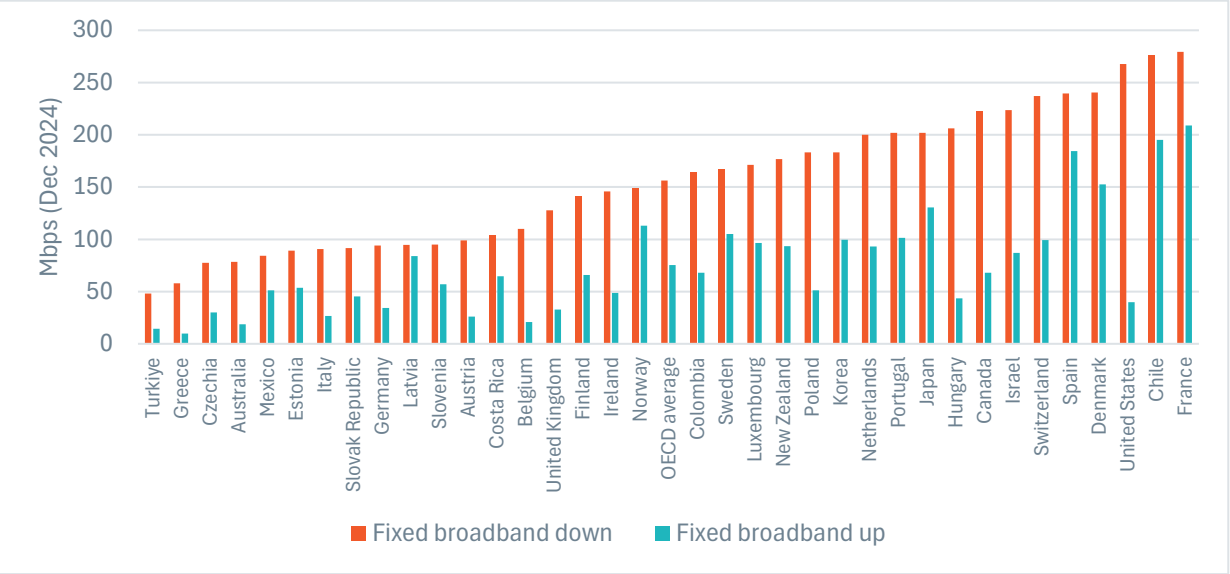
We observe quality on telecommunications networks in the form of broadband speeds. By these measures, New Zealand's performance is roughly average, despite having a relatively strong fixed broadband network but an underdeveloped mobile broadband network.

Mobile broadband speeds in New Zealand average 89.8 megabits per second down and 10.9 megabits per second up. The OECD average mobile broadband speeds are 86.0 megabits per second down and 13.6 megabits per second up. Benchmark countries average mobile broadband speeds are 83.1 megabits per second down and 14.3 megabits per second up.

Fixed broadband speeds in New Zealand average 176.9 megabits per second down and 93.4 megabits per second up. This is above the OECD average of 156.1 megabits per second down and 75.4 megabits per second up. Benchmark countries average fixed broadband speeds are 175.0 megabits per second down and 96.6 megabits per second down (Figure 27).

New Zealand's fixed broadband speeds are similar to the OECD average and benchmark countries

Figure 27: Fixed broadband download and upload speeds in OECD countries



Source: Speedtest Global Index.

9. Healthcare infrastructure

Table 20 outlines the controls that we use to determine benchmark countries for healthcare infrastructure.

9.1. Healthcare infrastructure controls

Table 20: Controls for healthcare infrastructure

Sector name	Control variables	Definition	Source
Healthcare	Share population aged 65+	Share of the population that is aged over 65 (inclusive).	World Bank World Development Indicators
	Share population aged 0-4	Share of the population that is aged 0-4 (inclusive).	World Bank World Development Indicators
	Urban population	Share of population living in urban areas as defined by national statistical offices.	World Bank World Development Indicators
	Public coverage for core set of services	Share of the population eligible for a defined set of basic healthcare goods and services.	OECD

Our controls for health infrastructure are relatively unique compared to the other sectors:

- **Demographic controls:** We selected the share of the population aged 65 and over and aged 4 and younger as controls, as they are the groups that have the highest hospital usage. We also consider the share of the population that lives in urban areas. This is because cities with significant urban populations may have different network configurations for healthcare provision.
- **Public versus private provision of services:** We consider that government provision of healthcare services may lead to differing levels of health infrastructure and delivery.

Based on these controls, the countries we have determined as benchmarks to New Zealand for healthcare infrastructure are listed in Table 21 below. The cells are colour coded relative to the OECD average, with red indicating that the value is below the OECD average, and green indicating that it is above.

Table 21: New Zealand's benchmark countries for health infrastructure

Country	GDP per capita (2017 PPP dollars)	Population ages 65 and above (% of population)	Population ages 00-04 (% of population)	Urban population (% of total population)	Public coverage for core set of services	Similarity score (RMSE)
New Zealand	$43,744	17%	6.0%	87%	100.0%	
United Kingdom	$48,563	19%	5.1%	85%	100.0%	0.85
OECD Average	$50,705	19%	5.2%	77%	87.0%	
Australia	$56,415	17%	5.8%	87%	100.0%	0.24
Sweden	$57,465	20%	5.5%	89%	100.0%	0.64
Denmark	$61,218	21%	5.4%	88%	100.0%	0.75
Iceland	$63,217	16%	6.0%	94%	99.6%	0.65
Norway	$88,791	19%	5.0%	84%	100.0%	0.94

Source: OECD Health at a Glance, World Bank World Development Indicators.

In general, New Zealand's benchmark countries for health infrastructure have a low share of their population aged over 65 and a high share aged under 4. They are also generally very urbanised and have provide public coverage for core healthcare services.

9.2. Healthcare infrastructure variables

The following table identifies the measures we found for each category of benchmarking.

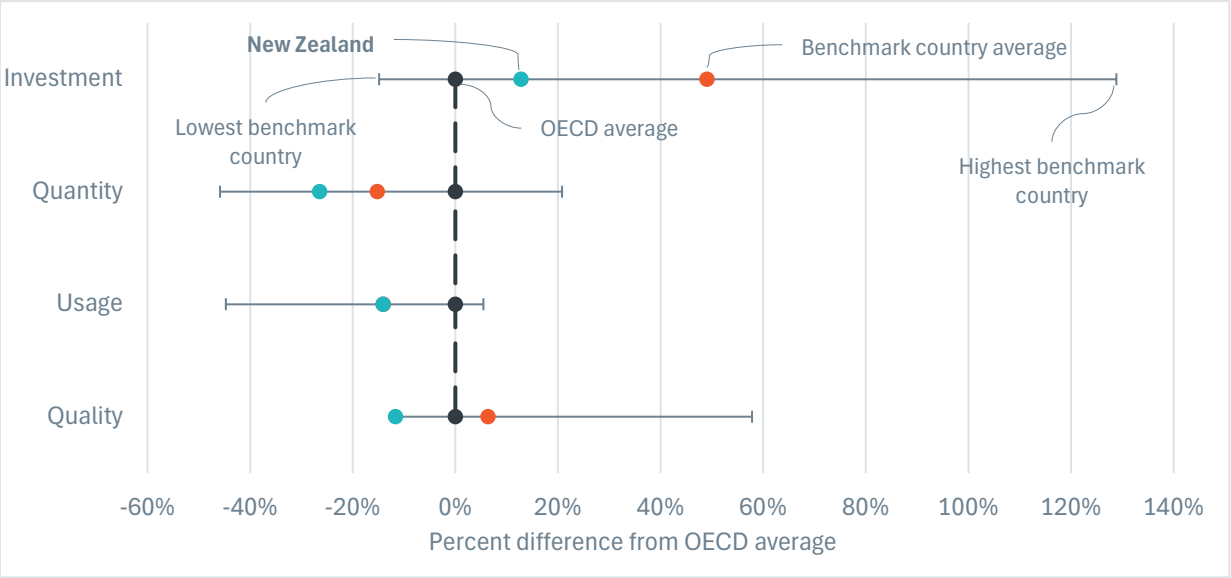
Table 22: Variables for healthcare infrastructure

			No. countries with data	
Category	Variable	Source	OECD	Benchmark
Investment	Human health and social work activities gross fixed capital formation as a share of GDP	Eurostat, OECD, Stats NZ	37	7
	Human health and social work activities gross fixed capital formation per person	Eurostat, OECD, Stats NZ	37	7
Quantity	Number of hospital beds per 1,000,000 people	OECD	38	7
	Number of medical machines per 1,000,000 people	OECD	34-36	7
Use	Annual bed days per person	OECD	31	7
	Average length of hospital stays	OECD	36	7
	Average occupancy rate of hospital beds	OECD	35	5
Quality	Waiting times for elective surgeries	OECD	13-18	4-6
	Healthcare-associated infection rate	European Centre for Disease Prevention and Control, Health Quality and Safety Commission	24	4
	Age of hospital buildings	Definitive Healthcare, Health Asset Register Tool, National Health Service	3	2

9.3. Healthcare infrastructure results

Figure 28 below shows the benchmarking results for health infrastructure. Overall, it appears as though across the measures we collected, New Zealand has lower investment, quantities, usage, and quality of health infrastructure than its peers. Although across all these measures, we are not far from the OECD average.

Figure 28: Benchmarking results for healthcare infrastructure



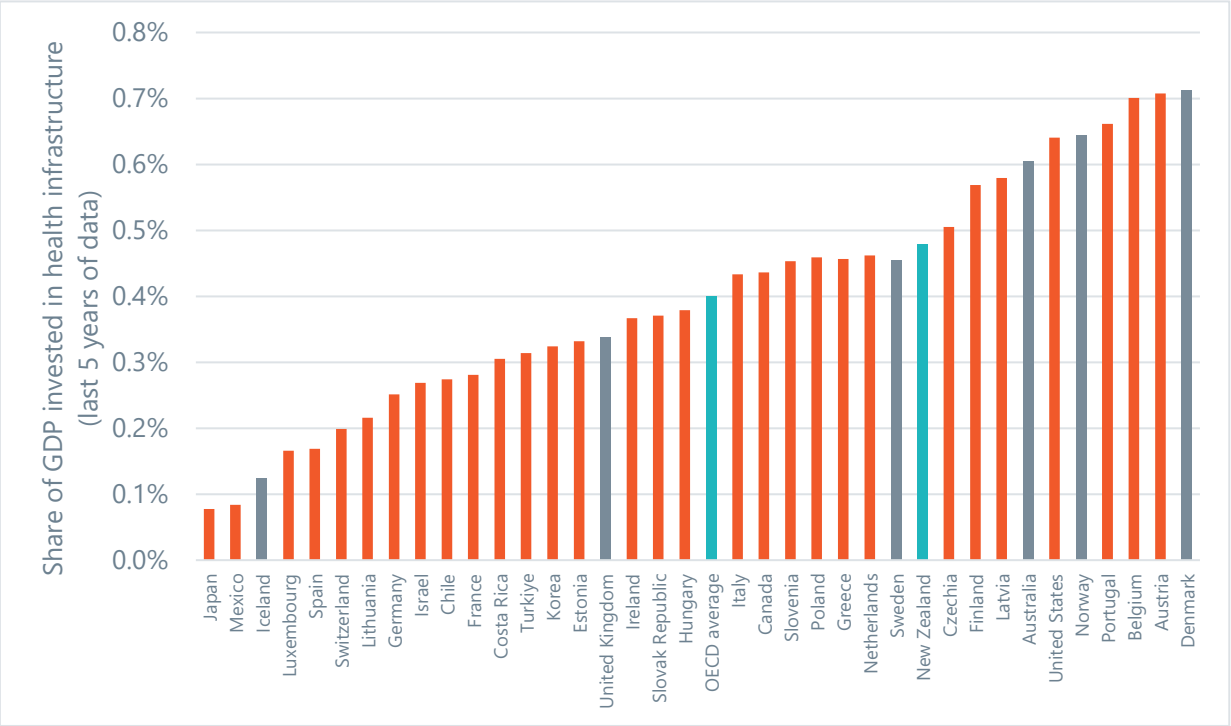
9.3.1. Healthcare infrastructure investment

For health infrastructure investment, New Zealand appears to be investing close to the OECD average, but moderately below our benchmark countries on a per capita basis.

New Zealand invests 0.48% of GDP in healthcare capital formation. This is above the OECD average of 0.40%, and equal to the benchmark country average of 0.48% (Figure 29). This includes all fixed assets used for human healthcare and social work, not just hospital buildings.

New Zealand invests a similar amount of GDP to benchmark countries in healthcare infrastructure

Figure 29: Share of GDP invested in health infrastructure in OECD countries



Source: OECD, Stats NZ, Eurostat.

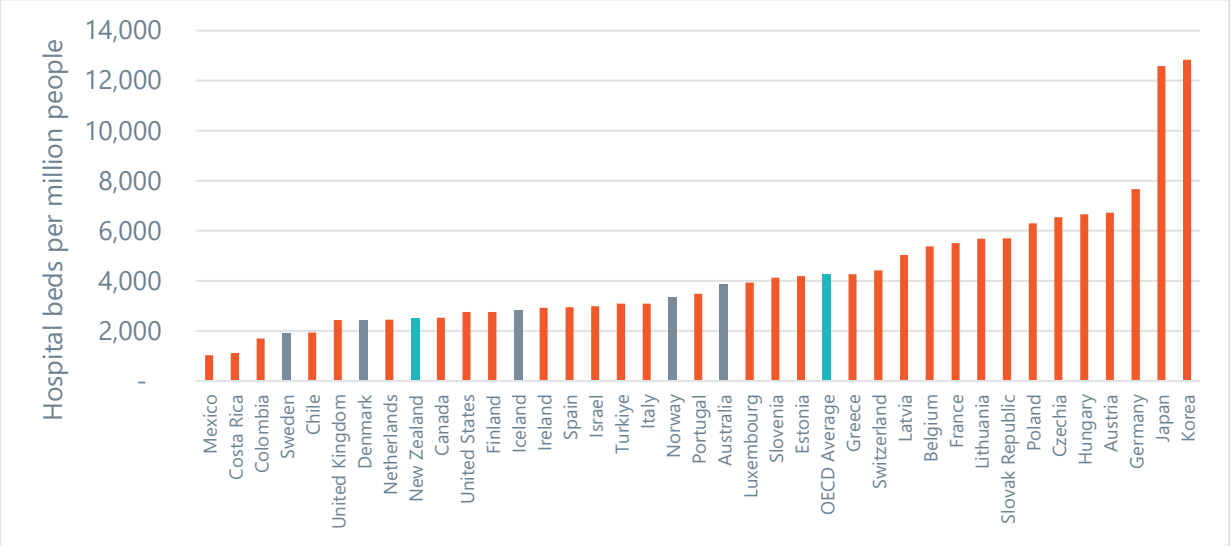
It is in per capita dollar terms that New Zealand's health infrastructure investment falls behind benchmark countries. In per capita dollar terms, New Zealand invests $207 USD per person per year, above the OECD average of $183, but well below the benchmark country average of $273 USD per person per year.

9.3.2. Healthcare infrastructure quantity

There appears to be some evidence that the amount of health infrastructure in New Zealand is lagging its peers.

One measure of health infrastructure quantity is the number of hospital beds. Figure 30 below shows the number of hospital beds per million people in OECD countries.

New Zealand has a low number of hospital beds compared to its benchmark countries
Figure 30: Hospital beds per capita in OECD countries



Source: OECD, World Bank World Development Indicators.

New Zealand has 2,481 hospital beds for every million people. This is below the OECD average of 4,250 and slightly below the benchmark country average of 2,871.

Another measure we examined was numbers of medical equipment. *Table* 23 below shows the amount of medical equipment per capita in New Zealand and benchmark countries. New Zealand has a comparable amount of medical equipment to the OECD average and benchmark countries, with a few exceptions, namely PET scanners and gamma cameras, where we have well below our peers.

New Zealand has low numbers of gamma cameras and PET scanners for our population, but an average to above average amount of other medical devices

Table 23: Medical device quantities per 100,000 people for New Zealand and comparable countries

Country	Radiation therapy equipment	Mammographs	Gamma cameras	PET scanners	MRI units	CT scanners
New Zealand	8.2	22.0	3.3	1.1	19.7	43.8
OECD average	7.8	23.4	9.0	2.5	19.1	29.6
Denmark	11.7	16.3	13.4	8.8	9.2	43.4
Australia	12.1	19.9	15.6	4.2	16.2	71.9
Sweden	6.1	12.8	6.7	2.7	17.5	23.7
Iceland	7.6	12.7	5.1	2.5	22.9	43.2
Norway	11.4	12.9	5.6	4.2	31.2	28.1

Source: OECD, World Bank World Development Indicators.

9.3.3. Healthcare infrastructure usage

We consider that health infrastructure usage is a function of factors well beyond the quality of the network, such as the overall health of the population and delivery systems of care. There is good information on hospital usage for benchmarking which might speak to the demand for hospital infrastructure for those in need of care.

In general, we find that the average New Zealander does not spend much time in hospital and their average length of stay is relatively short.

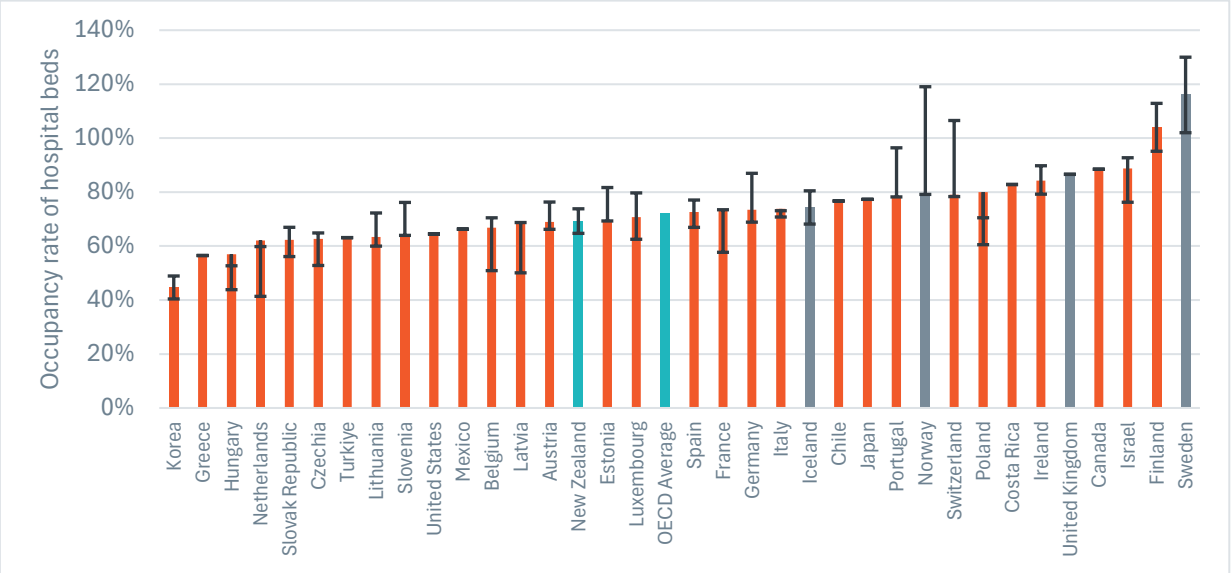
The average New Zealand spends 0.61 bed days per person per year in hospital. This is less than the OECD average of 0.84 days per person per year and less than the benchmark country average of 0.71 days.

The average length of stay in New Zealand's hospitals is 6.6 days, slightly below the OECD average of 7.3 days, but slightly above the benchmark country average of 5.9 days.

The average hospital in New Zealand appears to have modest capacity at any given point in time. On average, 62% of New Zealand's hospital beds are occupied at any one time. This is below the OECD average of 72% and the benchmark country average of 85%. An occupancy rate above 100% means a country's hospitals are over capacity with more patients than available beds.

New Zealand's hospitals typically have more spare bed capacity than its peers

Figure 31: Occupancy rate of hospital beds in OECD countries



Source: OECD. Notes: OECD data is only for somatic curative care occupancy rates. We estimate the number of psychiatric curative beds to get the occupancy rate for all curative beds. This allows us to estimate the curative hospital bed occupancy rate for New Zealand, Korea, Iceland, Finland, and Sweden where previously data was missing. The error bars are the estimation range for the aforementioned countries, but also for countries where data was not missing to show the accuracy of our estimation.

9.3.4. Healthcare infrastructure quality

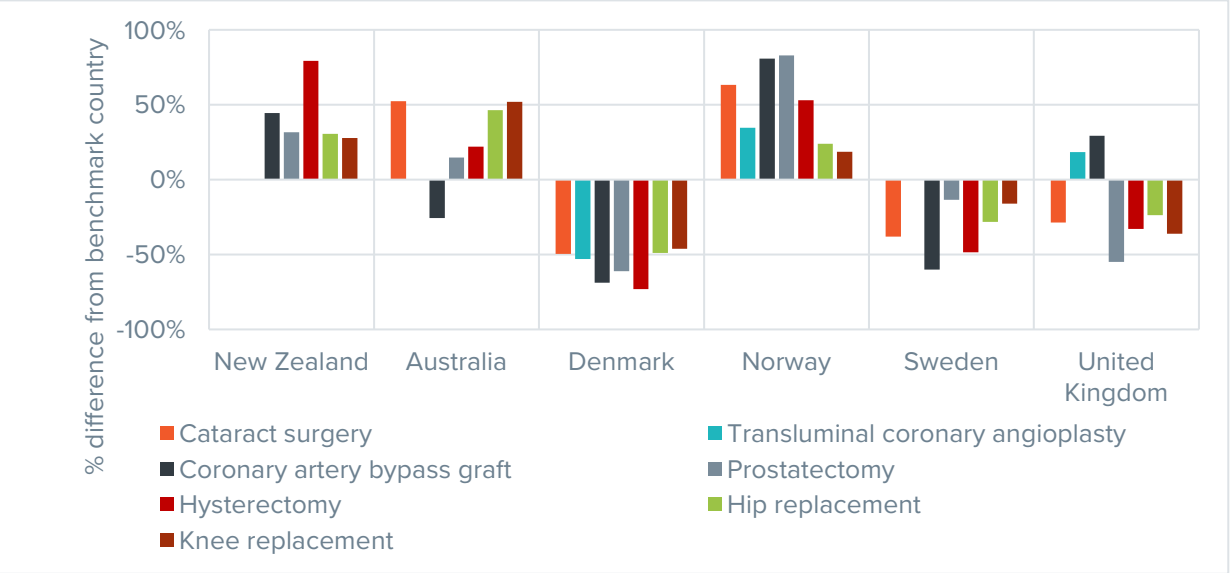
Our review of health infrastructure quality was focused on measures related to the quality of infrastructure itself, rather than quality of the overall health system or outcomes of the health care system.

The first measure we explored was waiting times for surgery. Waiting times for surgery could reflect a shortage of staff to perform these procedures, but they could also reflect a shortage of operating theatres and equipment.

Figure 32 below shows the percentage difference from the benchmark country means for waiting times for elective surgeries. Waiting times for cataract surgeries and transluminal coronary angioplasties in New Zealand are equal to the benchmark country average. Waiting times for the other elective surgeries we have data on are longer than in benchmark countries, however.

Waiting times for some elective surgeries tend to be longer in New Zealand than most of our peers

Figure 32: Difference from benchmark country average in waiting times for elective surgeries



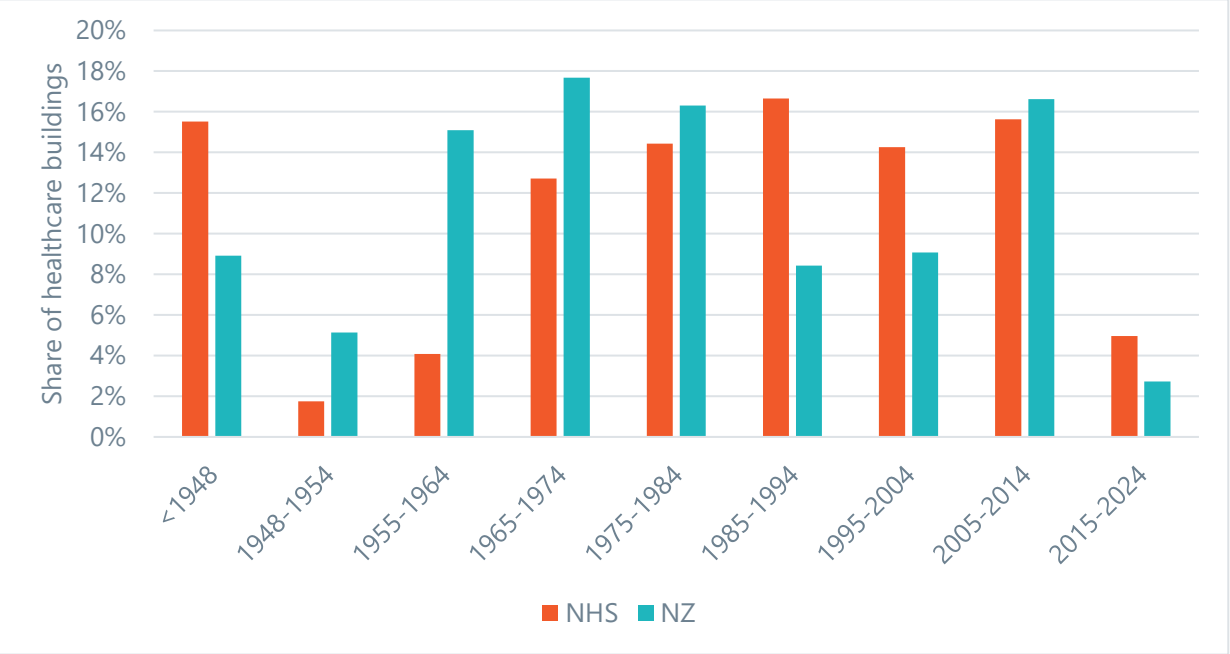
Source: OECD.

Another measure we studied was the likelihood of contracting an infection by using hospitals. By this measure, New Zealand is similar European OECD countries. The observed prevalence of healthcare-associated infections in New Zealand is 6.6%, just below the average rate of 7.0%.

Finally, we attempted to gather some data on the state of the infrastructure assets themselves. One measure of this is the average age of hospital facilities. Data for this is very limited, however. We found data for New Zealand, the NHS, and the United States. Data for New Zealand and the NHS is presented in *Figure 33* below.

New Zealand's hospitals tend to be older than the UKs

Figure 33: Share of healthcare buildings constructed over time in NZ and the UK



Source: Health Asset Register Tool, NHS.

Aside from a tail of buildings constructed pre-1948, the distribution of NHS buildings appears to be younger than hospital buildings in New Zealand. This appears to be due to not many hospital buildings being constructed in New Zealand between 1985 and 2004. The average age of hospital buildings in the United States is much younger than in New Zealand and in the NHS at only 13.3 years. However, the United States is not a benchmark country, having a very different healthcare system to New Zealand.

10. Education infrastructure

10.1. Education infrastructure controls

Table 24 below outlines the controls that we use to determine benchmark countries for education infrastructure.

Table 24: Controls for education infrastructure

Sector name	Control variables	Definition	Source
Education	Share population aged 5-17	Share of the population that is aged 5-17 (inclusive).	World Bank World Development Indicators
	Population density	Total population divided by the land area of the country, people per km^2.	World Bank World Development Indicators
	Average Y/Y change in population since 1960	Average percentage change in total population year over year from 1960 to 2023.	World Bank World Development Indicators
	Annual expected loss from natural disasters	The observed annual expected loss as share of GDP from natural disasters. This is the total damage from the largest natural disasters in a country's history, divided by the time over which these disasters took place.	EM-DAT
	Compulsory education ending age	The age at which compulsory education ends.	OECD

Like health infrastructure, the selected controls are largely bespoke for the sector.

We selected three demographic controls:

- Share of the population that is aged 5 to 17, to account for the relative demand for school infrastructure.
- Population density, to account for the challenges of providing a base level of education to sparsely populated areas.
- Average year-on-year rate of population growth since 1960, to account for overall demand for education infrastructure, as faster growing populations will generally require more education infrastructure.

We also include a control for countries that are especially exposed to natural hazard risk. Our engagement with stakeholders on this work highlighted that providing resilience for New Zealand's unique natural hazard risk drives considerable investment in schools.

Finally, we control for policy led demand for infrastructure, which is countries compulsory education age. Countries with higher age cut-offs will necessarily have more students and could require more education infrastructure.

Based on these controls, the countries we have determined as benchmarks to New Zealand for education infrastructure are listed in Table 25 below. The cells are colour coded relative to the OECD average, with red indicating that the value is below the OECD average, and green indicating that it is above.

Table 25: New Zealand's benchmark countries for education infrastructure

Country	GDP per capita (2017 PPP dollars)	Share population aged 5-17	Population density	Average Y/Y change in population since 1960	Annual expected loss from natural disasters	Compulsory education ending age	Similarity score (RMSE)
Chile	27,110	16.1%	26.4	1.41%	0.77%	18.0	0.73
New Zealand	43,744	16.4%	19.8	1.24%	0.57%	16.0	
OECD Average	50,705	14.8%	141.4	0.81%	0.15%	16.1	
Finland	51,964	14.1%	18.4	0.37%		16.0	0.99
Australia	56,415	15.9%	3.5	1.51%	0.18%	17.0	0.85
Iceland	63,217	15.8%	3.9	1.27%	0.06%	16.0	0.74
United States	65,720	16.1%	36.6	1.03%	0.07%	17.0	0.95
Norway	88,791	15.1%	15.2	0.69%	0.01%	16.0	1.00
Ireland	104,544	17.4%	76.4	0.97%	0.03%	16.0	0.94

Source: World Bank World Development Indicators, OECD.

Generally, New Zealand's benchmark countries for education infrastructure have a young, sparse population which has grown quickly since 1960. They also generally face some risk of natural disasters and have compulsory education ending around 16-17.

10.2. Education infrastructure variables

The following table identifies the measures we found for each category of benchmarking.

Table 26: Variables for education infrastructure

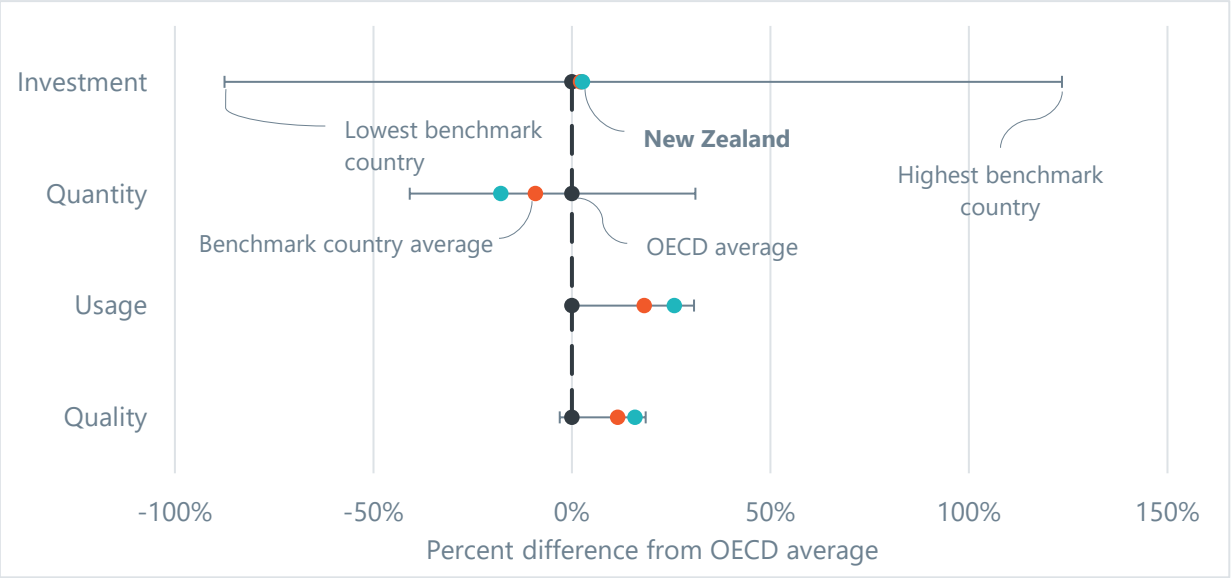
			No. countries with data	
Category	Variable	Source	OECD	Benchmark
Investment	Education gross fixed capital formation as a share of GDP	Bureau of Economic Analysis, OECD, Stats NZ	29	8
	Education gross fixed capital formation per 5–25-year-old	Bureau of Economic Analysis, OECD, Stats NZ	29	8
Quantity	Number of schools per 100,000 people	Australian Bureau of Statistics, British Educational Suppliers Association, Council of Ministers of Education Canada, Czech Statistical Office, Education Counts, Greece in Numbers, Irish Government, I.Stat (Italy), Ministry of Education (Chile), Ministry of Education (Korea), National institute of Statistics and Economic Studies (France), Norwegian Directorate for Education and Training, Official Statistics Portal (Lithuania), Republic of Estonia Ministry of Education and Research, Statistics Finland, Statistics	16	6

		Netherlands, World Bank World Development Indicators		
	Number of schools per 100,000 primary and secondary students	Same as above	16	6
	Average primary and secondary school size	Same as above	16	6
Use	Share of population that are students	OECD, World Bank World Development Indicators	38	8
Quality	Share of 15-year-old students affected by a lack of educational material	Programme for International Student Assessment	37	8
	Share of 15-year-old students affected by inadequate or poor-quality education material	Programme for International Student Assessment	37	8
	Share of 15-year-old students affected by a lack of physical infrastructure	Programme for International Student Assessment	37	8
	Share of 15-year-old students affected by inadequate or poor-quality physical infrastructure	Programme for International Student Assessment	37	8
	Share of 15-year-old students affected by a lack of digital resources	Programme for International Student Assessment	37	8
	Share of 15-year-old students affected by inadequate or poor-quality digital resources	Programme for International Student Assessment	37	8

10.3. Education infrastructure results

Figure 34 below shows the benchmarking results for education infrastructure. In general, there are no areas where New Zealand is clearly lagging its peers.

Figure 34: Benchmark results for education infrastructure



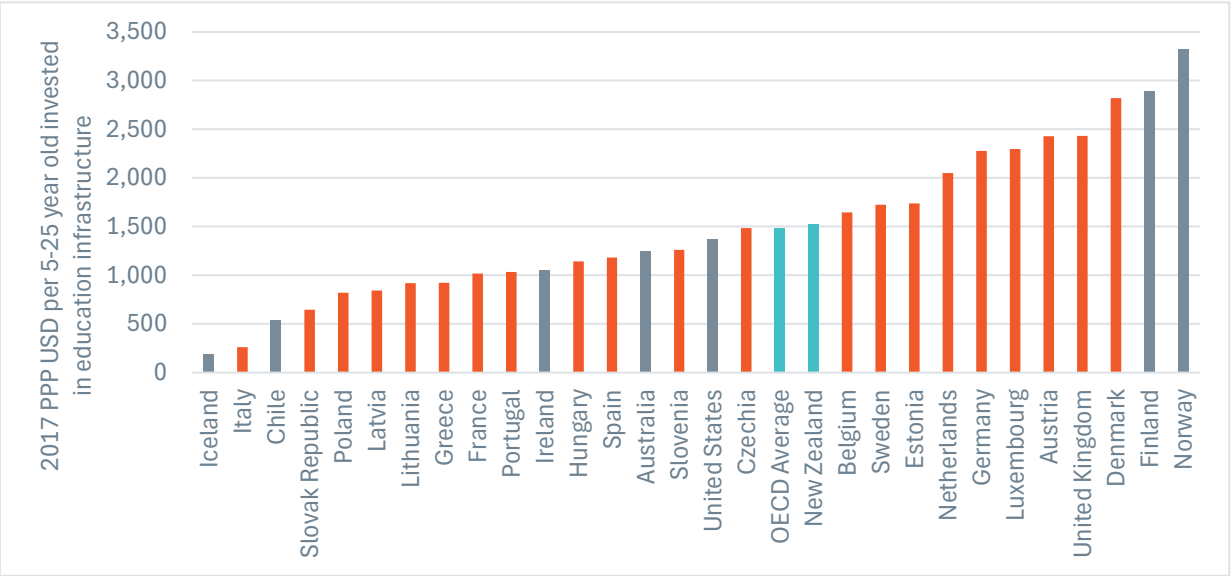
10.3.1. Education infrastructure investment

As a share of its GDP, New Zealand invests a significant amount on education infrastructure, well above the OECD average, but not necessarily much higher than its compactor countries. We invest 0.97% of our GDP on school infrastructure, above the OECD average of 0.70%. However, two of our benchmark countries, Norway and Finland, invest significantly more than us at 1.24% and 1.30% of GDP respectively.

On a per-student basis, New Zealand invests $1,525 2017 USD per person aged 5 to 25 on education infrastructure. This is just above the OECD average of $1,486 per 5- to 25-year-old. Benchmark countries range from Iceland, lowest in the OECD at $186 per 5- to 25-year-old, to Norway, highest in the OECD at $3,319 per 5- to 25-year-old.

On a per-student basis, New Zealand invests a similar amount to the OECD average and the benchmark country average on education infrastructure

Figure 35: Investment in education infrastructure per 5-to-25 year old in OECD countries



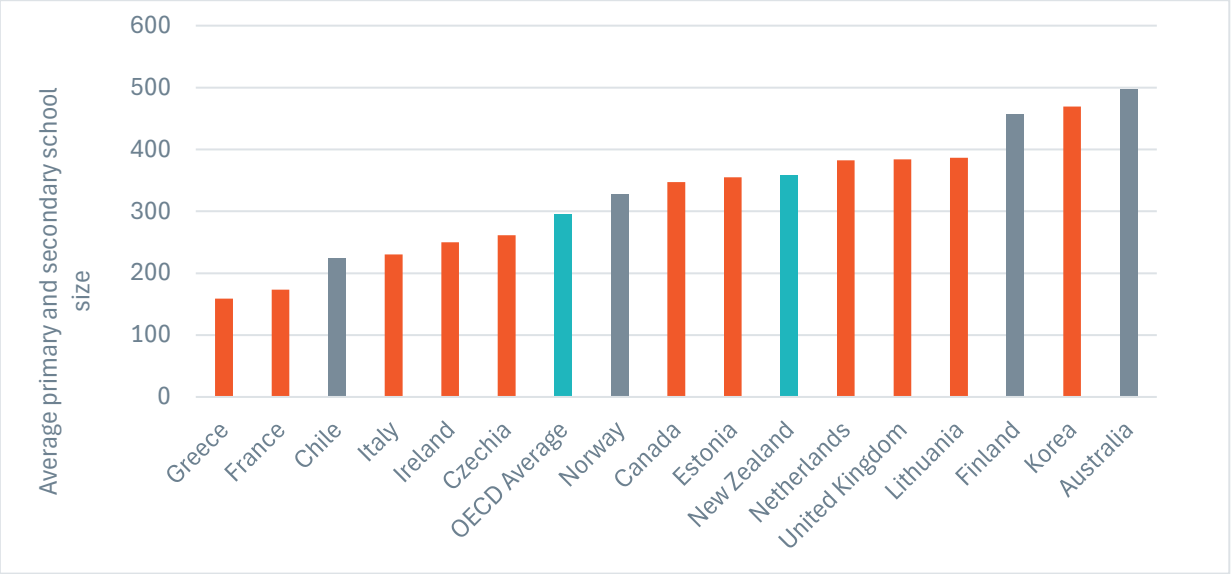
Source: OECD, Stats NZ, Bureau of Economic Analysis, World Bank World Development Indicators.

10.3.2. Education infrastructure quantity

New Zealand has approximately 2,300 primary and secondary schools. The average school has about 358 students. This is above the OECD average of 294 students. The average school size for our comparator countries is 376 students.

The average school size in New Zealand is above the OECD average, but below the benchmark country average

Figure 36: Average primary and secondary schools size in OECD countries



Source: World Bank World Development Indicators, various national agencies.

We were unable to locate standardised data on classroom sizes, or the number of classroom and student spaces.

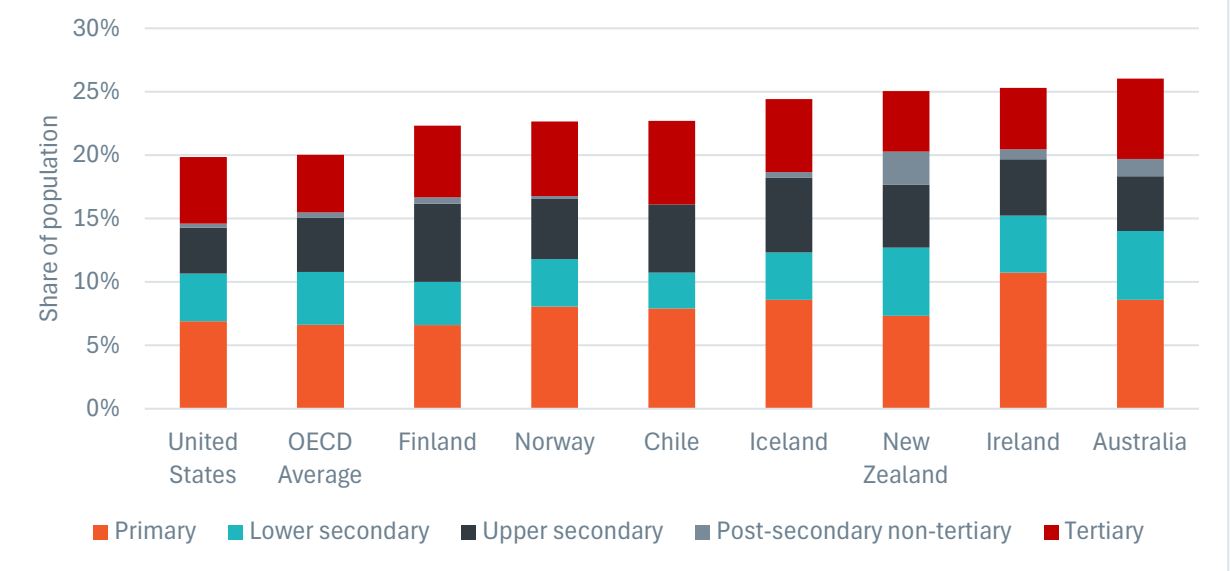
10.3.3. Education infrastructure usage

For primary and secondary education, since attendance until a certain age is compulsory by law, we consider that usage is best approximated by the number of students as a share of the population. We could not find information on the average attendance relative to capacity of schools across countries.

Figure 37 below shows the share of the population that are in different levels of education in New Zealand and in benchmark countries.

A significant share of New Zealand's population are students

Figure 37: Share of the population that are students in OECD countries by education level



Source: OECD; Levels of education are defined by International Standard Classification of Education (ISCED) levels. Primary education is ISCED level 1, lower secondary education is ISCED level 2, upper secondary education is ISCED level 3, post-secondary non-tertiary education is ISCED level 4, and tertiary education is ISCED levels 5 to 8.[6]

New Zealand has a relatively high share of its population that are students. This is particularly true for secondary students and post-secondary tertiary students (trade and apprentice schools). 25.0% of New Zealand's population are primary to tertiary students, above the OECD average of 20.0%. Benchmark countries have on average 23.5% of their population as students.

In New Zealand 4.8% of the population are tertiary students, above the OECD average of 4.5%. On average, 5.6% of the population in our benchmark countries are tertiary students.

10.3.4. Education infrastructure quality

As with health, we focused on finding measures that highlighted the quality of education infrastructure, rather than the quality of the education systems or the outcomes it achieves. To this effect, we sought measures that spoke to the conditions of schools and whether it is impacting the learning environment for teachers.

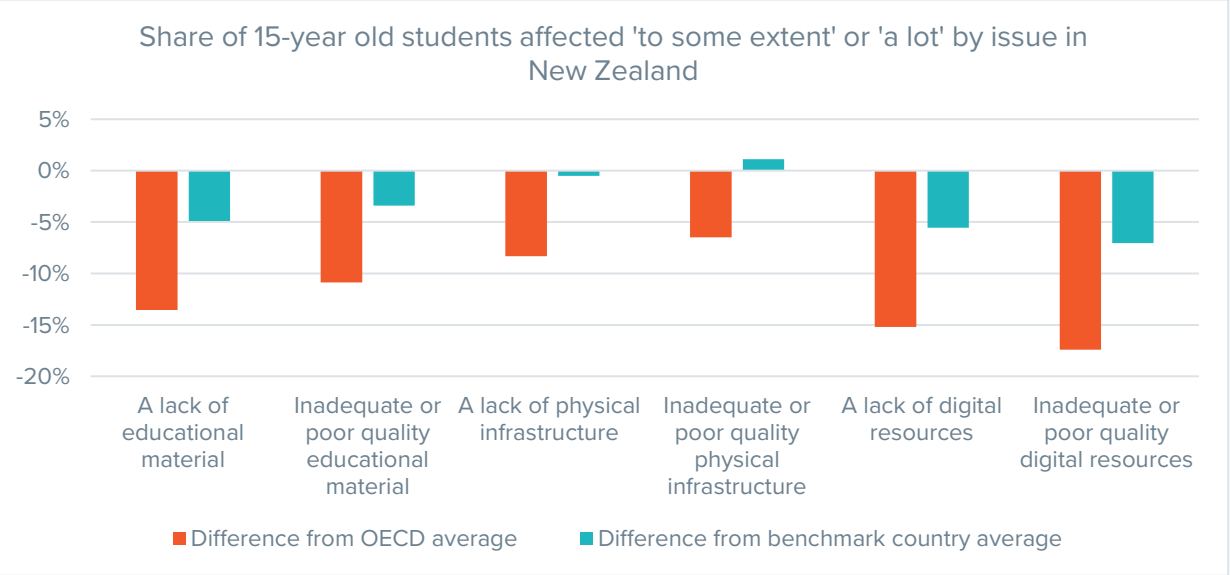
The Programme for International Student Assessment (PISA), a survey of high school principals and student performance, asks high school principals whether their school's ability to provide instruction is affected by certain factors. This includes asking about the quantity and quality of physical assets. Principals are asked through the PISA questionnaire to what degree their school's ability to provide instruction is affected by lacking or inadequate physical assets. Principals answer, 'not at all', 'very little', 'to some extent', or 'a lot'. The graph below shows how the share of students affected 'to some extent' or 'a lot' in New Zealand differs from the OECD and from benchmark countries.

The results from this survey indicate that generally, New Zealand high schools do not suffer from a lack of physical resources, relative to other OECD countries and our comparators.

[6] For more details see OECD handbook for internationally comparative education statistics 2018.

New Zealand high school students do not generally suffer from a lack of physical resources

Figure 38: Difference from the OECD average and benchmark country average in the share of students affected by a lack of or poor-quality physical resources in New Zealand



Source: PISA.

Figure 38 above shows how New Zealand compares to the OECD average and to the benchmark average on the PISA questions about physical resources. New Zealand is well above the OECD average on all measures. Very few 15-year-old students are affected 'to some extent' or 'a lot' by a lack of, or poor quality, physical resources. Our benchmark countries generally perform better than the OECD average. However, New Zealand is still better than the benchmark country average on most measures.

Bibliography

Alberta Government (n.d.). International roughness index and rut data. https://www.alberta.ca/international-roughness-index-and-rut-data

Australian Bureau of Statistics (2025, February). Schools. https://www.abs.gov.au/statistics/people/education/schools/latest-release

Azavea, Research for Community Access Partnership, & World Bank (2019, December). Rural access index measurement tool. https://rai.azavea.com/

British Educational Suppliers Association (n.d.). Key UK education statistics. https://www.besa.org.uk/insights/education-statistics/

Bureau of Economic Analysis (n.d.). National economic accounts. https://www.bea.gov/data/economic-accounts/national

Bureau of Infrastructure and Transport Research Economics (2025, January). Australian infrastructure and transport statistics yearbook 2024. Commonwealth of Australia. https://www.bitre.gov.au/publications/2025/australian-infrastructure-and-transport-statistics-yearbook-2024

Central Intelligence Agency (n.d.). The world factbook. https://www.cia.gov/the-world-factbook/

Commerce Commission (2024). Performance summaries for electricity distributors. https://comcom.govt.nz/regulated-industries/electricity-lines/electricity-distributor-performance-and-data/performance-summaries-for-electricity-distributors

Council of Ministers of Education, Canada (n.d.). Education in Canada – An overview. https://www.cmec.ca/299/Education_in_Canada__An_Overview.html

Czech Statistical Office (n.d.). Nursery, primary, and secondary education. https://csu.gov.cz/kraje-spolecne/early-childhood-primary-and-secondary-education

Definitive Healthcare (2024, June). U.S. states ranked by their average healthcare facility age. https://www.definitivehc.com/resources/healthcare-insights/us-states-average-healthcare-facility-age

Department of Infrastructure, Transport, Regional Development, Communications, and the Arts (n.d.). Asset registers and heavy vehicle infrastructure ratings. Australian Government. https://www.infrastructure.gov.au/infrastructure-transport-vehicles/transport-strategy-policy/heavy-vehicle-road-reform/background-heavy-vehicle-road-reform/heavy-vehicle-road-reform-phase-one

Education Counts (2024, November). Number of schools. https://www.educationcounts.govt.nz/statistics/number-of-schools

European Centre for Disease Prevention and Control (2024, May). Point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals.

European Commission (2024). EDGAR (Emissions Database for Global Atmospheric Research) Community GHG Database (a collaboration between the European Commission, Joint Research Centre (JRC), the International Energy Agency (IEA), and comprising IEA-EDGAR CO2, EDGAR CH4, EDGAR N2O, EDGAR F-GASES version EDGAR_2024_GHG. https://edgar.jrc.ec.europa.eu/

European Federation of National Associations of Water Services (2021). Europe's water in figures: An overview of the European drinking water and waste water sectors.

Eurostat (2024). National accounts. https://ec.europa.eu/eurostat/web/national-accounts

Food and Agricultural Organization of the United Nations (2024). Production / crops and livestock products. https://www.fao.org/faostat/en/#data/QCL

Government of Canada (2024). Canada's core public infrastructure survey. https://housing-infrastructure.canada.ca/rd/public-infra-data-donnees-publiques/ccpi-ipec-eng.html

Government and Municipalities of Québec (n.d.). https://donnees.montreal.ca/

Government of Ontario (2023, December). Pavement condition for provincial highways. https://data.ontario.ca/dataset/pavement-condition-for-provincial-highways

gov.ie (2024, June). Schools. https://www.gov.ie/en/schools/

Greece in Numbers (n.d.). Public services / education. https://www.greeceinnumbers.gr/en-gb/Public%20Services/Education

Health New Zealand Te Whatu Ora (unpublished). Health asset register tool.

INRIX (2025). 2024 Global traffic scorecard. https://inrix.com/scorecard/

International Energy Agency (2024). Monthly electricity statistics. https://www.iea.org/data-and-statistics/data-product/monthly-electricity-statistics

International Telecommunication Union (n.d.). https://datahub.itu.int/

I.stat (n.d.). Schools. https://esploradati.istat.it/databrowser/

Kalt, Gerald, Philipp Thunshirn, & Helmut Haberl (2021, September). A global inventory of electricity infrastructures from 1980 to 2017: Country-level data on power plants, grids and transformers, Data in Brief, 38(107351)

Ministry of Education (2019). Education statistics 2018: 2019 publication. https://bibliotecadigital.mineduc.cl/handle/20.500.12365/14293

Ministry of Education (2023). Education in Korea. https://english.moe.go.kr/

Moszoro, Mariano & Mauricio Soto (2022, May). Road quality and mean speed score. IMF Working Papers, 2022(95).

National institute of Statistics and Economic Studies (2024, November). Primary and secondary level educational establishments. https://www.insee.fr/en/statistiques/series/102374311

New Zealand Transport Agency Waka Kotahi (2024, September). Physical statistics – roads. https://www.nzta.govt.nz/planning-and-investment/learning-and-resources/transport-data/data-and-tools/

New Zealand Transport Agency Waka Kotahi (2024, September). Road condition. https://www.nzta.govt.nz/planning-and-investment/learning-and-resources/transport-data/data-and-tools/

National Health Service Digital (2024, December). Estates returns information collection. https://digital.nhs.uk/data-and-information/publications/statistical/estates-returns-information-collection/summary-page-and-dataset-for-eric-2023-24

Norwegian Directorate for Education and Training (n.d.). School size by type of education and ideological basis. https://opendata.cbs.nl/

Nunn, Nathan & Diego Puga (2012, February). Ruggedness: The blessing of bad geography in Africa. The Review of Economics and Statistics, 94(1), pp. 20-36.

Office of Rail and Road (2023, October). Benchmarking the condition of highway networks – Report by TRL Limited. https://www.orr.gov.uk/media/24817

Official Statistics Portal (n.d.). Number of educational institutions, number of pupils and students. https://osp.stat.gov.lt/

Ookla (2024). Speedtest global index. https://www.speedtest.net/global-index

Organisation for Economic Co-operation and Development (2022). Programme for international student assessment (PISA). https://www.oecd.org/en/data/datasets/pisa-2022-database.html

Organisation for Economic Co-operation and Development (2024a). Education at a glance. https://www.oecd.org/en/data.html

Organisation for Economic Co-operation and Development (2024b). Health statistics. https://www.oecd.org/en/data.html

Organisation for Economic Co-operation and Development (2024c). Investment spending in transport infrastructure. https://www.oecd.org/en/data.html

Organisation for Economic Co-operation and Development (2024d). Quarterly transport statistics. https://www.oecd.org/en/data.html

Organisation for Economic Co-operation and Development (2024e). Broadband and telecom databases. https://www.oecd.org/en/data.html

Organisation for Economic Co-operation and Development (2024f). Trends in the transport sector. https://www.oecd.org/en/data.html

Organisation for Economic Co-operation and Development & Eurostat (2024). Joint OECD/Eurostat questionnaire on inland waters.

Republic of Estonia Ministry of Education and Research (2024, June). Statistics and analysis. https://www.hm.ee/en/ministry/statistics-and-analysis

Rijkswaterstaat Ministry of Infrastructure and Water Management (2019). RWS Informatie: Schadebeoordeling – en meetmethoden bovenbouw.

Statistics Canada (2024). National accounts and gross domestic product. https://www150.statcan.gc.ca/n1/en/subjects/economic_accounts/national_accounts_and_gross_domestic_product

Statistics Finland (2025, February). Providers of education and educational institutions. https://stat.fi/en/statistics/kjarj

Stats NZ Tatauranga Aotearoa (n.d.). National accounts. https://www.stats.govt.nz/topics/national-accounts/

Taumata Arowai (2024, June). Network environmental performance report 2022/23.

Te Tāhū Hauora Health Quality & Safety Commission (2022, May). National point prevalence survey of healthcare-associated infections.

United Nations Economic Commission for Europe (2025, January). UNECE sustainable transport division. https://unece.org/transport

United States Energy Information Administration (n.d.). Coal and coke production. https://www.eia.gov/international/data/world/coal-and-coke/coal-and-coke-production

United States Geological Survey (2024, January). Mineral commodity summaries – Iron ore. https://www.usgs.gov/centers/national-minerals-information-center/iron-ore-statistics-and-information

United Nations Statistics Division (2024). National accounts. https://unstats.un.org/unsd/nationalaccount/

Utdannings-direktoratet (n.d.). The Norwegian education mirror 2022. https://www.udir.no/in-english/the-education-mirror-2022/compulsory-education2/number-of-pupils-and-schools

Water New Zealand (2022). National performance review 2021-22. https://www.waternz.org.nz/nationalperformancereview

Wilson, Nick, John Kerr, Adele Broadbent, & Michael Baker (2025, January). Plugging the gap: Aotearoa's piped water loss far worse than global leaders. Public Health Communication Centre Aotearoa.

World Bank (2020, December) Doing business. https://archive.doingbusiness.org/en/doingbusiness

World Bank (n.d.). World development indicators. https://datatopics.worldbank.org/world-development-indicators/

World Economic Forum (2019). Executive opinion survey, 2019 edition.

World Health Organization (2022). Mortality rate attributed to exposure to unsafe WASH services (per 100 000 population) (SDG 3.9.2).

World Resources Institute (2000). Coastal and marine ecosystems – Marine jurisdictions: Coastline length. https://web.archive.org/web/20120419075053/http://earthtrends.wri.org/text/coastal-marine/variable-61.html

Appendix A. Variable list

Table 27: Road infrastructure variables

Category	Variable	Definition	Source	Weight
Investment	Road investment as a share of GDP	Capital expenditure on new road infrastructure, including reconstruction, renewal and upgrades; and non-capital expenditure to maintain the condition and capacity of the existing road infrastructure, as a share of GDP.	OECD-ITF	1
	Road investment per km of road	Capital expenditure on new road infrastructure, including reconstruction, renewal and upgrades; and non-capital expenditure to maintain the condition and capacity of the existing road infrastructure, purchasing power parity adjusted to 2017 US dollars divided by kilometres of roads in the country.	CIA World Factbook, OECD-ITF, UNECE	0
Quantity	Road km per 100 sq. km	Kilometres of all roads per 100 square kilometres of land area.	CIA World Factbook, OECD-ITF, UNECE, World Bank World Development Indicators	1
	Road km per 100 people	Kilometres of all roads per 100 people.	CIA World Factbook, OECD-ITF, UNECE, World Bank World Development Indicators	1
Usage	Annual road freight tonne-km per capita	Any movement of goods using a road vehicle on the road network. Tonne-kilometre: unit of measurement of goods transport which represents the transport of one tonne by road over one kilometre. Average annual road tonne-kilometres per person.	OECD-ITF, World Bank World Development Indicators	0
	Annual road passenger-kilometres travelled per capita	Any movement of passengers using a road vehicle on the road network. Drivers of passenger cars, excluding taxi drivers, are counted as passengers. Service staff assigned to buses, coaches, trolleybuses, trams and goods road vehicles are not included as passengers. Road passenger-kilometre: unit of measurement representing the transport of one passenger by road over one	OECD-ITF, World Bank World Development Indicators	0

		kilometre. Average annual passenger-kilometres per person.		
	Millions of freight tonne-km per km of road	Any movement of goods using a road vehicle on the road network. Tonne-kilometre: unit of measurement of goods transport which represents the transport of one tonne by road over one kilometre. Average annual road tonne-kilometres per kilometre of road.	CIA World Factbook, OECD-ITF, UNECE	1
	Millions of passenger-kilometres per km of road	Any movement of passengers using a road vehicle on the road network. Drivers of passenger cars, excluding taxi drivers, are counted as passengers. Service staff assigned to buses, coaches, trolleybuses, trams and goods road vehicles are not included as passengers. Road passenger-kilometre: unit of measurement representing the transport of one passenger by road over one kilometre. Average annual passenger-kilometres per kilometre of road.	CIA World Factbook, OECD-ITF, UNECE	1
Quality	Paved roads ratio	Paved roads are those surfaced with crushed stone (macadam) and hydrocarbon binder or bituminized agents, with concrete, or with cobblestones, as a percentage of all the country's roads, measured in length.	Bureau of Infrastructure and Transport Research Economics, NZTA, World Bank World Development Indicators	1
	Perceived quality of road infrastructure	Response to the survey question 'In your country, what is the quality (extensiveness and condition) of road infrastructure?' (1 = extremely poor – among the worst in the world; 7 = extremely good – among the best in the world) 2018-19 weighted average or most recent period available.	World Economic Forum Executive Opinion Survey	1
	Road fatalities per 100 million passenger-kilometres travelled	People killed immediately or dying within 30 days because of a road crash, excluding suicides, divided by average annual passenger-kilometres.	OECD-ITF	1
	Road fatalities per 100,000 people	People killed immediately or dying within 30 days because of a road crash, excluding suicides, divided by total population.	OECD-ITF, World Bank World Development Indicators	1
	Rural access index	The proportion of the rural population who live within two kilometres of an all-season road (a road which will not be closed for more than two consecutive days and not more than two weeks per year in total).	Rural Access Index Measurement Tool, World Bank	1

Adjusted mean speed score	The sum of road distance between the largest city and other large cities divided by the travel time, both retrieved from Google Maps, adjusted for the geography of the country.[7]	International Monetary Fund	1
Hours lost in traffic per year	The total number of hours lost per person per year in congestion during peak commute periods compared to off-peak conditions.[8]	INRIX	1
International roughness index	The International Roughness Index is the accumulated suspension displacement of a vehicle as it travels over a road surface, calculated using quarter-car mathematical model of a vehicle's suspension.	Various sources including the Australian Department of Infrastructure, Dutch Rijkswaterstaat, Government and Municipalities of Quebec, Government of Alberta, NZTA, Transport Scotland, UK Office of Rail and Road, US Federal Highway Administration, Welsh Government	0
Road transport greenhouse emissions per capita	Kilograms of greenhouse gas emissions per capita because of road transport, not including road dust resuspension, measured in CO_2-equivalent.	Emissions Database for Global Atmospheric Research Community Greenhouse gas Database, World Bank World Development Indicators	0

[7] For more detail refer to https://www.elibrary.imf.org/view/journals/001/2022/095/article-A001-en.xml
[8] For more detail refer to https://inrix.com/scorecard/

Table 28: Rail infrastructure variables

Category	Variable	Definition	Source	Weight
Investment	Rail investment as a share of GDP	Capital expenditure on new railway infrastructure or extension of existing railways, including reconstruction, renewal and upgrades; and non-capital expenditure to maintain the original condition and capacity of the existing railway infrastructure as a share of GDP.[9]	OECD-ITF	1
Quantity	Rail length per 100,000 people	Total kilometres of railroad track per 100,000 people.	OECD-ITF	1
	Rail length per 100 square kilometres	Total kilometres of railroad track per 100 square kilometres of land area.	OECD-ITF, World Bank World Development Indicators	1
	Share of track electrified	Share of total kilometres of railroad track that are electrified.	OECD-ITF	1
Use	Annual rail goods tonne-kilometres per capita	Any movement of goods using a rail vehicle on the rail network. Tonne-kilometre: unit of measurement of goods transport which represents the transport of one tonne of goods by rail over one kilometre. Average annual rail tonne-kilometres per capita.	OECD-ITF, World Bank World Development Indicators	0
	Annual rail passenger-kilometres per capita	Any movement of passengers using a rail vehicle on the rail network. Members of the train crew are not included as passengers. Passenger-kilometre: unit of measurement representing the transport of one rail passenger by rail over one kilometre. Annual average passenger-kilometres per person.	OECD-ITF, World Bank World Development Indicators	0
	Millions of annual rail goods tonne-kilometres per kilometre of track	Any movement of goods using a rail vehicle on the rail network. Tonne-kilometre: unit of measurement of goods transport which represents the transport of one tonne of goods by rail over one kilometre. Average annual rail tonne-kilometres per kilometre of rail track.	OECD-ITF	1
	Millions of annual rail passenger-kilometres per kilometre of track	Any movement of passengers using a rail vehicle on the rail network. Members of the train crew are not included as passengers. Passenger-kilometre: unit of measurement representing the transport of one rail passenger by rail over one kilometre. Annual average passenger-kilometres per kilometre of rail track.	OECD-ITF	1

[9] Normally, non-capital expenditure would not be included in measures of investment but non-capital expenditure datapoints for some countries were too high to only include what we normally would classify as 'maintenance'.

Quality	Railway greenhouse gas emissions per capita	Kilograms of greenhouse gas emissions per capita because of railway transport, measured in CO_2-equivalent.	Emissions Database for Global Atmospheric Research Community Greenhouse gas Database, World Bank Development Indicators	1
	Perceived efficiency of train services	Response to the survey question 'In your country, how efficient (i.e. frequency, punctuality, speed, price) are train transport services?' (1 = extremely inefficient, among the worst in the world; 7 = extremely efficient, among the best in the world) 2018-19 weighted average or most recent period available.	World Economic Forum Executive Opinion Survey	1

Table 29: Electricity infrastructure variables

Category	Variable	Definition	Source	Weight
Investment	Electricity and gas gross fixed capital formation as a share of GDP	Capital account gross fixed capital formation in 'electricity, gas, steam and air conditioning supply' assets, as a share of GDP	Stats NZ, United Nations Statistics Division	1
Quantity	Distribution circuit-kilometres per capita	Circuit-kilometres of overhead lines and underground cables with a voltage level below 100 kilovolts, per capita.[10]	Kalt, G., Thunshirn, P., & Haberl, H. (2021)	1
	Transmission circuit-kilometres per capita	Circuit-kilometres of overhead lines and underground cables with a voltage level above 100 kilovolts, per capita.[11]	Kalt, G., Thunshirn, P., & Haberl, H. (2021)	1
	Electricity installed capacity	Kilowatts of installed electricity capacity, per capita.	US Energy Information Administration, World Bank World Development Indicators	1
Usage	Net electricity production per capita	Gross electricity production less the electrical energy absorbed by the generating auxiliaries and the losses in the main generator transformers, measure in kilowatt-hours, per capita.	International Energy Agency	1

[10] For more detail refer to https://www.sciencedirect.com/science/article/pii/S2352340921006351
[11] For more detail refer to https://www.sciencedirect.com/science/article/pii/S2352340921006351

Quality	Share of produced electricity lost in distribution	Share of net electricity produced lost due to transport and distribution of electrical energy. Losses in transformers which are not considered as integral parts of the power plants are also included.	International Energy Agency	1
	System average interruption frequency index	The average number of electricity service interruptions experienced by a customer in a year. Includes both planned and unplanned interruptions.	World Bank Doing Business, New Zealand Commerce Commission	1
	System average interruption duration index	The average total duration of outages, in hours, experienced by customers in a year. Includes both planned and unplanned interruptions.	World Bank Doing Business, New Zealand Commerce Commission	1
	Grams of greenhouse gas emissions per kWh of electricity production	Grams of CO_2 equivalent greenhouse gas emissions per kWh of net electricity production.	International Energy Agency	1

Table 30: Water infrastructure variables

Category	Variable	Definition	Source	Weight
Investment	Water supply, sewerage and drainage services gross fixed capital formation as a share of GDP	Capital account gross fixed capital formation in 'water supply, sewerage and drainage services' assets, as a share of GDP.	Eurostat, Statistics Canada, Stats NZ, United Nations Statistics Division	1
Quantity	Drinking water network kilometres per 1,000 people	Kilometres of drinking water pipes per 1,000 people.	European Federation of National Associations of Water Services, Statistics Canada, Water New Zealand	1
	Wastewater network kilometres per 1,000 people	Kilometres of wastewater sewer network per 1,000 people, including both combined sewers (stormwater and wastewater) and separate sewers.	European Federation of National Associations of Water Services, Statistics Canada, Water New Zealand	1

	Share of population connected to public water supply	Share of total population with water supplied by economic units engaged in collection, purification and distribution of water.	Eurostat, Water New Zealand	1
	Share of population connected to public sewerage	Share of total population connected to a system of conduits which collects and conducts wastewater.	Eurostat, Water New Zealand	1
Use	Gross freshwater abstractions m^3 per capita	Cubic metres of freshwater taken from ground or surface water sources, either permanently or temporarily, and conveyed to a place of use, per capita.	OECD	1
	Public water supply m^3 per capita	Cubic metres of freshwater taken from ground or surface water sources, either permanently or temporarily, and used for public water supply, per capita.	OECD	1
Quality	Perceived reliability of water supply	Response to the survey question 'In your country, how reliable is the water supply (lack of interruptions and flow fluctuations)?' (1 = extremely unreliable; 7 = extremely reliable) 2018-19 weighted average or most recent period available.	World Economic Forum Executive Opinion Survey	1
	Mortality rate attributed to exposure unsafe WASH services	Number of deaths resulting from unsafe exposure to drinking water, sanitation, and hygiene services, per 100,000 people.	World Health Organisation	1
	Rate of non-revenue water	Share of water that is pumped then lost or unaccounted for.	European Federation of National Associations of Water Services, Taumata Arowai	1

Table 31: Telecommunication infrastructure variables

Category	Variable	Definition	Source	Weight
Investment	Total investment in fixed, cellular mobile, and other wireless as a share of GDP	Total investment in fixed, cellular mobile, and other wireless, as a share of GDP.	OECD	1
Quantity	Number of fixed broadband subscriptions per 100 people	Total number of fixed broadband subscriptions (fibre/LAN, cable, DSL, fixed wireless, satellite, and other), per 100 people.	OECD	1

	Share of fixed broadband subscriptions that are fibre	The share of total fixed broadband subscriptions that are fibre/LAN.	OECD	1
	Number of fixed broadband subscriptions per 100 people	Number of fixed subscriptions with high-speed access to the public Internet at downstream speeds equal to, or greater than, 256 kbits/s, per 100 people.	World Bank World Development Indicators	1
	Number of mobile broadband subscriptions per 100 people	The number of data, and voice and data only, mobile broadband subscriptions, per 100 people.	OECD	1
	Share of population covered by at least 4G	Share of the population that are within range of at least a 4G/LTE mobile cellular signal, irrespective of whether they are subscribers.	International Telecommunication Union	1
	Share of population covered by 5G	Share of the population that are within range of at least a 5G mobile cellular signal, irrespective of whether they are subscribers.	International Telecommunication Union	1
	Number of mobile cellular subscriptions per 100 people	Number of subscriptions to a public mobile telephone service that provides access to the Public Switched Telephone Network using cellular technology, per 100 people.	World Bank World Development Indicators	1
	Number of fixed telephone subscriptions per 100 people	The number of active analogue fixed telephone lines, voice-over-internet-protocol subscriptions, fixed wireless local loop subscriptions, Integrated Services Digital Network voice-channel equivalents, and fixed public payphones, per 100 people.	World Bank World Development Indicators	1
Use	Fixed broadband traffic per subscription	Gigabytes of traffic generated by fixed broadband subscribers measured at the end-user access point, measured by adding download and upload traffic, divided by the number of fixed broadband subscriptions.	International Telecommunication Union	1
	Mobile broadband traffic per subscription	Gigabytes of broadband traffic originating from within the country from 3G or other more advanced mobile networks, divided by the number of mobile broadband subscriptions.	International Telecommunication Union	1
	Annual SMS per person	Number of mobile short-message service messages sent, both to national and international destinations, divided by the number of mobile cellular subscriptions.	International Telecommunication Union	1
	Annual domestic mobile traffic per person	Total number of minutes of calls made by mobile subscribers within a country, divided by total population.	International Telecommunication Union	1

Quality	Fixed broadband down speed	Typical download speed of a fixed broadband connection, measured in megabits per second.	Speedtest Global Index	1
	Fixed broadband up speed	Typical upload speed of a fixed broadband connection, measured in megabits per second.	Speedtest Global Index	1
	Mobile broadband down speed	Typical download speed of a mobile broadband connection, measured in megabits per second.	Speedtest Global Index	1
	Mobile broadband up speed	Typical upload speed of a mobile broadband connection, measured in megabits per second.	Speedtest Global Index	1

Table 32: Healthcare infrastructure variables

Category	Variable	Definition	Source	Weight
Investment	Human health and social work activities gross fixed capital formation as a share of GDP	Capital account gross fixed capital formation in 'human health and social work activities' assets, as a share of GDP.	Eurostat, OECD, Stats NZ	0
	Human health and social work activities gross fixed capital formation per person	Capital account gross fixed capital formation in 'human health and social work activities' assets, purchasing power parity adjusted to 2017 US dollars per person.	Eurostat, OECD, Stats NZ	1
Quantity	Number of hospital beds per 1,000,000 people	Total number of hospital beds (somatic and psychiatric; public and private), per 1,000,000 people.	OECD	1
	Number of medical machines per 1,000,000 people	Number of radiation therapy equipment, mammographs, gamma cameras, positron emission tomography scanners, magnetic resonance imaging units, and computed tomography scanners, per 1,000,000 people.	OECD	1/6 each
Use	Annual bed days per person	Total number of days in which a person admitted as an inpatient is confined to a bed and in which the patient stays overnight in a hospital, divided by total population. Includes curative care in all hospitals, excludes day cases and bed days of healthy newborns.	OECD	1
	Average length of hospital stays	Total number of days in which a person admitted as an inpatient is confined to a bed and in which the patient stays overnight in a hospital, divided by the number of discharges during the year. Includes curative care in all hospitals, excludes day cases and average length of stay for healthy newborns.	OECD	1

	Average occupancy rate of hospital beds	The occupancy rate is calculated as the number of bed days divided by the number of beds available multiplied by the number of days in the year. OECD data is only for somatic curative care occupancy rates. We estimate the number of psychiatric curative beds to get the occupancy rate for all curative beds. This allows us to estimate the curative hospital bed occupancy rate for New Zealand, Korea, Iceland, Finland, and Sweden where previously data was missing.	OECD	1
Quality	Waiting times for elective surgeries	Mean waiting time in days from specialist assessment to treatment for cataract surgeries, transluminal coronary angioplasties, coronary artery bypass grafts, prostatectomies, hysterectomies, hip replacements, and knee replacements. Data is presented as the percentage difference from the OECD mean, and percentage difference from the benchmark country mean.	OECD	1/7 each
	Healthcare-associated infection rate	Share of patients who acquire an infection during their stay in a hospital or another healthcare setting	European Centre for Disease Prevention and Control, Health Quality and Safety Commission	1
	Age of hospital buildings	Distribution of the share of hospital buildings built within a given period	Definitive Healthcare, Health Asset Register Tool, National Health Service	0

Table 33: Education infrastructure variables

Category	Variable	Definition	Source	Weight
Investment	Education gross fixed capital formation as a share of GDP	Capital account gross fixed capital formation in 'education' assets, as a share of GDP.	Bureau of Economic Analysis, OECD, Stats NZ	1
	Education gross fixed capital formation per 5–25-year-old	Capital account gross fixed capital formation in 'education' assets, purchasing power parity adjusted to 2017 US dollars per person aged 5 to 25 years old (inclusive).	Bureau of Economic Analysis, OECD, Stats NZ	1

	Number of schools per 100,000 people	Total number of primary and secondary schools, per 100,000 people.	Australian Bureau of Statistics, British Educational Suppliers Association, Council of Ministers of Education Canada, Czech Statistical Office, Education Counts, Greece in Numbers, Irish Government, I.Stat (Italy), Ministry of Education (Chile), Ministry of Education (Korea), National institute of Statistics and Economic Studies (France), Norwegian Directorate for Education and Training, Official Statistics Portal (Lithuania), Republic of Estonia Ministry of Education and Research, Statistics Finland, Statistics Netherlands, World Bank World Development Indicators	1
Quantity	Number of schools per 100,000 primary and secondary students	Total number of primary and secondary schools, per 100,000 primary and secondary students.	Australian Bureau of Statistics, British Educational Suppliers Association, Council of Ministers of Education Canada, Czech Statistical Office, Education Counts, Greece in Numbers, Irish Government, I.Stat (Italy), Ministry of Education (Chile), Ministry of Education (Korea), National institute of Statistics and Economic Studies (France), Norwegian Directorate for Education and Training, OECD, Official Statistics Portal (Lithuania), Republic of Estonia Ministry of Education and Research, Statistics Finland, Statistics Netherlands	1
	Average primary and secondary school size	Number of primary and secondary students, divided by the total number of primary and secondary schools.	Australian Bureau of Statistics, British Educational Suppliers Association, Council of Ministers of Education Canada, Czech Statistical Office, Education Counts, Greece in Numbers, Irish Government, I.Stat (Italy), Ministry of Education (Chile), Ministry of Education (Korea), National	1

			institute of Statistics and Economic Studies (France), Norwegian Directorate for Education and Training, OECD, Official Statistics Portal (Lithuania), Republic of Estonia Ministry of Education and Research, Statistics Finland, Statistics Netherlands	
Use	Share of population that are students	Number of students enrolled in primary education, lower secondary education, upper secondary education, post-secondary non-tertiary education, and tertiary education, divided by the total population.	OECD, World Bank World Development Indicators	1
Quality	Share of 15-year-old students affected by a lack of educational material	Share of 15-year-old students whose principal responds either 'not at all', 'very little', 'to some extent', or 'a lot' to the question 'is your school's capacity to provide instruction hindered by a lack of educational material (e.g. textbooks, IT equipment, library or laboratory material)?'.	Programme for International Student Assessment	1
	Share of 15-year-old students affected by inadequate or poor-quality education material	Share of 15-year-old students whose principal responds either 'not at all', 'very little', 'to some extent', or 'a lot' to the question 'is your school's capacity to provide instruction hindered by inadequate or poor-quality educational material (e.g. textbooks, IT equipment, library or laboratory material)?'.	Programme for International Student Assessment	1
	Share of 15-year-old students affected by a lack of physical infrastructure	Share of 15-year-old students whose principal responds either 'not at all', 'very little', 'to some extent', or 'a lot' to the question 'is your school's capacity to provide instruction hindered by a lack of physical infrastructure (e.g. building, grounds, heating/cooling, lighting and acoustic systems)?'.	Programme for International Student Assessment	1
	Share of 15-year-old students affected by inadequate or poor-quality physical infrastructure	Share of 15-year-old students whose principal responds either 'not at all', 'very little', 'to some extent', or 'a lot' to the question 'is your school's capacity to provide instruction hindered by inadequate or poor-quality physical infrastructure (e.g. building, grounds, heating/cooling, lighting and acoustic systems)?'.	Programme for International Student Assessment	1

Share of 15-year-old students affected by a lack of digital resources	Share of 15-year-old students whose principal responds either 'not at all', 'very little', 'to some extent', or 'a lot' to the question 'is your school's capacity to provide instruction hindered by a lack of digital resources (e.g. desktop or laptop computers, internet access, learning management systems or school learning platforms)?'.	Programme for International Student Assessment	1
Share of 15-year-old students affected by inadequate or poor-quality digital resources	Share of 15-year-old students whose principal responds either 'not at all', 'very little', 'to some extent', or 'a lot' to the question 'is your school's capacity to provide instruction hindered by inadequate or poor-quality digital resources (e.g. desktop or laptop computers, internet access, learning management systems or school learning platforms)?'.	Programme for International Student Assessment	1

Appendix B. Creating comparison scores and whisker graphs

Overall Approach

This appendix will outline how we created a figure showing New Zealand's relative positions on investment, quantity, usage, and quality of investment (parameters). This information is basis for the 'whisker' graphs we use to display the benchmarking results. It will also outline the advantages and disadvantages of this approach.

For most parameters, we found multiple metrics and variables. To improve the interpretability of our results, we sought to combine these into one 'score'. At a high level, the following steps were taken to create a relativity score:

1. For each parameter, for each metric, each country's value is normalised to be the difference from the OECD average.
2. For each country, all metrics for a given parameter are averaged using a simple average without weights.
3. The range and average of the benchmark countries is calculated as the upper bound, lower bound, and average country for Step 2.
4. New Zealand is compared to this range and average.

The following example shows how we created the comparative statistic and whisker graph for the quantity of road infrastructure.

We created two metrics for this parameter: Road kilometres per 100 square kilometres of land area and road kilometres per 100 people.

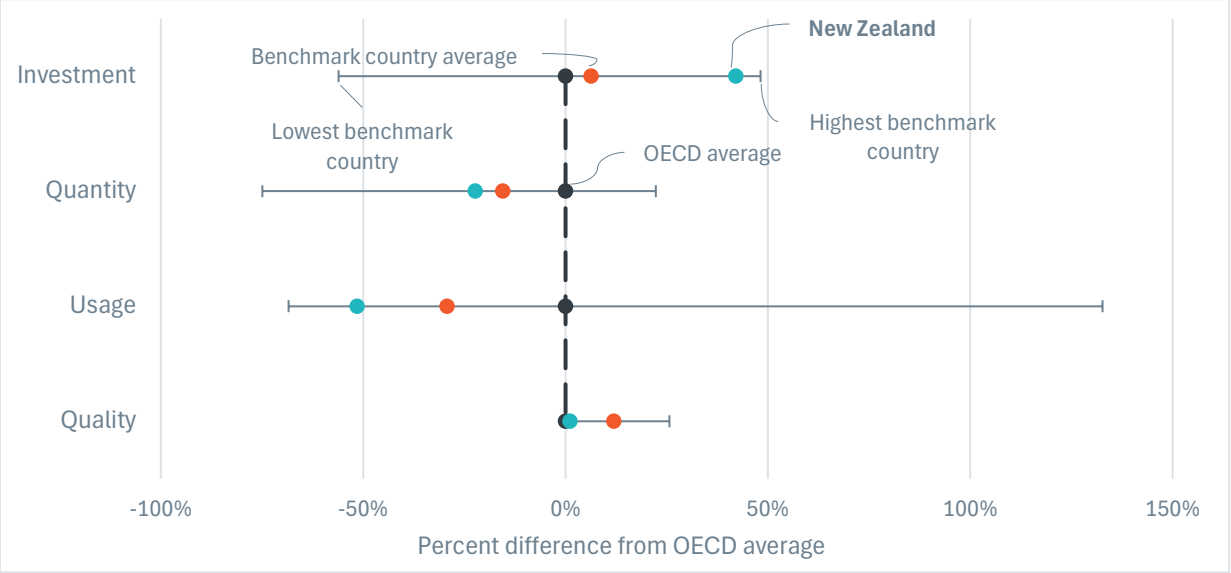
The difference from the OECD average for these two metrics for our benchmark countries are shown in the table below. The overall quantity parameter is then the simple average of these two variables, shown in the right most column.

Table 34: Quantity variables for road infrastructure

	(A) Difference from OECD average	(B) Difference from OECD average	(C) Simple average of (A) and (B)
Country	Road km per 100 sq. km	Road km per capita	Quantity
Spain	-74%	-76%	-75%
Norway	-79%	19%	-30%
Finland	-71%	34%	-18%
Sweden	-61%	29%	-16%
Canada	-90%	102%	6%
Czechia	35%	-17%	9%
Iceland	-90%	134%	22%
New Zealand	-71%	26%	-22%
		Minimum	-75%
		Benchmark country average	-16%
		Maximum	22%

This is done for each of the parameters (investment, quantity, usage, and quality). The values for New Zealand, the benchmark country average, the minimum benchmark country, and the maximum benchmark country are then shown on a whisker graph like the one below.

Figure 39: Road benchmarking results



Discussion and sensitivity of our results

Creating simple comparison scores across multiple metrics for international benchmarking requires a careful interpretation of the result.

We opted for this approach because it has some clear advantages for interpretability:

- It allows us to easily compare New Zealand against both the OECD average and the benchmark country average.
- By including the lowest and highest benchmark countries, we gain information about the distribution of metrics across countries within each parameter.

However, we recognise some of the drawbacks of our approach.

The main drawback involves the weighting of different metrics. Within each parameter, we generate a comparative percentage with a simple average, implicitly weighting each variable equally. A more robust approach would apply weights to these metrics depending upon the relative importance of input and output measures.

For instance, with measures of road quantity, we equally weight the scale of the road network relative to land area and the number of people in a country. This implies countries should rate the importance of a road network that serves people and a network that geographic parts of the country (even if there is no one living there) equally.

We plan on updating our international benchmarking work in the future to account for this.

The other main drawback is that for many parameters, the number of metrics is not the same for each country. For instance, for measures of quality, a given country may have five complete metrics, while another would only have three. This means that the overall score for the country (column C above) is the simple average of five metrics for one country, but only three for another.

It is possible that our results would change if we only created a score for only countries that had complete data for all metrics.

Finally, this approach does not allow us to make assessments about the efficient or optimal amount or quality of infrastructure. Rather it just compares New Zealand against countries identified as similar and against the OECD average. We have identified this as an area for future work.

Stability analysis

The tables below outline the stability analysis we completed for the road infrastructure measures. Each set of weights (A to G) removes a certain variable from the calculation of the score for that parameter. This allows us to see how sensitive our results are to inclusion or exclusion of certain variables.

Table 35 shows the weights we used to test the stability of the road parameters. A 0.00 means that the variable was removed when using that set of weights.

Table 35: Weights used for analysing the stability of road parameters

Weights	Original weights	A	B	C	D	E	F	G
Road spending	1.00							
Road km per capita	1.00	0.00	1.00					
Road km per 100 sq. km	1.00	1.00	0.00					
Passenger-km to road length	1.00	0.00	1.00					
Freight tonne-km to road length	1.00	1.00	0.00					
Paved roads ratio	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00
Perceived quality of road infrastructure	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00
Road fatalities to passenger-km	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00
Road fatalities per 100,000 people	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00
Rural access index	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00
Adjusted mean speed score	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00
Hours lost in traffic	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00

Table 36 below shows how the results vary when using the weights above. As we can see from the minimum, median, and maximum at the bottom of the table, New Zealand's results are stable and don't change much when different combinations of variables are used. Investment does not change as there is only one variable used.

Table 36: Stability of road parameters

	Difference from OECD average			
Weighting used	Investment	Quantity	Usage	Quality
Original weights	33.6%	-20.1%	-32.9%	-12.4%
A		-21.5%	-31.1%	-14.5%
B		-19.4%	-34.7%	-13.3%

C				-14.6%
D				-6.3%
E				-14.0%
F				-13.4%
G				-11.0%
Minimum	33.6%	-21.5%	-34.7%	-14.6%
Median	33.6%	-20.1%	-32.9%	-13.4%
Maximum	33.6%	-19.4%	-31.1%	-6.3%

We also stability tested the results for rail infrastructure, electricity infrastructure, and health infrastructure. The results for electricity and health are largely stable when using different combinations of variables.

The results for rail infrastructure show the greatest amount of instability when using different combinations of variables. There is instability in the usage parameter and in the quality parameter. Instability in the usage parameter comes from there being only two variables (passenger usage and freight usage), which vary greatly from one another for New Zealand. This means when we only use freight usage, New Zealand is above the OECD average, but when we only use passenger usage, New Zealand is well below the OECD average. When these variables are given equal weight (as they are in the body of this report) New Zealand is below average on usage. This highlights the potential for exploring a more robust approach to weighting variables.

Instability in the quality parameter also comes from there being only two variables which measure very different things. Other, more stable sectors, such as electricity and health, benefit from a greater number of metrics.

We haven't tested telecommunications, water, or education infrastructure. However, of these, telecommunications and education are most likely to be unstable. Telecommunications due to similar reasons to rail usage (limited variables measuring very different things i.e. fixed broadband focused measures verses mobile telecommunications measures). Education due to similar reasons to rail quality (limited number of variables, apart from for education quality).

Overall, our stability testing highlights that there is potential for improving the way that we weight variables.