New Zealand's infrastructure challenge

Quantifying the gap and path to close it

Final Report

October 2021

SENSE PARTNERS

DATA LOGIC ACTION

Key points

New Zealand has an infrastructure deficit. We need around $104b more public capital to meet the current shortfall. If we keep investing at the current rate, we will not keep up with renewals and future demand. We will be short by another $106b in 30 years' time (in today's prices).

Because our current and future investments will need renewing and upgrading, the total bill to spend our way out of our infrastructure challenges over 30 years would be more than $1 trillion (in today's prices). There are binding political and financial constraints in borrowing and investing such large sums. The infrastructure construction workforce would need to grow from around 40,000 now to 78,000 in 15 years, and 97,000 at year 30 – which would drive up costs due to labour shortages.

The size of the challenge is too large to fix by simply investing more. Adding more infrastructure doesn't always lead to better economic outcomes either. For example, more roads can also lead to more driving and hence more congestion, which is a cost to society. Rather, we need to invest more as well as reduce demand, increase efficiency and do better integrated spatial planning.

The historical deficit arose out of a slump in investment in the 1980s and 1990s. A recovery in investment since the early 2000s hasn't been enough to meet our infrastructure needs.

The same issues will affect us in the future. Adapting and responding to climate change and other factors such as service level improvements (like safer roads and improved earthquake resilience) will add to cost.

Each asset comes with a long tail of maintenance and renewal spending. Almost 60% of investment should go towards renewals – arguably not keeping up with renewals has been contributed heavily to the current deficit.

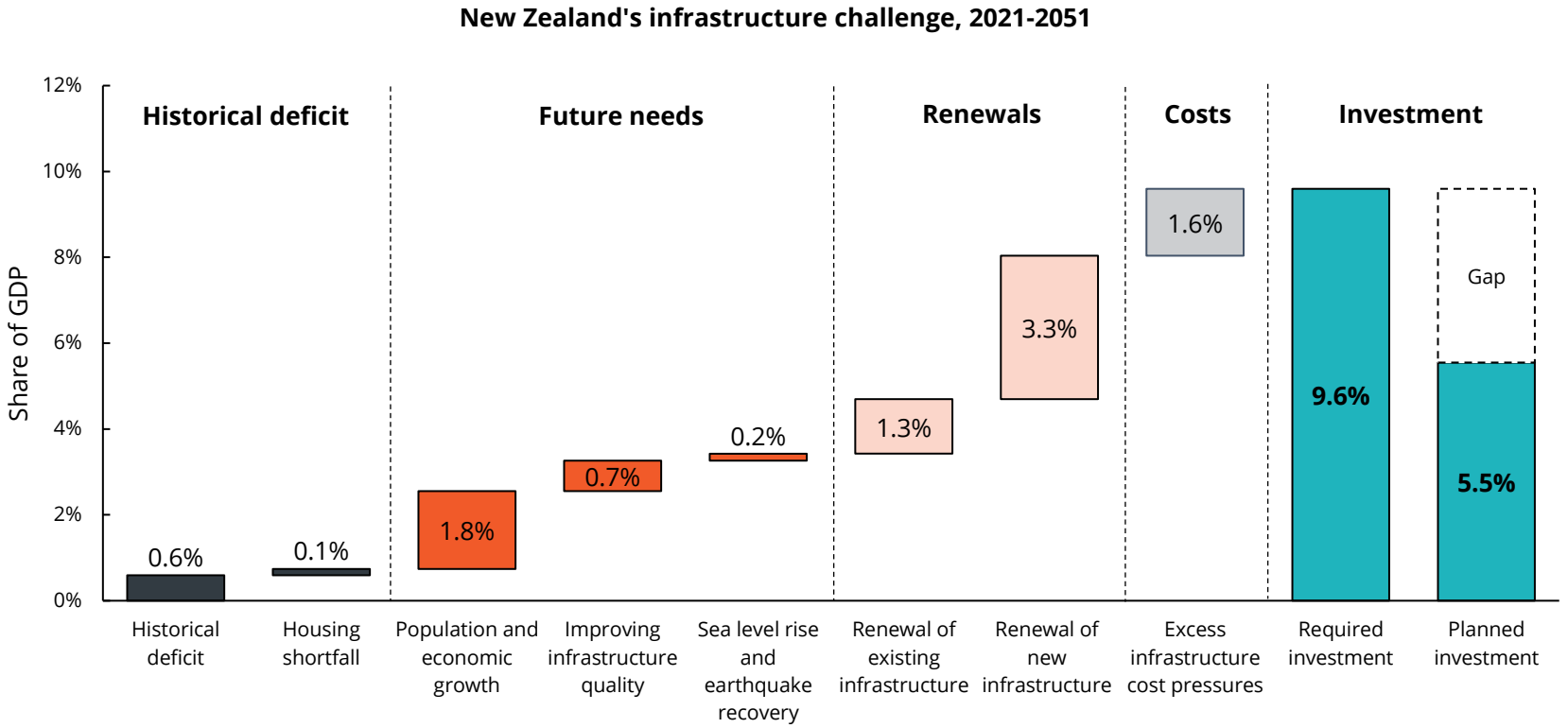
We cannot build our way out of the infrastructure challenge. To close both deficits with increased investment alone will require a near doubling of investment as a share of the economy. Public investment is currently around 5.5% of GDP. Nearly doubling this would create a fiscal burden, unlikely to be palatable to both local and central government. It would also require a larger workforce to plan, deliver and maintain the additional infrastructure.

Policy makers can respond to unmet need using four basic tools: demand management, new infrastructure, efficiency improvements and spatial planning. The choice or mix of tools will depend on the project, economic and political context, but all levers should be used.

Our top-down estimates are a useful guide of how much investment is needed, but it does not tell us what or where. The gold standard is to develop a pipeline of projects with clearly defined goals and trade-offs to improve the financing and delivery of infrastructure.

Policy makers face key uncertainties in addressing infrastructure gaps: accurately forecasting demand and the financing, coordination, and delivery of infrastructure projects. Efforts to improve project development, investment environment and standardisation of systems would also help reduce the complexity and uncertainty of infrastructure investment. There are no easy solutions. We must pull all levers to address our infrastructure challenges.

Figure 1: Investment would have to nearly double to invest our way out of our infrastructure deficit



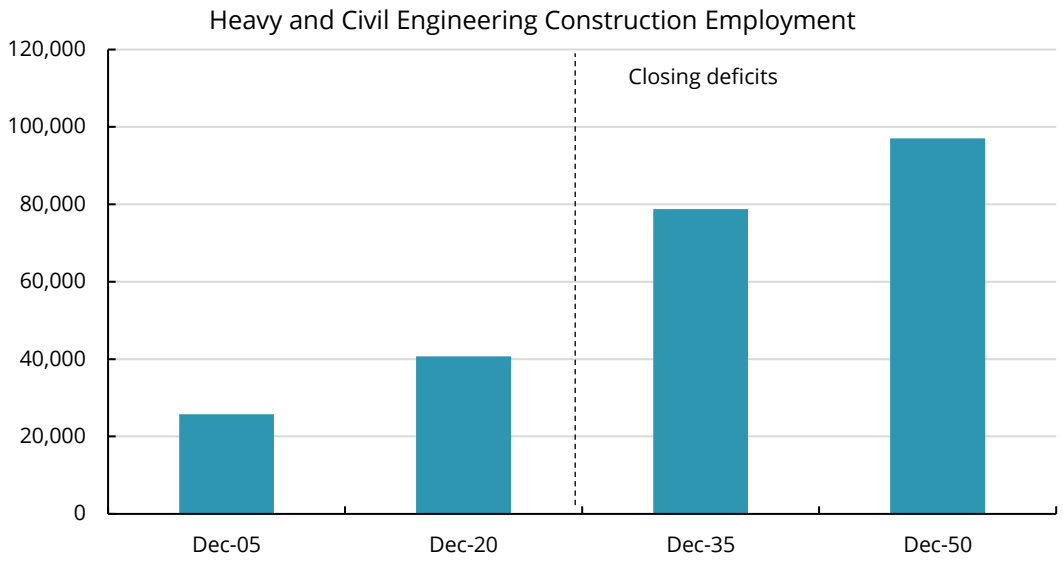
Source: Sense Partners

Figure 2: We conservatively estimate significant infrastructure deficits: both historical and future

Rounded to nearest $100m, 2020$	**Central government**	**Local government**	**Total**
Historical deficit			
Starting shortfall based on target private to public capital ratio	65,200	17,800	83,000
Housing shortfall (115k overcrowded)	12,000	8,600	20,600
Total known shortfall 2020	77,200	26,400	103,600
Future deficit			
Shortfall at current investment rate	67,200	16,200	83,400
Sea-level rise	13,100	9,400	22,500
Estimated future shortfall in 30 years	80,300	25,600	105,900
Estimated total infrastructure deficit	**157,500**	**52,000**	**209,500**
Memo item:			
Net capital stock, 2020	144,586	94,926	239,512

Source: Sense Partners

Figure 3: Closing deficits with investment alone would need the workforce to double



Source: Sense Partners

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1. Introduction

The Infrastructure Commission asked Sense Partners to extend earlier work on the infrastructure deficit for the Association of Consulting and Engineering (ACE) New Zealand[1] by adding greater detail, analysis and projected scenarios to close the deficit over the Commission's 30-year strategic time horizon.

2. Infrastructure deficit: definition, causes and approaches

Infrastructure is broadly defined. Infrastructure services are delivered through complex and costly network systems.[2] Infrastructure can cover transport, power, telecommunications, and water supply and sanitation services. In this report, we focus on the network assets held in government ownership (both local and central government). Around 88% of public sector assets are built environment related and exclude land (or non-produced assets). We leave aside private sector investment in infrastructure assets, as private investment has largely kept pace with demand.

Another way to think about infrastructure is through scale effects. Initial investments in infrastructure are large, but the marginal cost of servicing additional customers is usually low and decreasing.[3] This is not the case if there is a deficit, which is where New Zealand finds itself, as large marginal investments are required to fill both the shortfall and to meet future growth.

2.1. Defining the deficit

Infrastructure planning takes place amidst accumulation of past decisions, uncertainty of future demand, future environmental stresses, changing fiscal space and the political and institutional economy. It is difficult to maintain an optimal quantity and quality of infrastructure across all cycles.[4] Lumpy development timelines and data gaps make it unclear how much infrastructure is required and where.

We take a top-down macro approach to quantify the infrastructure gap for New Zealand and required investment to close the deficit over a 30-year period. The estimates are sensitive to input assumptions and should be seen as an input into a planning exercise.

Infrastructure gaps refer to demand for infrastructure services and an accompanying shortfall in supply. There are two broad approaches:

- **Historical infrastructure deficit** or the shortfall in quantity and/or quality of infrastructure today. For example, the Report Card for America's Infrastructure evaluates

[1] Sense Partners, 2020.
[2] Rozenberg & Fay, 2019.
[3] Asian Development Bank, 2017.
[4] Rozenberg & Fay, 2019.

infrastructure quality against current capacity. It scores this against metrics of current physical condition, funding, potential to meet future need, operation, maintenance, public safety, resilience and innovation using a letter grade.[5] It signals infrastructure suitability. There are sources that put a dollar figure on how much investment is required to bring the current stock of infrastructure up to a desired level. This is the historical deficit.

- **Future infrastructure deficit** is "the difference between a country's investment need, and what would be spent under current trends".[6] This is a forward-looking definition.

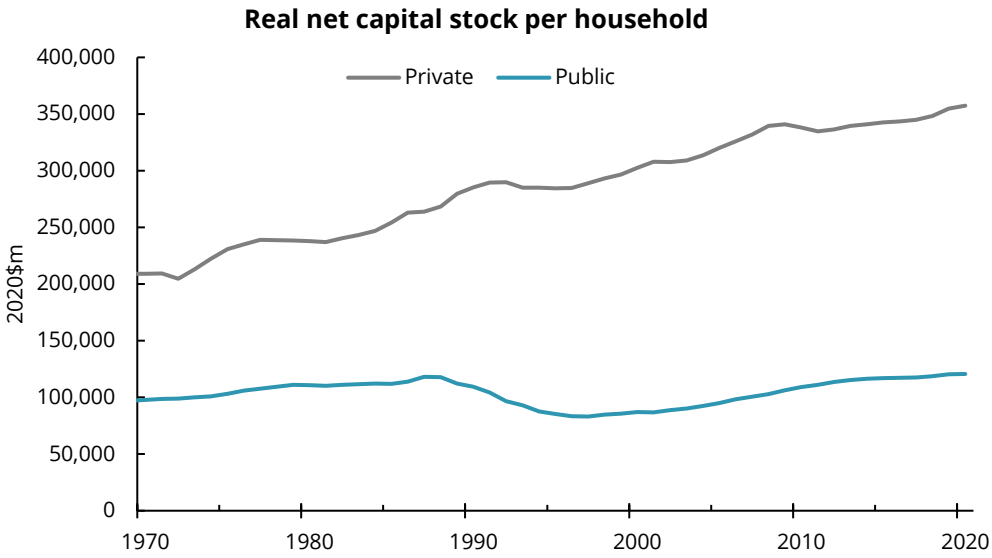
Both these deficits matter.

2.2. Measuring the deficit

There are three broad methods to measure deficits:

1) **Macro approach:** Top-down estimates of required versus actual rates of investment. This is the approach we take, looking at public sector investment relative to private sector.

Figure 4: Stock of private capital has trended higher over time, but public capital has not



Source: Stats NZ, Sense Partners

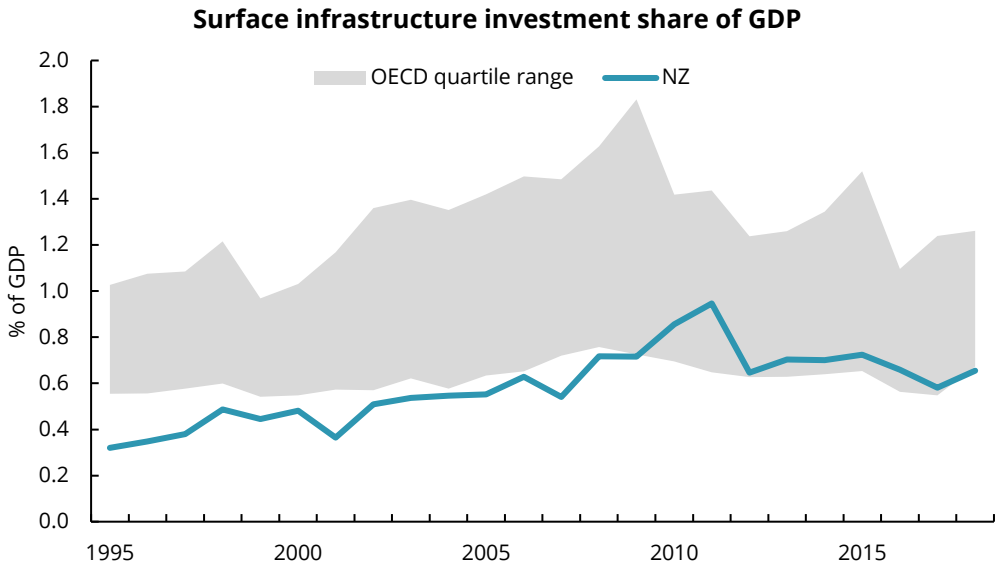
- Macro estimates of infrastructure gaps are measured at industry (electricity or ports, for example) or asset class (civil and heavy engineering construction, non-residential construction or public sector) levels[7] – for example, the ratio of public to private sector investments.

[5] https://infrastructurereportcard.org/
[6] Oxford Economics, 2017.
[7] OECD, 2016.

- This is the approach we take. We assume that private sector investment has kept pace with underlying economic need and that public investment has lagged (Figure 4).
- If a shortfall appears in private sector investment, there will be an economic opportunity for someone to close it unless there are regulations or other binding barriers stopping it from happening (for example, building a dirty coal burner, which is banned).
- We use this divergence to measure how much public infrastructure capital we should have now and how much we should have in 30 years' time.

2) **Cross-country comparison:** Cross-country comparisons of investment and capital stock relative to GDP. This does not account for geographic and measurement issues. We do not pursue this approach.

Figure 5: New Zealand's investment in land transport is near the lower end of the OECD



Source: OECD, Stats NZ, Sense Partners

- Top-down measures sometimes compare infrastructure investment or capital stock as a share of GDP between countries.[8] However, cross-country comparisons do not capture geographic differences (for example, some places may need more infrastructure spread over a large area or may have difficult terrain) and are often affected by data measurement issues. We do not pursue this approach here.
- However, our cross-country analysis shows that New Zealand followed a similar pattern of reduced public sector investment since the 1980s relative to other OECD countries, but surface infrastructure investment level of spending (as a

[8] Woetzel et al., 2016.

share of the economy) has been near the bottom quartile of OECD countries (Figure 5).

3) **Bottom-up 'pipeline' approach:** Often considered the preferable approach, if it looks at not just what is planned but what is required subject to stated goals.

- Bottom-up approaches, such as regional infrastructure pipelines, are preferable. They deal with specific locations and needs.
- They require identification of a specific goal, meaning greater transparency around why projects were chosen and how they were prioritised.[9]
- Such needs-based assessments are easier to quantify and coordinate than in the aggregate.[10]
- City or region-based analysis for infrastructure makes more sense, as countries are effectively networks of regional economies. Infrastructure needs to be prioritised and coordinated at a subnational or regional level.[11]
- This makes investments easier to coordinate. This is work currently being undertaken by the Commission and is perhaps the best way to quantify renewals, improvements, gaps and future proofing required. That is not the remit of this report.

[9] Ibid.
[10] Rozenberg & Fay, 2019.
[11] Cisneros & Fulton, 2021.

3. Our approach to estimating the deficit and closing it

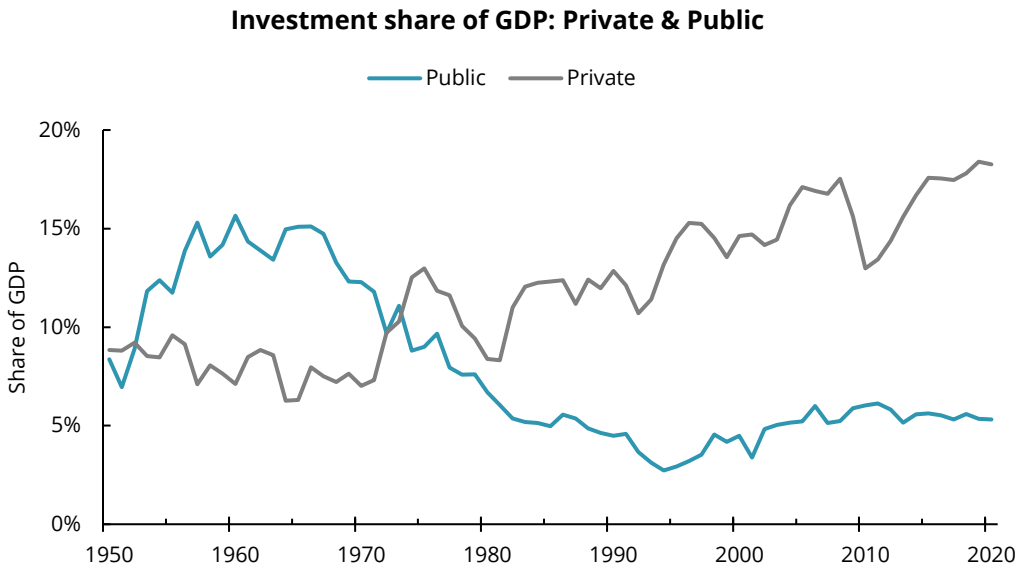
We constructed a long-term database of investment data from national accounts, with most indicators beginning in 1950. We are interested in:

- net real capital stock (which includes estimates of depreciation and is valued at replacement cost)
- gross fixed capital formation (capital spend)
- price deflators
- GDP
- population
- households
- employment in the Heavy and Civil Engineering Construction sector.

We define infrastructure for this report as the public sector owned stock of assets. While there are other measures, such as infrastructure network assets, or wider definitions that include social or all housing, our analysis shows much of the underinvestment has been in the public sector rather than private (Figure 6).

As per the literature, we establish both historical and future infrastructure deficit estimates.

Figure 6: Public investment has been low for decades, although improved since the early 2000s



Source: Stats NZ, Sense Partners

3.1. Historical deficit of $104b

We estimate a historical infrastructure deficit of $104b. This is made up of a shortfall in public investment relative to the private sector and the estimated infrastructure necessary for 115,000 additional homes (to eliminate current overcrowding).

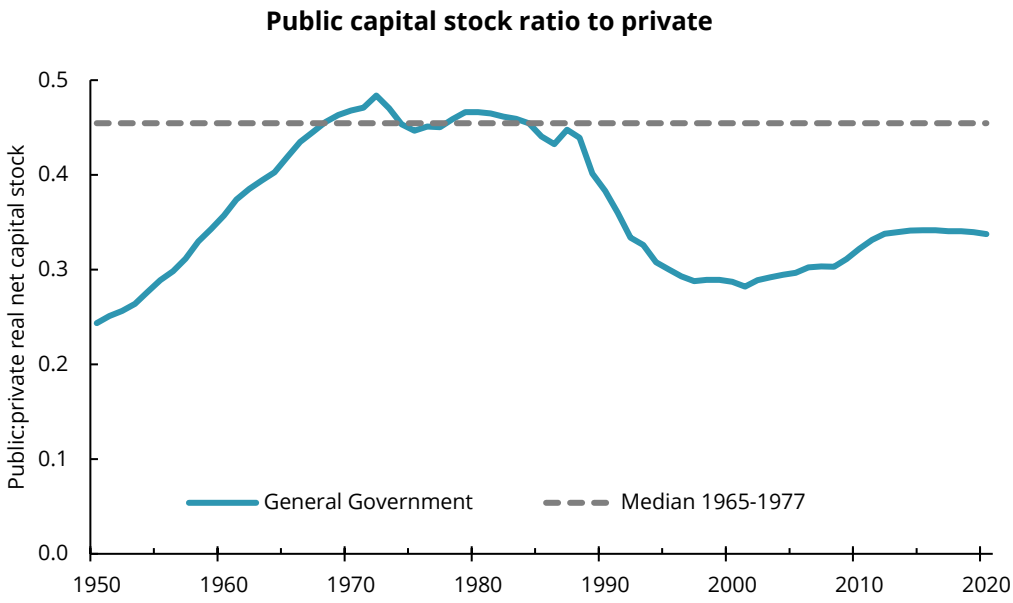
We take the following approach:

- We assume that public and private capital should move in tandem. They both provide necessary capital for economic activity. We assume private investment and capital have increased largely in line with demand and commercial and regulatory constraints. We assume constant returns to scale between private and public capital.
- This may not hold for every infrastructure asset, some of which may have large economies of scale such as the ultrafast fibre broadband network. If this were applied generally, we would need less public capital relative to private capital. However, international evidence suggests that is not the generalised case – private and public capital move together (cointegrated).[12] We make this simplifying assumption, supported by literature, and our own local experience where the lack of public investment appears to have led to substantial costs, such as through traffic congestion, crumbling water and sewerage assets, and insufficient housing supply.
- Over 1965–1977, public and private sector capital were in balance (Figure 7) – we set this as our target or ideal ratio of public to private capital. This assumption is very sensitive. The periods before and after were affected by special circumstances. Before 1965 was a long period of nation building to deal with deficits. 1978 was the onset of the second Oil Shock, which was followed by the Think Big era of public investment (which included investments that were later found to be uneconomic) and then the economic reforms of the 1980s (which included significant public asset sales and a long period of fiscal consolidation and depressed investment). Since the 2000s, public investment has steadily increased, but not enough to recover from the decades of underinvestment in the 1980s and 1990s.
- Based on our ideal balance of public and private capital stock (Figure 7), we estimate the infrastructure deficit was $83b in 2020.
- We then add an estimate for housing shortfall. Currently, there are 115,000 households in overcrowded homes. If new infrastructure capital is created for these households so they are no longer overcrowded, the additional capital would be $21b.
- Our historical deficit is the sum of the ideal public to private capital stock and the infrastructure associated with the housing shortfall. The total is $104b.
- We cross-check this estimate with another approach. We look at how much public capital we currently have for each household at replacement cost versus how much we are investing in each new household (or the additional rate). For each household, we currently

[12] Dreger et al. (2015)

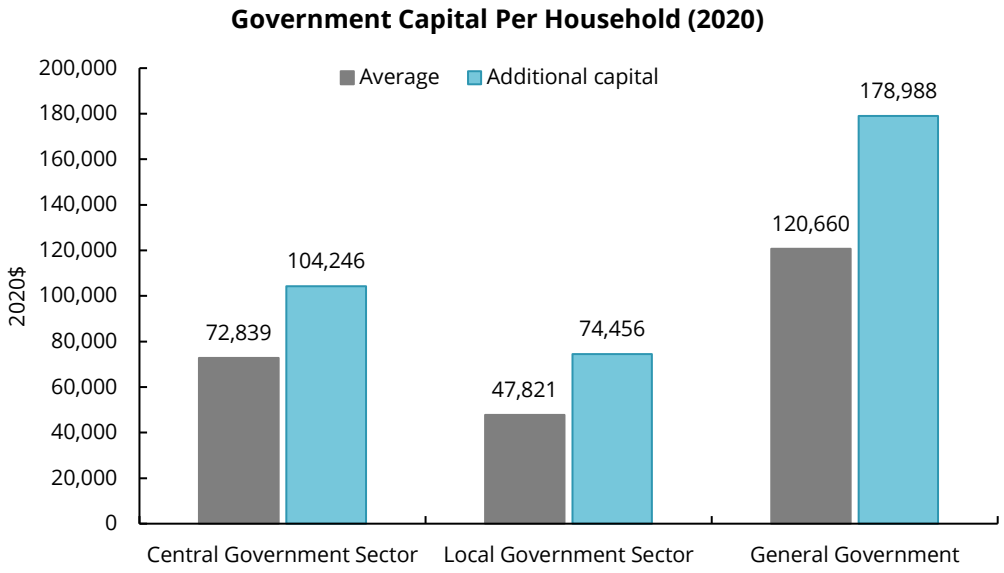
have $121,000 of public capital stock, but for each new household, we are increasing the capital stock by $179,000 (Figure 8). Across 1.8 million households, this difference equates to a deficit of $106b, which is very similar to our other estimate.

Figure 7: Public capital has not kept pace with underlying demand



Source: Stats NZ, Sense Partners

Figure 8: The cost of servicing additional new demand is high in New Zealand, as we often have to deal with past under-investment



Source: Stats NZ, Sense Partners

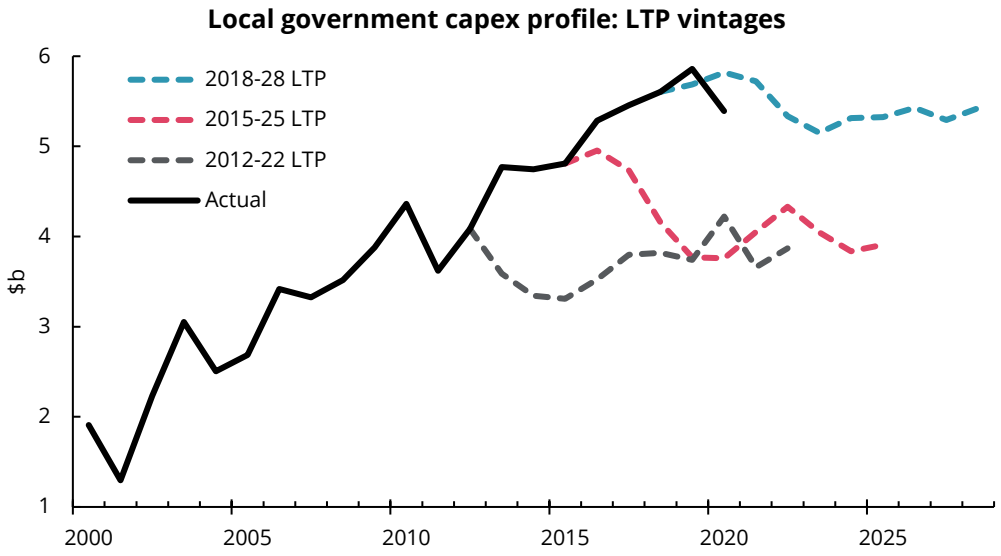
3.2. Additional future deficit of $106b

We estimate the additional future deficit based on current trends will be $106b in 30 years – that is, current investment rates are not enough to meet renewals, service quality increases and demand growth.

We take the following approach:

- We assume our ideal balance of private and public capital (as used in the historical deficit calculations) holds in the future. We project forward investment by the private and public sectors at current rates. We use the Government's published forecasts in the Budget for available years and the Long-Term Fiscal Model projections for outer years.
- We assume that, in the absence of action of address infrastructure deficits, the investment share of GDP remains the same over the projection period. Public investment is assumed to be 5.5% of GDP and private investment 17% of GDP (the average of the decade to 2020). We do not use planned capital expenditure by central and local government, which does not project forward 30 years, and past projections have been too conservative (Figure 9).

Figure 9: Planned infrastructure spending is not a reliable guide for future investments

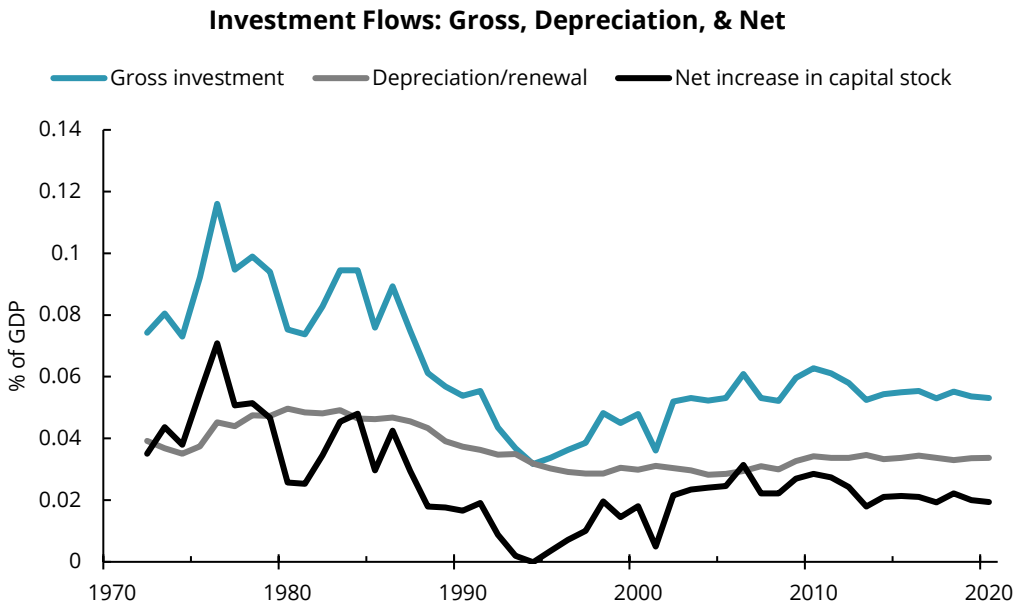


Source: Stats NZ, DIA

- We assume depreciation (consumption of fixed capital) also remains stable at 4.6% of capital stock for both public capital, and 5.2% for private capital (which has been stable around these rates for the past decade). Around 60% of investment spending should be on renewals to offset depreciation (Figure 10 and Figure 11) – although planned renewal is below this at 43% (Figure 12). Arguably, investment to date has not been sufficient to offset depreciation, service level improvements, and demand growth.

- We estimate that, at current patterns, and in addition to the historical deficit, the future public capital stock will be $83b lower than our ideal level at current prices.
- In the data, we also observe increases in the levels of service – for example, investment spending to increase drinking water quality, road safety, or improved resilience to natural hazards. These increases account for nearly a third of planned capital investment by local government, for example (Figure 12). Based on past trends, we estimate that spending to increase service levels will be similar in magnitude to spending to service growth.
- We also include indicative assumption for the cost of natural hazards, focusing on the impacts of rising sea levels and earthquake recovery. Rising sea levels are likely to affect $5.2b of local government assets.[13] Combined with associated complementary central government assets, the total bill is likely to be around $12.5b in today's prices. In addition, even one major earthquake similar to the 2011 Canterbury Earthquake or the 2016 Kaikoura Earthquake could cost $10 billion for infrastructure restoration. These estimates are illustrative at best, as we do not account for potentially higher costs of infrastructure delivery in more difficult terrain or the impact of more extreme weather events as opposed to just higher sea-levels.
- We estimate the additional future deficit will total $106b in today's prices if current investment trends continue, and we account for service-level changes and rising sea-level impact on public infrastructure.

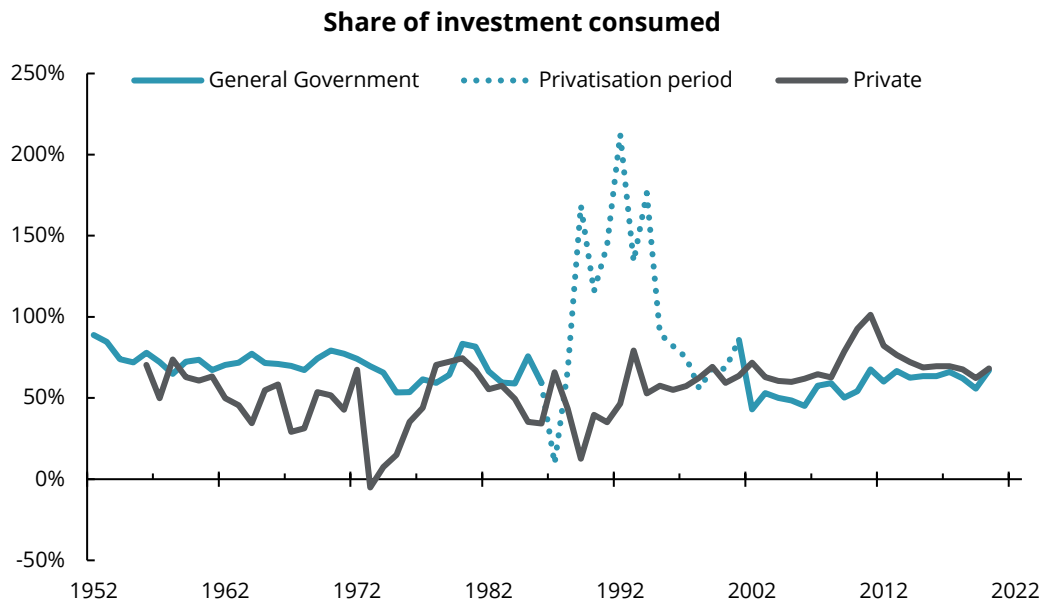
Figure 10: Around 60% of investment spending is on renewals…



Source: Stats NZ, Sense Partners

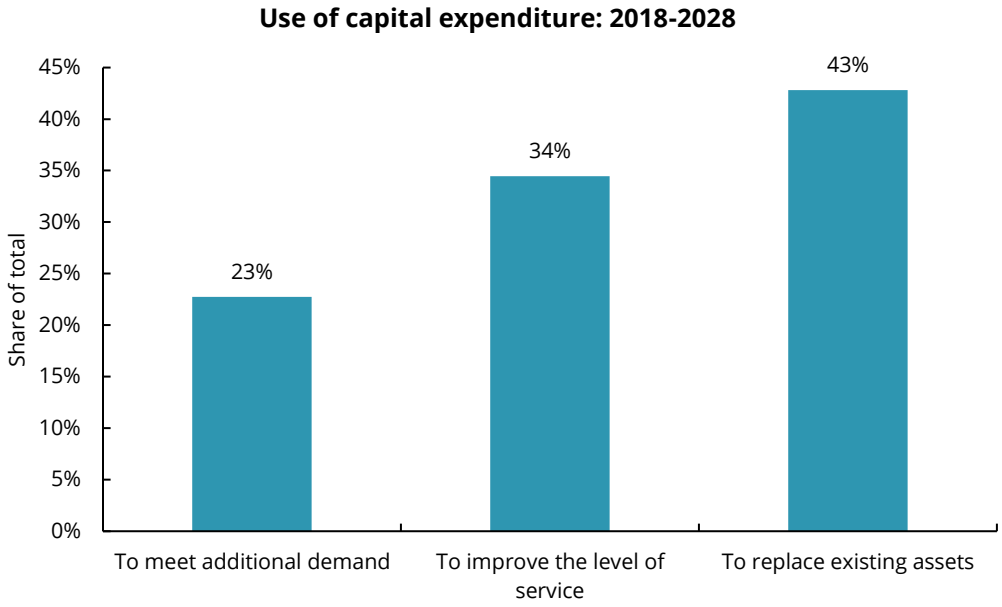
[13] Simonson & Hall, 2019.

Figure 11: …and the share has been consistent over time



Source: Stats NZ, Sense Partners

Figure 12: Much of planned new investment spending is in renewals and improving the level of service – about a quarter used to meet additional demand



Source: DIA

3.3. Total current and future deficit of $209b

We estimate the historical infrastructure deficit of $103,500m and future deficit of $105,900m (in 2020 prices or real terms) and a total deficit of $209,400m (Figure 13).

Our historical deficits are conservative, rather than excessively pessimistic. For example, water infrastructure repairs and transport congestion costs alone are probably worth over $125b.

- Recent estimates suggest water infrastructure requires investment of $70b-$90b excluding population growth and resilience issues.[14]
- Traffic congestion currently costs around $3.2b per year.[15] The capitalised cost of traffic congestion over the next 30 years would be $55b (at a 6% discount rate, growing by inflation rate).

Figure 13: We have significant deficits in infrastructure

Rounded to nearest $100m, 2020$	**Central government**	**Local government**	**Total**
Historical deficit			
Starting shortfall based on target private to public capital ratio	65,200	17,800	83,000
Housing shortfall (115k overcrowded)	12,000	8,600	20,600
Total known shortfall 2020	77,200	26,400	103,600
Future deficit			
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Sea-level rise	13,100	9,400	22,500
Estimated future shortfall in 30 years	80,300	25,600	105,900
Estimated total infrastructure deficit	**157,500**	**52,000**	**209,500**
Memo item:			
Net capital stock, 2020	144,586	94,926	239,512

Source: Sense Partners

[14] Coughlan, 2020.
[15] Refer Appendix A

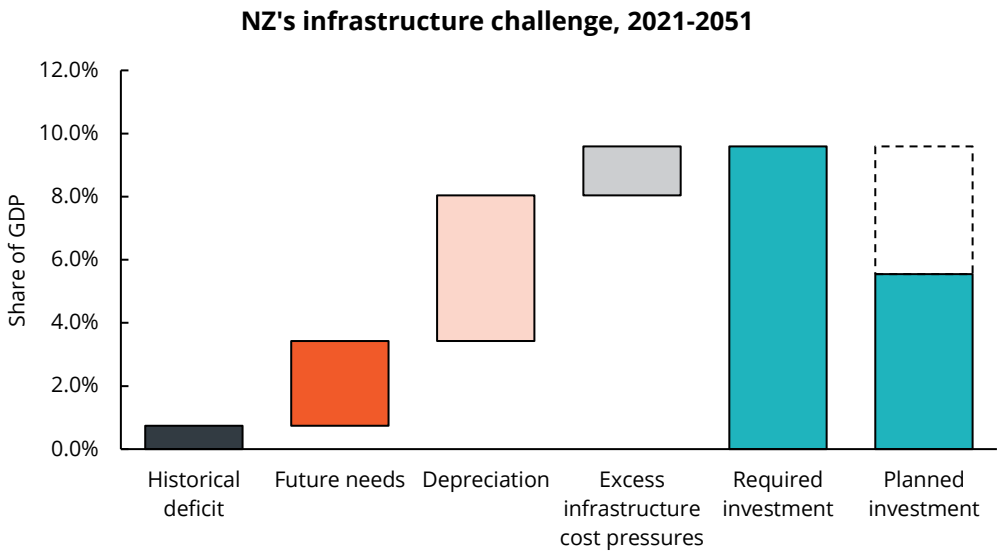
3.4. Closing the deficit is a big ask through more investment alone

We estimate large infrastructure deficits, but historical and in the future. Policy makers can choose a combination of levers to close the deficit including:

- new infrastructure
- demand management
- efficiency improvements
- spatial planning.

To close both deficits with increased investment alone will require a near doubling of investment as a share of the economy. Public investment is currently around 5.5% of GDP (Figure 14). It would have to increase to 8.0% of GDP to close both deficits, or 9.6% after taking excess infrastructure cost pressures into account.

Figure 14: Public investment would need to nearly double to close both the historical and future deficits and address cost pressures

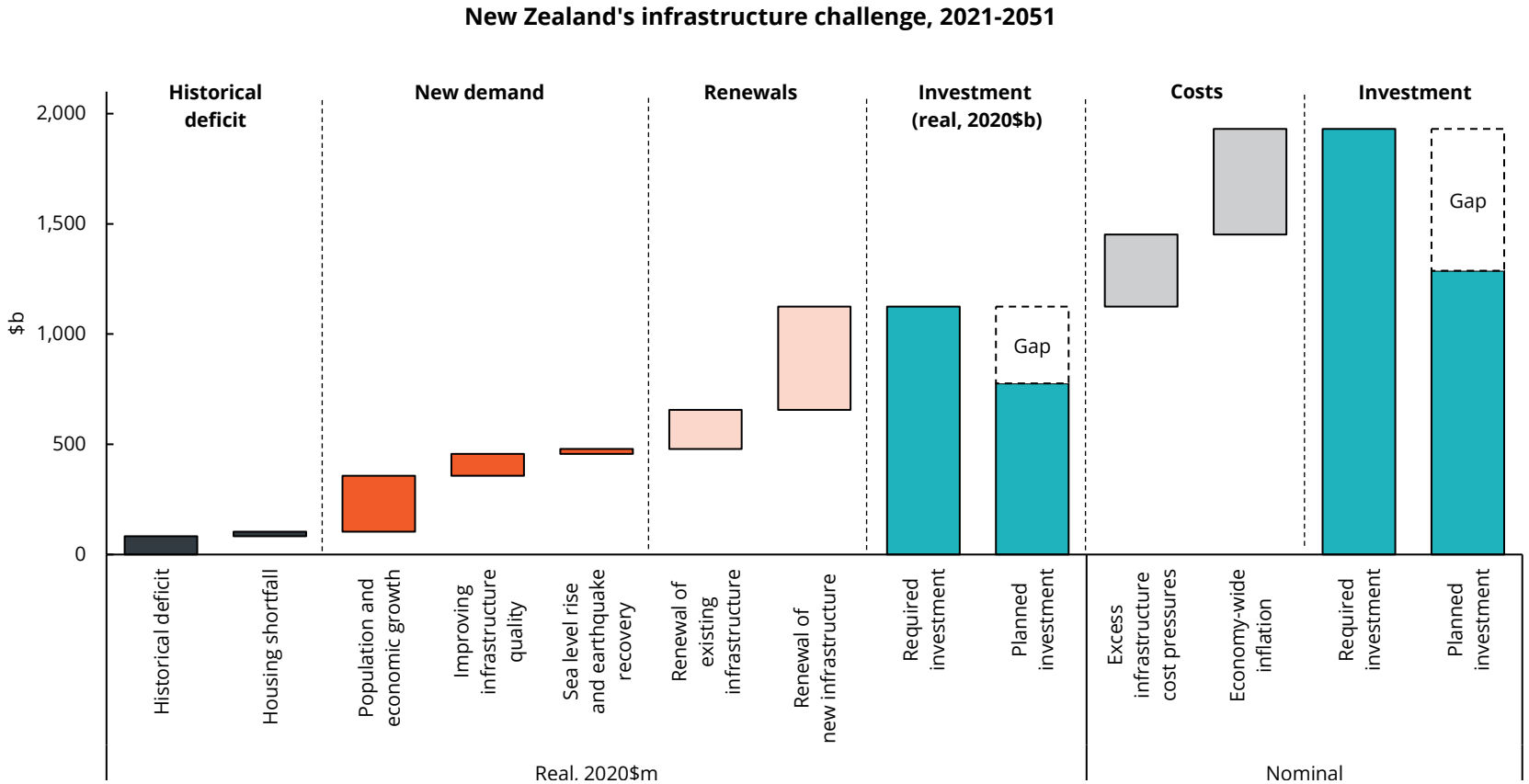


Source: Stats NZ, Sense Partners

How the future deficit evolves:

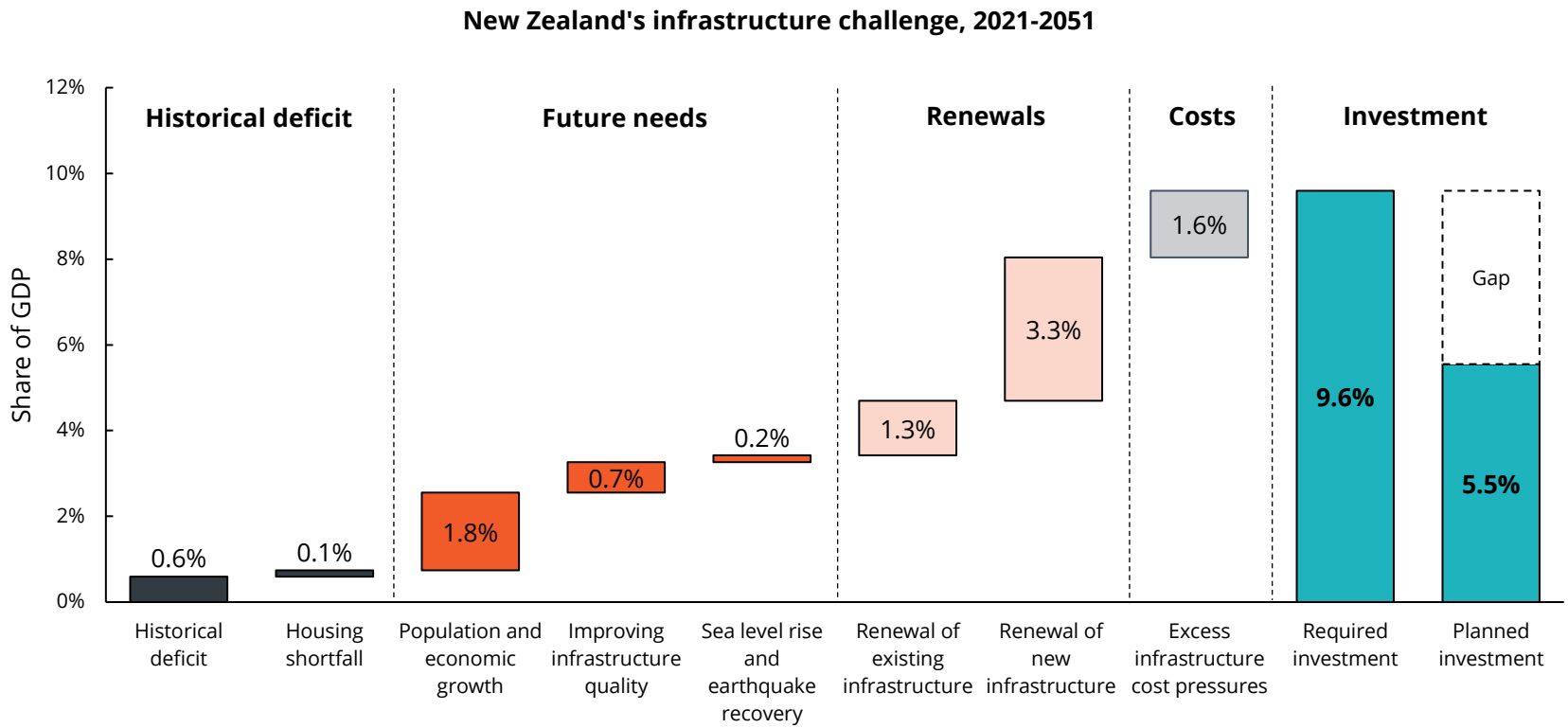
- The waterfall charts in Figure 15 (in $b summed over the next 30 years) and
- Figure 16 (expressed as a share of GDP over the next 30 years) show how the future deficit develops.

Figure 15: Future deficit will be driven by a massive renewal bill, demand growth and quality/service level increases…



Source: Sense Partners

Figure 16: …and cost increases

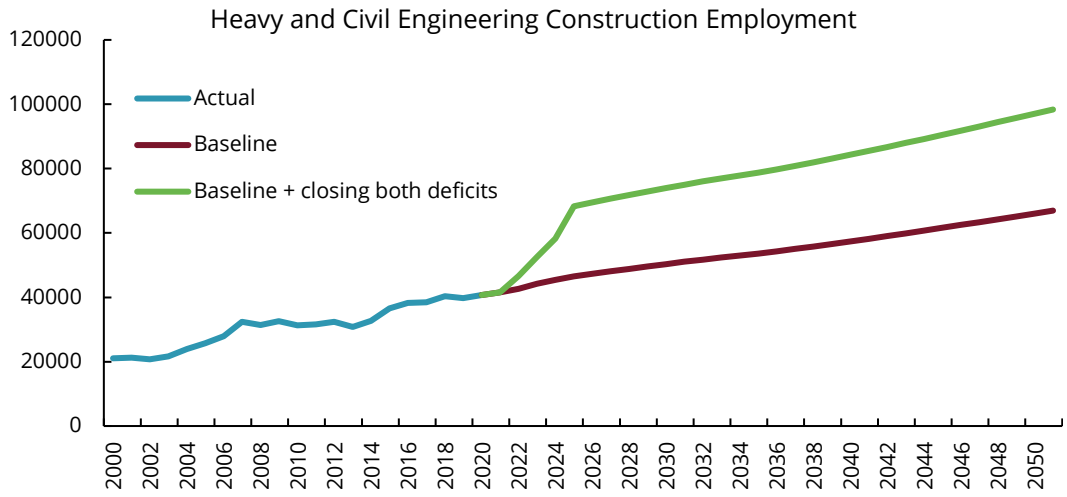


Source: Sense Partners

- We start with the historical deficit. Future demand is driven by growth in the number of households (demographic), economic growth per household (prosperity) and increasing capital intensity of the economy (the same as that of the private sector of the economy). In 30 years this increases the size of the capital stock by nearly 100% or double in size.
- The interaction factor, which largely captures increases in service quality improvements, adds to future infrastructure demand. This is roughly 60% of new demand growth from above. This is in line with the assumptions we see by local governments in their long term plans.
- Our assumed natural hazard costs are small compared to other drivers. Our estimate is conservative and is meant to simply highlight that even the quantified costs for one sector can miss complementary investments in others.
- The largest component is depreciation and renewals (**Error! Reference source not found.**). These renewals are not just for existing assets (around 27% of all renewals over the next 30 years) but also baseline level investments (around 55% of future renewals) and the additional investment we would need to close current and future deficits (18% of future renewals). The very large renewal bill shows that infrastructure deficits cannot be closed by increased investments alone – they need to be accompanied by careful plans for future renewals as well as using other tools to manage demand.
- Inflation will also add to cost, but some of this will be in the general level of price increases. This inflation effect can usually be captured by increases in tax revenue and is not necessarily an additional burden.
- Excess inflation in the 'other' construction sector is likely to be higher than general inflation in the economy if the investment programme is to be nearly increased from current baseline levels. We assume investment increases to the ideal rate over 5 years. We model inflation in 'other' construction as a function of the output gap or spare capacity in the sector using a Hodrick-Prescott filter (a data-smoothing technique that estimates the long-term trend – the deviation from it is the output gap). We estimate inflation in the 'other' construction sector would add over $320b of additional cost or 1.6% of GDP over the next 30 years. Much of this would come from labour cost inflation.
- The industry can scale up. The 'other' construction sector grew from 20,000 workers to 30,000 in 2000–2007 and then again to 40,000 over 2013–2018. However, labour productivity growth is sluggish at around 0.5% per annum. Rapid increases in demand lead to cost increases. To close both deficits, there needs to be nearly 90,000 staff at the peak compared to 52,000 on current trends (Figure 17). It would be inflationary unless spread over a long period, but then it would be hard to close the deficit.
- The massive increase in investment would increase fiscal pressures. Borrowing by central government is 1.2x core Crown revenue and local government 2.6x primary income. For context, household debt is 1.6x disposable income (Figure 18). Debt servicing costs are 9% of core revenue for local authorities and 4% for central government (Figure 19). Many local authorities cannot continue to borrow to invest. Fast-growing places have generally borrowed to keep up with demand, although not universally (Figure 20). Some fast-

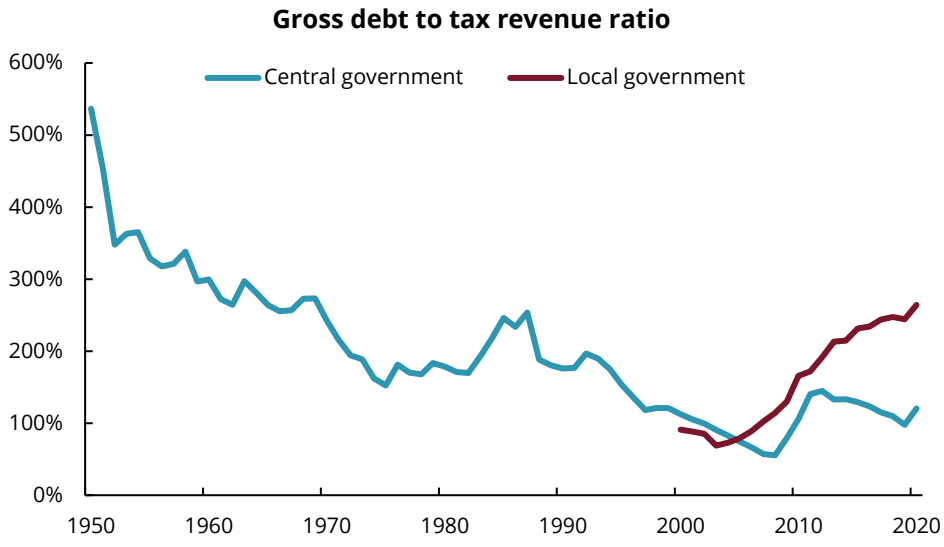
growing places such as Queenstown and Selwyn have not borrowed despite very high population growth. Some small places have a lot of debt (such as South Taranaki and Waitomo), which needed to invest but had little population growth. Too much or too little population growth can be an issue for funding.

Figure 17: Closing the deficit through investment alone would require doubling the infrastructure construction workforce



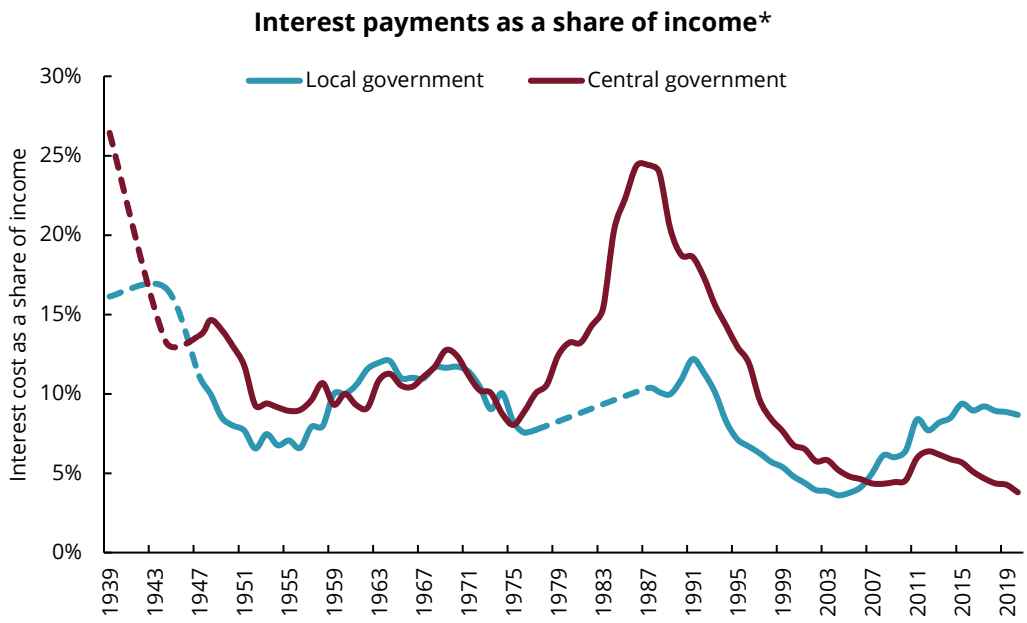
Source: Stats NZ, Sense Partners

Figure 18: Local government borrowing headroom has reduced…



Source: Stats NZ, Treasury, Sense Partners

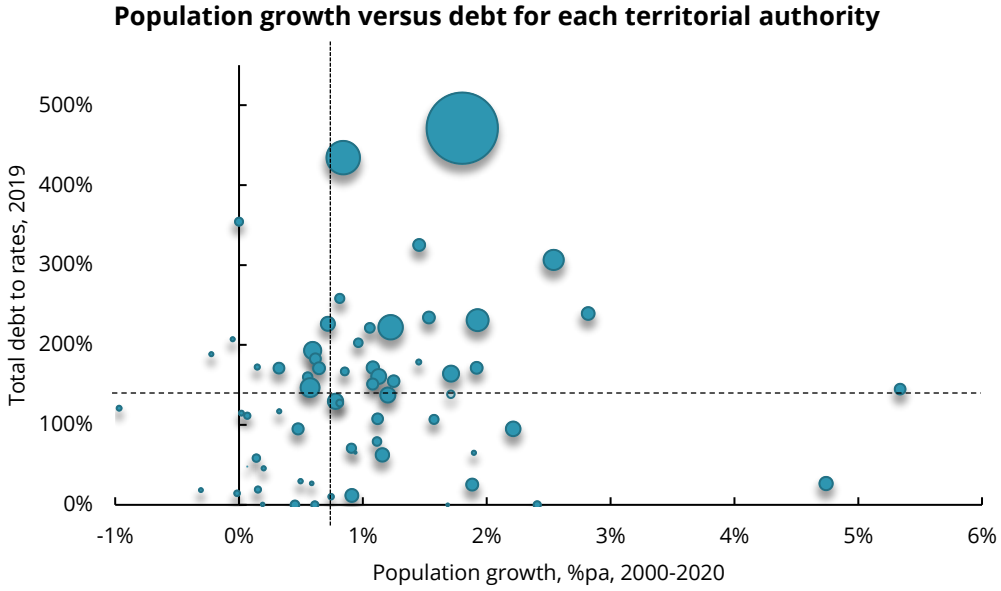
Figure 19: …but debt servicing costs remain less than 10% of core revenue



* Local government income = primary income in national accounts.
Central government income = core Crown revenue; taxation revenue pre-1972.

Source: Stats NZ, Treasury, Sense Partners

Figure 20: Fast-growing places tend to borrow more but not all – some places with little growth also borrow more

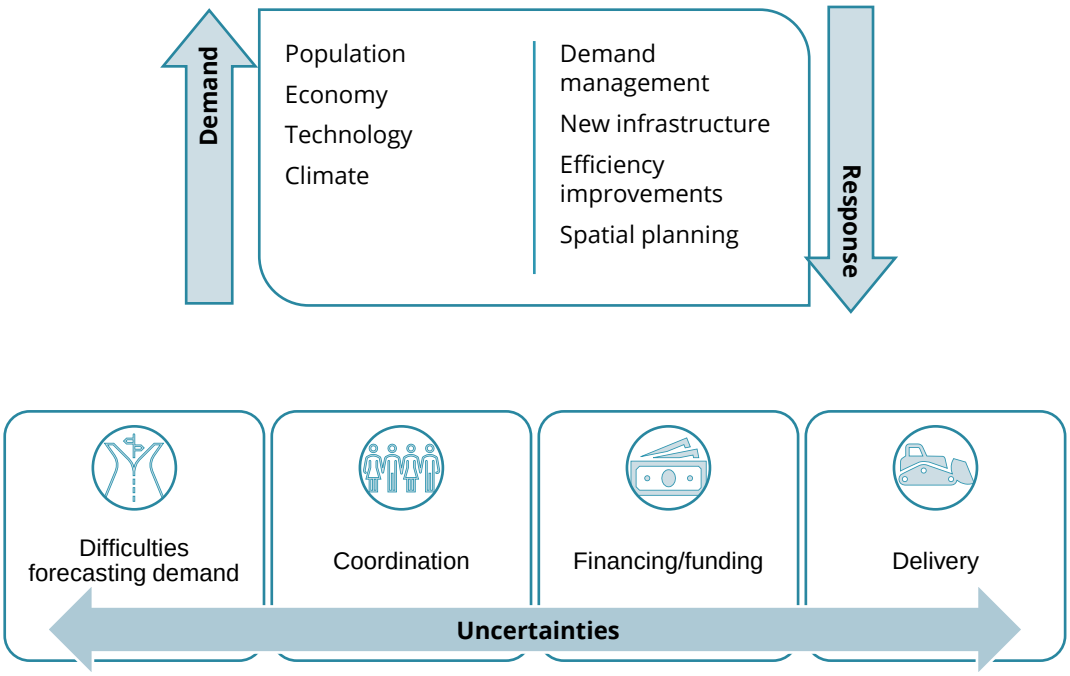


Source: Stats NZ, Sense Partners

4. Drivers of deficits and tools to close them

Infrastructure investments are long lived and rely on projections that are realistic, scenario-based, and used with sufficient humility. Models need to have broad **demand drivers**, the tools for **policy response** and clear understanding of **uncertainties** (Figure 21).

Figure 21: Drivers, responses and uncertainties of future infrastructure



Source: Adapted from Ives et al., 2017.

4.1. Demand

There is no international best practice in estimating infrastructure gaps.[16] Analysts use various data sources (such as digital, energy, telecommunications and finance data) and methods to compile estimates of future demand.[17]

Also, some drivers of infrastructure demand (such as economic growth and demographics) also affect the tax revenue or returns to fund them – the relationship is dynamic and

[16] Asian Development Bank, 2017.
[17] https://www.worldbank.org/en/data/datatopics/infrastructure

complex.[18] These uncertainties add to practical issues with planning and maintaining infrastructure networks with limited resources.

For example, the UK uses a model to forecast future infrastructure demand, changing assumptions around four drivers of demand: population, economy, technology and climate.[19] Uncertainties in each change the nature of demand for infrastructure. This makes the model highly sensitive to assumptions made. The assumptions and projections are also prone to error, meaning scenario analysis is necessary to ensure projections are not anchored by a false sense of accuracy.

4.2. Response

Infrastructure planning models and frameworks also need to incorporate how policy makers respond to that demand. In the UK model, policy makers respond to unmet need across four areas: demand management, new infrastructure, efficiency improvements and spatial planning. The choice or mix of tools will depend on the project, economic and political context.

4.3. Uncertainties

Policy makers face four key uncertainties in addressing infrastructure gaps in a timely and affordable way: accurately forecasting demand (which is intrinsically uncertain) and the financing, coordination and delivery of infrastructure projects.

4.3.1. Difficulty forecasting demand

Forecasting demand is challenging, not only because of forecast inaccuracies of inputs but also how the economy may evolve in the future due to technological change or climate change, for example. Given infrastructure assets are for future need, this can be a big challenge.

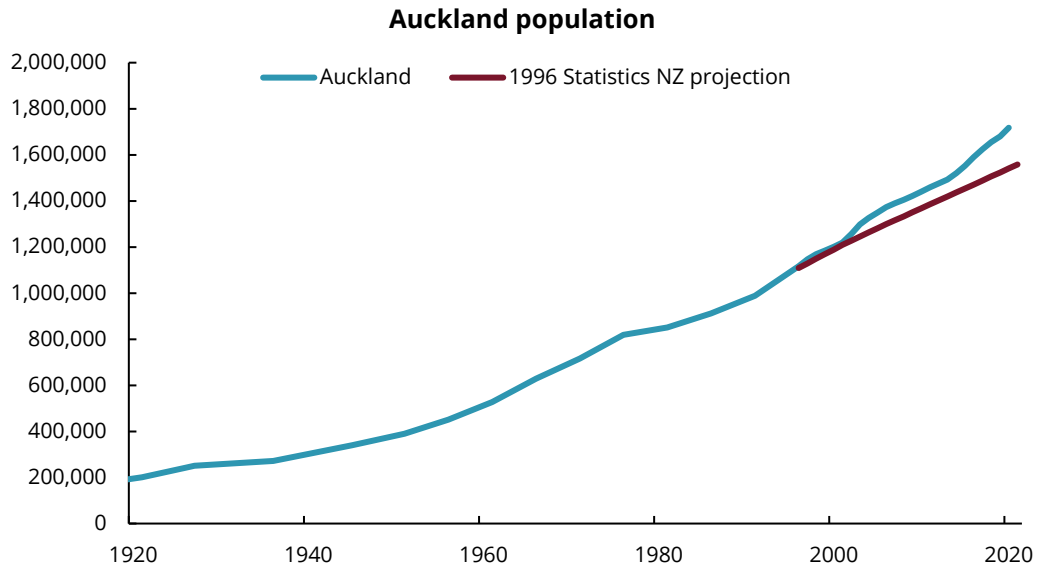
Each forecast is the midpoint of a range of possible futures. In other words, each point forecast is surrounded by a standard error. Forecasters attempt to incorporate all current information and possible future direction of economic drivers. They try to incorporate known uncertainties such as the direction of interest rates. However, there are also 'unknown' uncertainties such as the COVID-19 pandemic – the timing, impact and policy response could not have been predicted with accuracy beforehand.

For all these reasons, it is helpful to appreciate the extent of past forecast errors. Population projections are a key input, but population projections have been too conservative over recent decades. For example, Auckland's 2020 population was 10% higher than projections made 24 years earlier and 6% higher than projections made 19 years earlier (Figure 22).

[18] Oxford Economics, 2017; Woetzel et al., 2016.
[19] Ives et al., 2017.

The gaps are not only in fast-growing areas. Even in small places like Wairoa (one of the most deprived areas of New Zealand), the population in 2020 was 19% higher than projections made 19 years earlier.

Figure 22: Population projections are useful but prone to large errors



Source: Stats NZ, Sense Partners

4.3.2. Financing

Infrastructure involves making large upfront investments, but there are big uncertainties in the timing and quantity of future demand, policy responses (including new supply or reducing demand) and returns to the investor and society.

A well-performing infrastructure network requires substantial financial and political resources to maintain the quality and condition of infrastructure and to meet future needs.[20] The need to improve the investment environment for infrastructure projects is widely understood as a policy challenge.

The risk of uncertain returns can make raising finances challenging (capital markets issue). Societal benefits (positive externalities) from infrastructure are sometimes higher than private returns, which may be insufficient at driving private infrastructure investment. As a result, infrastructure may be underprovided if left to the market.

There are some specific challenges:

- A general lack of knowledge about the wide array of tools available to finance infrastructure – even among longstanding practitioners in the field. Tools that are

[20] OECD, 2011.

available lack designs aimed at high-level decision makers and tend to privilege a particular financing option.[21]

- Public and private sources of finance are both important but not easily substitutable. Each has its own incentive structures, goals and mandates. Meeting infrastructure investment needs requires credible financing plans, such as integrated national financing frameworks.[22]
- Regulatory and demand uncertainty spikes transaction costs. This makes it harder to incentivise adequate private investment and compounds coordination challenges because of gaming.

4.3.3. Coordination

Infrastructure returns (both private and social) are uncertain both in terms of quantum and timing, and they also generally require upfront investment for long-term gains. Timing difference in costs (early) and benefits (later) can make decisions politically difficult. These issues arise even in well-functioning political systems.

Often, decisions have to be coordinated across multiple agencies (such as territorial authority, education and transport agencies) or political jurisdictions (for example, contiguous territorial authorities), but incentives are siloed or local. These contribute to the underfunding of infrastructure.[23]

This makes the role of government policy instrumental, but this itself creates a problem: short-term political considerations and government borrowing constraints can hinder consistent long-term planning and investment. Overcoming coordination challenges is a key to better infrastructure policy.[24]

A coherent and coordinated approach is necessary – an infrastructure deficit need not be met with simply more infrastructure, which may have other consequences.

Quality strategic planning is necessary for a successful infrastructure programme.[25] Coordination is a common challenge for planning and infrastructure delivery. Challenges include the following:

- A need for long-term, top-down, strategic coordination.[26] Current planning systems do not adequately provide for effective longer-term or integrated infrastructure planning. Inconsistencies in decision making also fail to provide certainty for investment by infrastructure providers and other investors.[27] The value of strategic coordination was seen in the post-quake rebuild in Canterbury. A regional strategic plan across Greater Christchurch (Christchurch City Council, Selwyn District Council, Waimakariri District

[21] George, Kaldany & Losavio, 2019.
[22] Woetzel et al., 2016.
[23] Oxford Economics, 2017.
[24] OECD, 2016.
[25] Ibid.
[26] Ibid.
[27] MFE, 2010.

Council, Environment Canterbury, Canterbury District Health Board and Waka Kotahi NZ Transport Agency) was already available, which was fast tracked for the rebuild process.

- Poor incentives for information sharing across silos or political jurisdictions. Information gaps are compounded because the information is often private and valuable, as it can provide opportunities for gaming and rent seeking. This undermines the quality of decision making.[28]
- An environment averse to risk taking and innovation. Governments are loath to experiment with economically and politically sensitive infrastructure assets. The costs of getting it wrong are too high. When faced with uncertainty and rapidly changing technology, they tend towards traditional modes of infrastructure. This 'bakes in' older technology and creates challenges for future resilience.[29]

4.3.4. Delivery

The OECD describes infrastructure delivery as "mainly a governance challenge", which can make infrastructure spending more effective,[30] and cites these needs:

- Good regulatory design and delivery to ensure sustainable and affordable infrastructure over the life of the asset.
- Improved management of value. Governments must ensure that infrastructure projects are affordable and the overall investment envelope is sustainable. This requires dedicated processes, capable organisations and relevant skills to ensure value for money.
- Better data. Systems are needed for systematic collection of relevant data and institutional responsibility for analysis, dissemination and learning from data.
- Ongoing management of use. There is an emphasis the value of monitoring systems and institutions to ensure good management of existing infrastructure.
- A greater focus on future resilience. Infrastructure systems should be resilient, adaptable to new circumstances and future proof.

Construction sector capacity and capability

Construction sector capacity and capability is also a key driver of delivery. Woetzel et al. note: "Each country is unique, and none excels at all aspects of infrastructure delivery. Policy makers are not always sure where their country stands relative to peers and what really constitutes best practices and best-in-class cost of delivery internationally."[31] They find cases where similar build costs differed by 50% in neighbouring countries.[32]

[28] https://infrastructure.aecom.com/infrastructure-funding
[29] We Forum, 2019.
[30] OECD, 2016.
[31] Woetzel et al., 2016
[32] Ibid.

Limited standardisation between projects stymies affordably scaling up sector capacity. The UN attributes some construction sector productivity issues to: [33]

- sector fragmentation
- low skills development and educational attainment in construction sectors
- insufficient planning and design budgets spent upfront, which compounds project risks
- principal-agent problems between the public and private sector that discourage innovation in design
- information asymmetries and unskilled buyers, which lead to poor outcomes
- regulation that inadvertently encourages sector fragmentation.

4.4. Policy settings

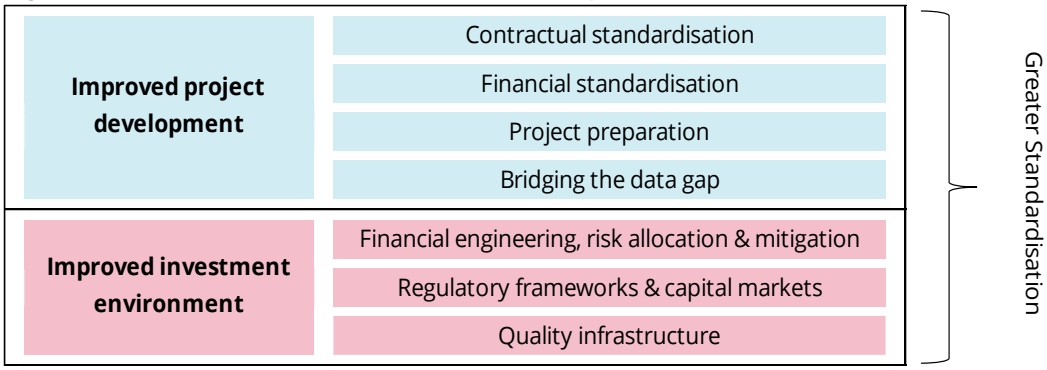
Policies usually focus on improving delivery of infrastructure, given the uncertainties and challenges discussed, against various objectives of sustainability, quality, resilience and affordability, for instance.[34]

Top-down approaches focus on fixing the broad policy settings preventing the quantity and quality of infrastructure investment. Bottom-up approaches emphasise integrated planning to make the magnitude of infrastructure need clearer.[35]

The OECD identifies three areas for focus (Figure 23):[36]

- Improving project delivery.
- Improving the investment environment for infrastructure.
- Promoting greater standardisation in construction.

Figure 23: Pillars and workstreams of the Roadmap to Infrastructure as an asset class



Source: OECD

[33] Ibid.
[34] Ives et. al., 2017.
[35] Cisneros & Fulton, 2021.
[36] OECD, 2018.

Policy wise, these map logically to challenges previously discussed around coordination, financing and delivery (top-down and bottom-up policy). Issues with forecasting demand can also be addressed with improved spatial planning (bottom-up policy).

4.4.1. Improved project development

The UN says to prioritise three to five interventions that will improve infrastructure delivery rather than repeated reviews.[37] Strengthening the pipeline of suitable projects with clearly defined goals and trade-offs improves the financing and delivery of infrastructure.[38]

4.4.2. Improved investment environment

Improving certainty of the investment environment and future projects may require bringing in other sources of finance (institutional investors and public-private partnerships) with new mechanisms for appropriate projects.[39] Public-private partnerships (PPPs) are one tool. They are not a full substitute for public investment.

PPPs should be used for projects that have sufficient profits commensurate with risk, amenable to private supply. The private sector can bring efficiencies, and issues of externalities and equity are managed. They need not always be large projects. PPPs for small projects can often make more sense.

Not all PPPs can deliver higher efficiency and lower costs. Globally, they account for only 5–10% of total investment.[40] Instead, developing PPPs can help fill capacity and capability gaps in public agencies.[41]

Efforts should address the following:

- Support institutional investors into infrastructure projects. Institutional investors and banks globally have $120 trillion in assets that could partially support infrastructure projects. New Zealand has $77b in KiwiSaver funds and a total of $171b in managed funds.[42] For example, 18% of Australian investments are in the 'alternative' asset class, which would supply $14b from KiwiSaver and $32b from all managed funds.[43] This could be a valuable source of capital and market discipline in investment projects. Policy makers can reduce impediments (or create incentives) that restrict the flow of financing to infrastructure.
- Create tools for investor certainty. Creating investable project pipelines that are prioritised against goals and with trade-offs clearly identified can improve private sector investment in infrastructure projects.[44]

[37] Woetzel et al., 2016.
[38] Ibid.
[39] Ibid.
[40] Ibid.
[41] Ibid.
[42] RBNZ Managed Funds Assets, December 2020. https://www.rbnz.govt.nz/statistics/t41
[43] PwC, 2020.
[44] World Economic Forum, 2019.

- Reduce transaction costs by pooling projects. Pooling projects, including the development of respective funds, indexes and securitisation vehicles, can lower transaction costs and improve the investability of infrastructure.[45]
- Develop securities exchanges. Governments can significantly increase private investment in infrastructure assets by adding liquidity to securities exchanges – for instance, issuing equity and debt on government-owned infrastructure projects and infrastructure operators to encourage private investment.[46]
- Explore value-capture mechanisms. User charges, public revenue support and ancillary funding are models that capture value uplift but are not always well applied and developed in infrastructure projects. Greater focus on these mechanisms creates better ways to align costs and benefits of infrastructure investments.

4.4.3. Improving standardisation of systems

Improving the standardisation of construction delivery, system planning and data is crucial. This requires a systems approach, moving beyond a project-by-project view to upgrading systems for planning, operating and delivering infrastructure.

Close coordination between the authorities responsible for different asset classes, clear separation of political and technical responsibilities and clarity about the roles of (and effective engagement between) the public and private sectors are required.[47]

5. Conclusion

New Zealand has a large infrastructure deficit. We have a shortfall of $104b today. On current investment trends, we will have an additional future shortfall of $106b in 30 years (in today's prices). The size of the deficit is too large to fix by simply investing more. Rather, we need to invest more as well as reduce demand, increase efficiency and do better integrated spatial planning.

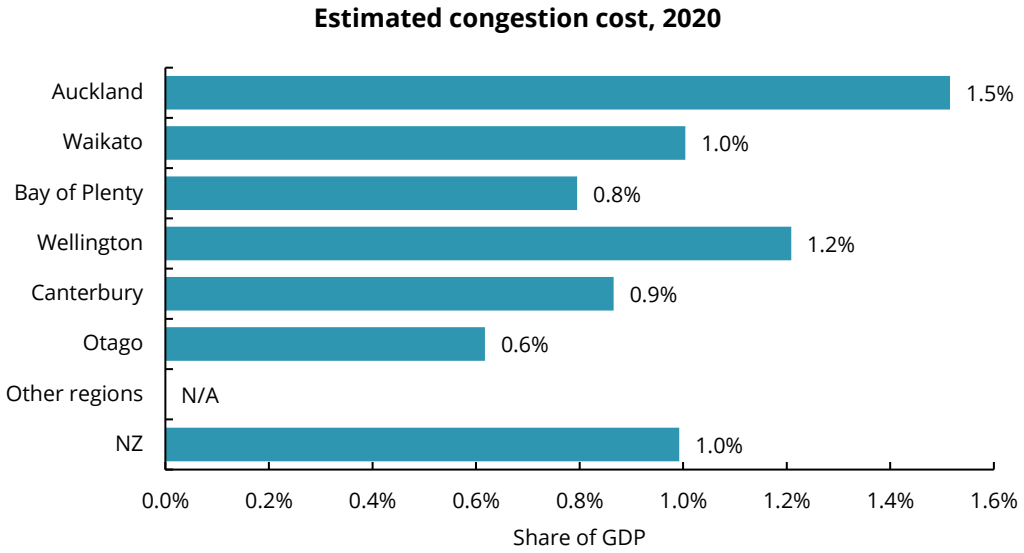
There is no easy way to change the way we do things. We need better coordination, more standardisation, a robust objectively prioritised pipeline, clear separation between politics, governance and delivery and to attract private capital into right-sized infrastructure projects. We cannot build our way out. We must work our way out.

[45] Woetzel et al., 2016.
[46] Ibid.
[47] Dobbs et al., 2013.

Appendix A: Cost of congestion to NZ of $3.2b per annum

Public investment needs to also consider potential pitfalls. For example, increasing capacity may not lead to time savings if new infrastructure becomes congested. We estimate traffic congestion across New Zealand cost $3.2b or 1% of GDP in 2020.

Figure 24: 1% of GDP congestion cost in 2020; Auckland and Wellington most affected



Source: Sense Partners update and extension of Ian Wallis Associates (2013)

Congestion reduces public benefits

We assume public capital is imperfectly substitutable for private capital, and that public capital is non-rival in nature. But this does not hold in every setting. The services from public capital goods decrease as more agents use them. For example, in traffic congestion. Allowing for congestion, public capital is not a pure public good.[48]

When we invest in more road for example, it may lead to more economic potential, but some of that may be blunted by congestion effects due to induced demand (that is more people drive because of more capacity, until the initial time saving benefits are exhausted).

Updating and extending congestion estimates

We estimate regional costs of congestion, linked to the original Auckland estimate of congestion costs in 2013 (updated to 2020), adjusting differences in GDP per capita, economic size, driving prevalence of workers and local time lost to congestion. This is a top-down

[48] Cuban (2019)

approach – which does not account for local experiences – and as such should be used as an indicative estimate.

The 2013 report for NZTA estimated congestion to the Auckland economy of $1,250m. Tom Tom reports the rate of congestion has remained broadly stable, at around 30% of the time. So, we assume the congestion cost has remained the same share of regional GDP. This gives us a 2020 estimate of $1,857m.

Other regions are also experiencing increasing congestion. Tom Tom reports congestion data for Waikato (Hamilton), Bay of Plenty (Tauranga), Wellington (Wellington city), Canterbury (Christchurch)[49], and Otago (Dunedin). The data is for urban centres. We assume this applies to the regional council area, as a proxy for the labour market area affected by the congestion. We look at these regions only, as we do not have any data to see congestion in other regions.

We estimate that the Auckland congestion cost in 2020 was $152 per commuter hour in congestion. We derive regional rates proportionately to regional GDP per capita. We then apply the regional driver share of workers to GDP and Tom Tom hours lost to congestion for a typical commuter.

The results are summarised in the following table. We estimate the 2020 cost of congestion to New Zealand was $3.2b or 1% of GDP in 2020.

Figure 25: Updated and extended congestion cost estimates

Element		**Time lost to congestion for typical commute**	**Estimated cost to economy**	**Share of workers who drive**	**Regional GDP**	**GDP per capita**	**Commuter affected GDP**	**Cost per GDP per hour of congestion**
Source		Tom Tom	Estimates	Statistics NZ	Statistics NZ	Statistics NZ	Calculation	Calculation
Units		Hours per year	$m	Share of total	$m	$	$m	$
Formula		(a)	(b)=(g) x (f) x (a)	(c)	(d)	(e)	(f)=(c) x (d)	(g) = [(b) / (a) / (f)] * $[(d)_{Local}/(d)_{Auckland}]$
Region	**Urban area**							
Auckland	Auckland	135	1,857	74%	122,557	71,358	90,607	152
Waikato	Hamilton	110	280	76%	27,884	56,139	21,308	*119*
Bay of Plenty	Tauranga	85	150	79%	18,884	55,986	14,831	*119*
Wellington	Wellington	131	487	58%	40,272	74,303	23,497	*158*
Canterbury	Christchurch	87	346	76%	39,961	61,869	30,200	*132*
Otago	Dunedin	71	88	71%	14,180	57,807	10,022	*123*
NZ			3,207		323,142			

Source: Sense Partners top-down update and extension of Ian Wallis Associates (2013)

[49] https://www.tomtom.com/en_gb/traffic-index/christchurch-traffic/

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