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Te Waihanga

Economic performance of New Zealand’s construction industry

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

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Cut to the chase

Rautaki Hanganga o Aotearoa, The New Zealand Infrastructure Strategy, emphasises that we need a productive and financially sustainable construction sector to help address our infrastructure challenges. The construction sector is crucial for infrastructure provision: it accounts for around 80% of the cost to build and maintain infrastructure. Likewise, infrastructure is an important client for the construction sector.

The aim of this Research Insights piece is to improve our evidence base on the economic performance of New Zealand's construction sector, and in particular the heavy and civil engineering construction sector. We measure and benchmark several key economic metrics for the construction sector, including changes in labour productivity, construction output prices, labour requirements, firm profitability, and solvency and liquidity risks.

Achieving faster construction productivity growth is important

Productivity increases when firms learn how to produce more using fewer resources. We find that New Zealand industries that have achieved faster productivity growth have experienced lower price inflation (Figure 1). These industries also experience faster increases in the quantity and quality of goods and services they produced and less pressure on workforce capacity. In the long run, we estimate that a 1% increase in labour productivity leads to a 0.6% reduction in prices, a 0.3% increase in real output, and a 0.7% reduction in labour requirements.

Figure 1: Labour productivity and output price growth in 27 New Zealand industries

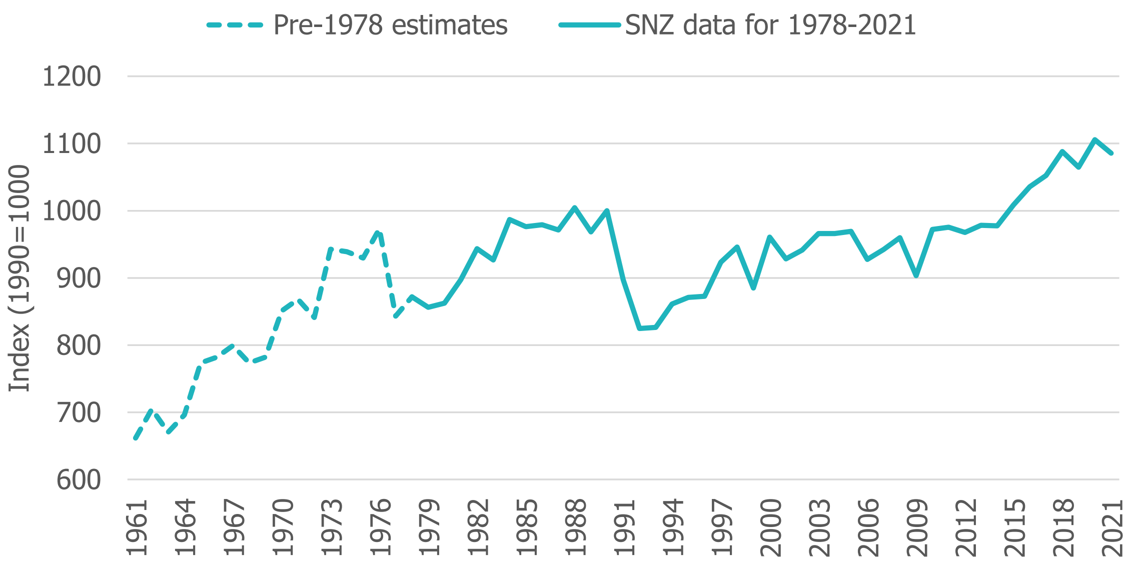
Source: Te Waihanga analysis of SNZ productivity and producer price index data for 27 industry sectors covered in SNZ's productivity statistics. The performance of the construction industry is highlighted on the chart. The dashed grey line shows a linear trend-line through the data.

Lifting construction productivity plays a key role in addressing our infrastructure challenges. It can help us to contain infrastructure delivery cost inflation, increase infrastructure delivery, and moderate our workforce capacity pressures.

The good news about construction productivity

After a period of rapid productivity growth in the 1960s and early 1970s, New Zealand's construction sector experienced three decades of stagnant productivity. However, we have achieved sustained improvements in construction productivity since the late 2000s (Figure 2). During this time, the construction sector reversed its historical productivity growth underperformance. Rather than lagging behind economy-wide productivity growth, construction as a whole matched the rest of the economy.

Figure 2: Long-run multifactor productivity growth in the New Zealand construction industry



Source: Pre-1978 estimates were compiled from Carson and Abbott (2012); 1978-2021 estimates are from SNZ's Industry Productivity Statistics (Statistics New Zealand, 2022d). Series have been indexed to 1990 = 1000.

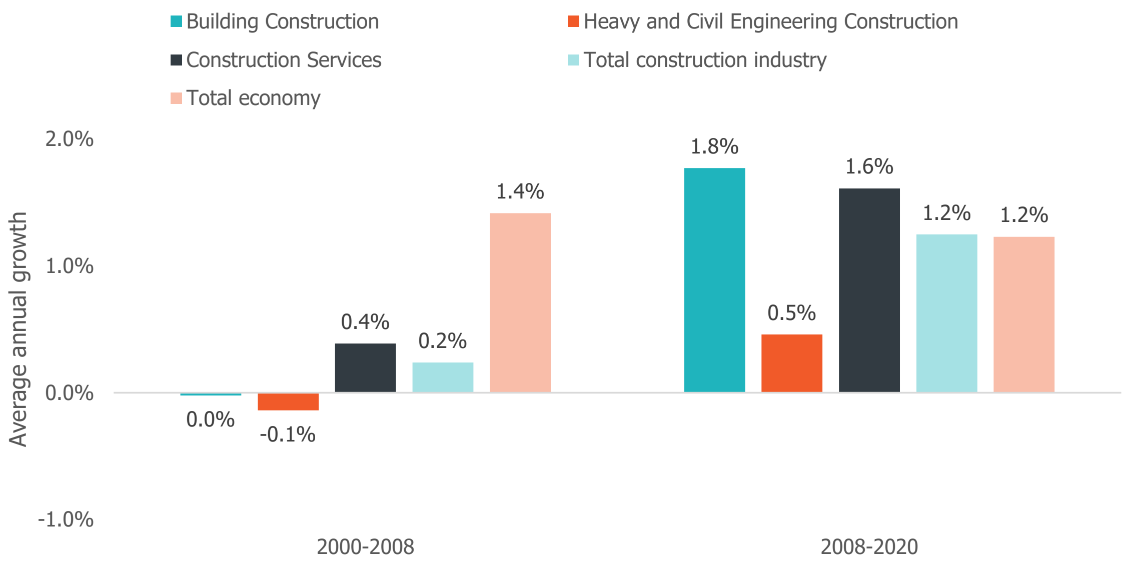
New Zealand's construction productivity growth is in the middle of the pack compared to other OECD countries. Over the last two business cycles (2000-2008 and 2008-2020) we had the thirteenth-fastest construction labour productivity growth in the OECD. Our performance lags behind some Eastern European transition economies experiencing 'catch-up' growth in productivity, but leads many other countries, including the likes of the United States and Japan.

Heavy and civil engineering construction lags behind

Our improved construction productivity growth record is mainly due to 'vertical' construction of residential and non-residential buildings. 'Horizontal' construction, ie heavy and civil engineering construction, continues to experience slow productivity growth (Figure 3). Between 2000 and 2020, labour productivity increased 23% in building construction, 25% in construction services, and only 5% in civil construction.

If civil construction had matched the productivity growth performance of building construction over the last 20 years, we estimate that infrastructure construction prices would be about 10% lower, the quantity and quality of new infrastructure construction would be about 5% higher, and workforce requirements would be about 11% lower.

Figure 3: Labour productivity growth in construction sub-sectors



Source: Te Waihanga labour productivity estimates for construction sub-sectors

International evidence highlights factors that can lift construction productivity

We identify several factors that are related to higher rates of construction productivity growth among OECD countries. First, we find that catch-up growth potential matters – countries with lower starting incomes tend to experience faster productivity growth. Second, we find that more efficient construction regulation is associated with faster productivity growth. Third, we find countries that shifted the composition of construction output towards road-building tended to experience slower productivity growth, possibly indicating a broader pattern of underperforming civil construction productivity growth.

However, some other factors do not appear to play a strong role. We find little evidence that economies of scale drive faster productivity growth – if anything, larger countries experience slower productivity growth than smaller ones. Construction market dynamics, like boom-and-bust cycles, population growth rates, and house price growth, seem to have little impact on construction productivity growth.

We also find some evidence that countries' choices about how to measure price indices (a key input into productivity statistics) may affect measured construction productivity growth, although this finding bears further investigation.

Construction firms have been resilient during early stages of the Covid-19 pandemic, but pressures are mounting

We use data from the Ministry of Education's Supplier Finance Tool to analyse the financial performance of around 150 large firms in the vertical construction and civil construction space. These firms represent around 40% of revenue in the non-residential construction and vertical construction space and play an important role in supplying public infrastructure.

These firms' profitability, solvency risk, and liquidity risk improved slightly through the early stages of the Covid-19 pandemic in 2020 and 2021. This highlights the resilience of the construction sector during this period and significant government financial support through measures like the Covid-19 wage subsidy.

However, our analysis also highlights that the construction sector face ongoing solvency risks, as reflected in high debt-to-equity ratios for a significant share of firms. In 2022, cost pressures have risen across the construction sector, primarily due to supply chain difficulties and increased prices for construction materials. To date, these have not caused an upsurge in firm liquidations – but this is a risk if pressures continue to mount.

More work is needed

It is hard to lift productivity in infrastructure construction. Infrastructure projects are complex and often involve working within or integrating with existing networks. They can face significant uncertainty about ground conditions that can result in scope or timeframe changes.

However, the example of building construction, where productivity recently accelerated after a long period of little to no growth, shows that it *is* possible to lift performance. And international evidence suggests that some conventional stories about the causes of slow construction productivity growth in New Zealand, such as our small population size and boom-bust-cycles in construction, don't seem to hold up.

Our research highlights a few factors that we should explore further, including:

- The role of workforce capacity and capabilities: Infrastructure projects often rely on experienced professional and trades staff who can foresee and manage problems. Do we have the right skills to drive productivity?
- The link between competition and productivity: Building construction firms tend to be smaller, while the civil construction market is more concentrated in fewer, larger firms. While there are downsides to small firm size, international evidence shows that increased competition can drive higher productivity. How do these dynamics play out in the New Zealand construction industry?
- Systems for consenting and approving infrastructure products: Internationally, countries with more inefficient construction permitting systems tend to experience slower construction productivity growth. Does our system reduce productivity growth, for instance by limiting innovation in infrastructure design or construction methods?
- How we account for changes in the quality of infrastructure: In recent decades, design standards for infrastructure have changed, due to public demand for things like safer roads, cleaner water, and better environmental mitigation. Are our productivity measures accurately capturing the value of these changes?

These are not simple questions to answer, but they are important. Achieving faster infrastructure construction productivity growth is essential for addressing our infrastructure challenges. Understanding the factors driving our current performance is the first step to achieving that goal.

Introduction

We need a productive and financially sustainable construction sector

Infrastructure is construction-intensive: construction accounts for around 80% of the cost to build and maintain infrastructure.[1] And infrastructure is an important client for the construction sector: network infrastructure delivery and maintenance represents approximately 80% of total demand for heavy and civil engineering construction services.[2]

Rautaki Hanganga o Aotearoa, The New Zealand Infrastructure Strategy, emphasises that we need a productive and financially sustainable construction sector to help address our infrastructure challenges. Lifting labour productivity can enable us to build and maintain more infrastructure with our current and future workforce, relieving pressure on the sector. Keeping a close eye on the sustainability of construction firms can help prevent loss of capacity in downturns.

Section 7.5 of the *Strategy*, on building workforce capacity and capabilities, reviews some challenges we face in this area. Historically, construction productivity has grown slower than productivity in the rest of the economy , and the sector is facing historic challenges recruiting, training, and retaining workers. As a result of these issues, the *Strategy* recommends improving information on future workforce needs to enable firms to invest in workforce development and productivity improvements.

Improving the evidence base

The aim of this Research Insights piece is to improve our evidence base on the economic performance of New Zealand's construction sector. We focus on the heavy and civil engineering construction sector in particular, due to the important role it plays in delivering and maintaining infrastructure.

Our research measures and benchmarks several key economic metrics for the construction sector, including changes in labour productivity, construction output prices, labour requirements, firm profitability, and solvency and liquidity risks.

First, we analyse the long-run economic performance of New Zealand's overall construction sector, and the heavy and civil engineering construction sector. The aim of this is to understand how infrastructure construction has performed, relative to other sectors of the economy over the last two business cycles (2000-2008 and 2008-2020). To do this, we focus on the link between productivity growth, price growth, output growth, and labour requirements.

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[1] This is a rough estimate. By way of comparison, SNZ's National Accounts industry production and investment data suggests that construction goods account for roughly 80% of the value of capital stock in five infrastructure-intensive industries (utility services, transport, IT and telco, education, health care).

[2] This is a rough estimate. According to SNZ's Annual Enterprise Survey, total revenue of the heavy and civil engineering construction sector in 2020 was around $13.6bn. (This includes the sector's direct contribution to GDP and intermediate inputs used by the sector.) Data from the Global Infrastructure Hub suggests that New Zealand's total capital investment in networked infrastructure was around 4.5% of GDP, or around $14.6bn. Assuming 80% of this is spent on civil construction, this suggests total civil construction spending of around $11.7bn, ie around 86% of civil construction output. As a cross-check, SNZ's National Accounts data on gross fixed capital formation by industry suggests that the electricity, water, transport, and telco industries account for around 80% of gross fixed capital formation for non-building construction assets.
However, the heavy and civil engineering construction industry only accounts for around 21% of total construction industry output.

Overall, we answer the question: to what degree have productivity improvements flowed through to lower growth in construction prices and labour requirements, as opposed to increased output from the sector?

Second, we benchmark the long-run economic performance of New Zealand's overall construction sector against other OECD countries. The aim of this section is to understand how New Zealand's construction productivity growth record compares to our peer countries over the last two business cycles (2000-2008 and 2008-2020).

Third, we analyse the recent economic performance of New Zealand's civil construction sector. The aim of this section is to better understand current or emerging pressures on the sector in the post-Covid environment (2020-2022). This section focuses on shorter-term challenges like labour market constraints, supply chain issues, firm profitability, and solvency and liquidity risks facing construction firms.

Why does productivity growth matter?

The first two sections of this paper focus on construction productivity growth. But, to paraphrase Monty Python, what has productivity growth ever done for us? Why is it important?

Theory and evidence suggest that productivity growth in construction can help to bring down the cost to deliver infrastructure and make it easier to address our infrastructure challenges. To understand these relationships, we draw on William Baumol's unbalanced growth model, which outlines the link between industry-level productivity growth and other outcomes like price inflation (Baumol, 1967; Hartwig, 2011; Nordhaus, 2008).

Baumol's model does not explain why some industries experience faster productivity growth than others. Rather, it examines what happens when productivity growth differs between industries over a long period of time. Faster productivity growth allows some industries to produce more without expanding their workforce. Industries experiencing slower productivity growth, by contrast, need to grow their workforce more to increase production.

As long as consumers continue to want goods and services that are produced by all industries, slow-productivity-growth industries will need to hire more workers to increase production. To allow them to attract workers, wage increases in slow-productivity-growth industries must match wage increases in high-productivity growth industries. To pay wage bills that rise faster than productivity, prices in slow-productivity-growth industries must increase at a faster rate than prices in high-productivity-growth industries. This phenomenon is known as Baumol's cost disease.

Figure 4 illustrates this phenomenon using data on changes in productivity and output prices for 27 New Zealand industries over the last two business cycles. In both periods, industries that experienced faster labour productivity growth tended to experience lower rates of price inflation.

Figure 4: Labour productivity and output price growth in 27 New Zealand industries

Source: Te Waihanga analysis of SNZ productivity and producer price index data for 27 industry sectors covered in SNZ's productivity statistics. The performance of the construction industry is highlighted on the chart. The dashed grey line shows a linear trend-line through the data.

Nordhaus (2008) outlines the implications of unbalanced industry productivity growth for prices, real output, nominal output, labour inputs, and wage growth (see Box 1 for definition of these terms). We use SNZ's industry-level productivity statistics, output price indices, and wage data to empirically test whether the Baumol model holds true for the New Zealand economy. Appendix 1 outlines our methodology, which is based on Nordhaus (2008) and Hartwig (2011).

Figure 5 summarises how we expect these variables to change in response to a 1% increase in labour productivity at the industry level. We estimate impacts over different time periods (short-term impacts over a single year, medium-term impacts over business cycles, and long-term impacts over the whole 2000-2020 period).[3] We find that the key predictions of the Baumol model apply to the New Zealand economy:

- **Cost disease**: Prices inflation is higher in slow-productivity-growth industries. A 1% increase in labour productivity is estimated to reduce prices by around 0.6% in the short run and in the long run.[4]
- **Stagnating real output**: Real output growth is slower in slow-productivity-growth industries. A 1% increase in labour productivity is estimated to increase real output by around 0.8% in the short around 0.3% in the long run.

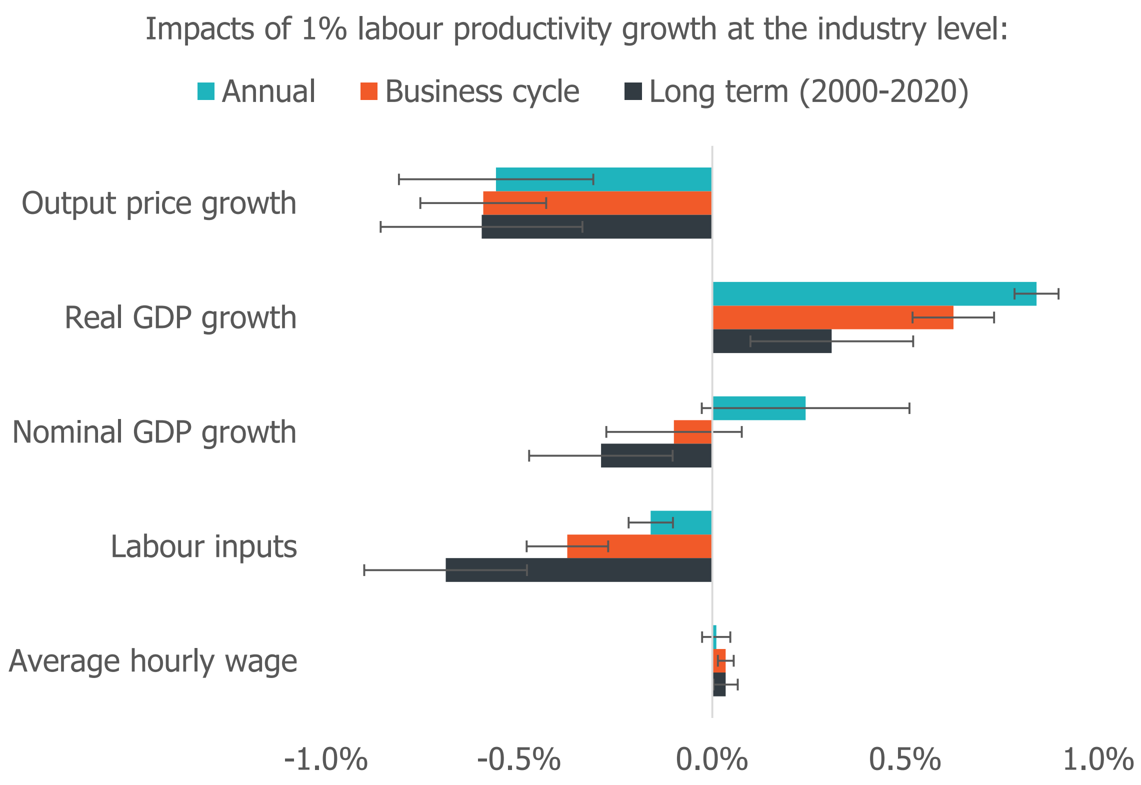
[3] In models that use annual changes or changes across business cycles, we include random effects for industry and time period to control for persistent industry characteristics and broad differences in macroeconomic performance between different time periods. In addition, Appendix 1 shows that results are similar if multifactor productivity growth is substituted for labour productivity growth.

[4] By comparison, Nordhaus (2008) estimates that a 1% increase in labour productivity leads to a roughly 1% reduction in output prices for US industries, while Hartwig (2011) estimates effects that range from 0.4% to 0.8%, depending upon time period, for European industries.

- **Unbalanced nominal output growth**: Slow-productivity-growth industries account for an increasing share of total nominal economic output (ie the dollar value of work completed) in the long run. A 1% increase in labour productivity is estimated to increase nominal output in the short but decrease it by around 0.3% in the long run.
- **Unbalanced employment growth**: Labour input requirements increase more rapidly in slow-productivity-growth industries. A 1% increase in labour productivity is estimated to reduce labour requirements by around 0.2% in the short and by around 0.7% in the long run.
- **Uniform wage growth**: Wages grow at a similar rate across all industries, regardless of differences in productivity growth. Although economy-wide labour productivity growth is important for lifting wages and living standards, industry-level wage growth is set by the need to attract workers, rather than industry-level productivity growth.

What this means is that faster productivity growth allows industries to bring down price inflation, increase real output, and alleviate pressure on workforce capacity. Achieving faster rates of construction productivity growth could play an important role in containing cost inflation and managing long-term workforce pressures.

Figure 5: Testing the implications of the Baumol model in New Zealand industries, 2000-2020



Source: Te Waihanga analysis of data for 27 New Zealand industries. Error bars indicate +/- one standard error.

Box 1: Key metrics for the economic performance of the construction sector

- **Nominal output**: This measures an industry's contribution to gross domestic product (GDP) in current dollar terms. It is measured as total industry revenue minus the cost of goods and services purchased from other industries or imported.
- **Real output**: This measures an industry's contribution to GDP in constant-dollar terms. It reflects the total quantity and quality of goods and services produced by the industry. It is measured by dividing nominal output by the relevant output price index.
- **Price index**: Producer price indices measure changes in prices for the inputs used by industries or the outputs produced by industries. Price indices typically adjust for changes in the quality of goods and services over time.
- **Productivity**: Productivity reflects the quantity and quality of output that is produced for a given quantity of inputs. Productivity increases when firms work out how to do more with less. **Labour productivity** is calculated by dividing real output by a measure of labour inputs, such as total hours worked. **Multifactor productivity** is calculated by dividing real output by a measure of total labour inputs and capital inputs, including equipment and machinery used in production.

For more information on these measures, see Productivity Commission (2021) and Jiang and Rossouw (2020).

Long-run performance of the NZ construction sector

In this section, we use Statistics New Zealand data to explore the economic performance of the New Zealand construction industry over time. We compare key outcomes for three construction sub-sectors (see Box 2), and examine whether labour productivity is growing at different rates in civil construction, which is most relevant for infrastructure delivery. Appendix 1 describes how we constructed estimates of labour productivity growth for sub-sectors.

Our analysis builds on previous research, much of which identifies issues with New Zealand's construction productivity performance. Carson and Abbott (2012) review the history of productivity analysis of the construction industry in New Zealand, finding that productivity grew reasonably rapidly in the 1960s and early 1970s and stagnated between the mid-1970s and the 2000s. Tran and Tookey (2011) and Page and Norman (2014) observe that construction productivity growth lagged behind the economy as a whole in the 1990s and 2000s. More recently, Productivity Commission (2021) review the long-run and recent productivity performance of the New Zealand economy at both an aggregate and industry level.[5]

In contrast with previous research, Jaffe, Le, and Chappell (2016) and Jaffe and Chappell (2018) use firm-level data to show that productivity grew faster in construction than in the economy as a whole between 2001 and 2012; although there were important differences between different construction sub-industries. They also examine firm-level drivers of productivity growth.

Box 2: Defining construction sub-sectors

We use the Australia-New Zealand Standard Industrial Classification 2006 (ANZSIC06) to divide the construction sector into three parts:

Building Construction (ANZSIC06 industry E30): This includes both residential and non-residential building construction. This corresponds to what is sometimes called 'vertical' construction.

Heavy and Civil Engineering Construction (ANZSIC06 industry E31): This includes road and bridge construction and other civil engineering construction. This corresponds to 'horizontal' construction.

Construction Services (ANZSIC06 industry E32): This includes a range of subcontractor services, including land development and subdivision services, concreting and roofing services, and installation and finishing trades like plumbing, electrical, painting, and flooring services. For the most part, these are inputs into 'vertical' construction.

Long-run patterns of construction productivity growth

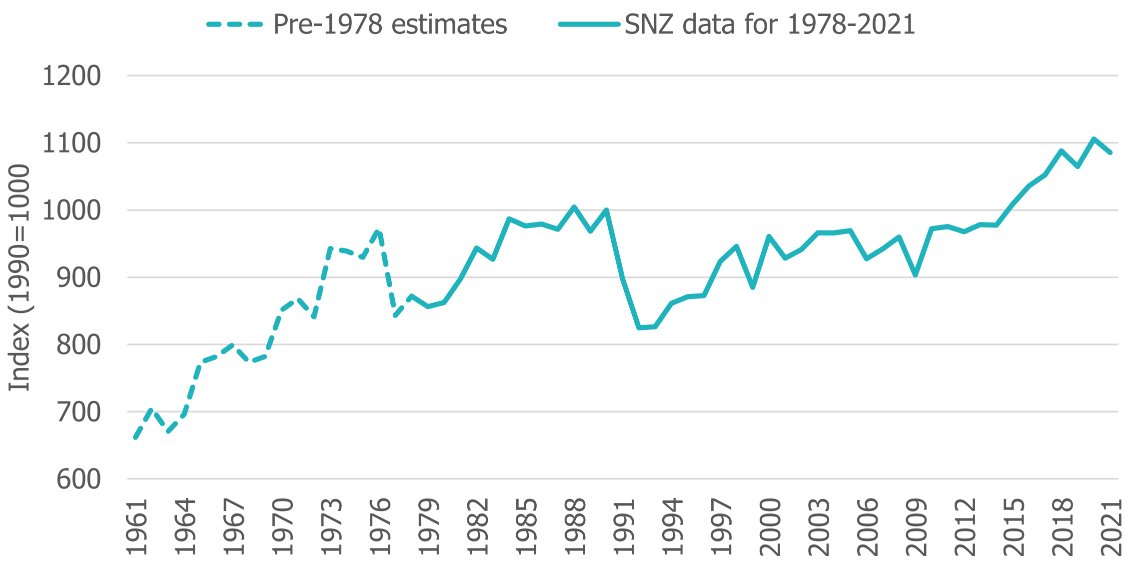
Figure 6 summarises productivity trends in the New Zealand construction industry for the 1961-2021 period. Construction productivity grew rapidly between the early 1960s and mid 1970s, prior

[5] The Productivity Commission concludes that the construction productivity growth continued to underperform the economy as a whole over the 2008-2020 period. However, this is due to their use of industry productivity statistics for 2020 that were revised upwards in mid-2022. As a result of this revision, the construction industry's labour productivity growth is now estimated to match the economy as a whole between 2008 and 2020.

to stagnating between the late 1970s and late 2000s. Productivity levels dropped sharply during recessions in the late 1970s and early 1990s, followed by a slow recovery to previous levels.[6]

Construction demand dropped sharply after the 2008 Global Financial Crisis, but construction productivity did not fall as it had done in the late 1970s and early 1990s.[7] Since then, construction productivity has entered a period of sustained improvement, seemingly escaping from the boom-and-bust cycle of the previous three decades.

Figure 6: Long-run multifactor productivity growth in the New Zealand construction industry



Source: Pre-1978 estimates were compiled from Carson and Abbott (2012); 1978-2021 estimates are from SNZ's Industry Productivity Statistics (Statistics New Zealand, 2022d).[8] Series have been indexed to 1990 = 1000.

Economic trends in construction sub-sectors, 2000-2020

Construction makes up an increasing share of the New Zealand economy

Figure 7 shows the growth of the construction sector relative to other parts of the New Zealand economy. In 2000, construction made up slightly less than 5% of New Zealand's GDP (1.1% building construction; 1.2% civil construction; 2.5% construction services). But by 2020, construction had grown to nearly 8% of GDP, mostly driven by growth in building construction and construction services (2.0% building construction; 1.6% civil construction; 4.0% construction services).

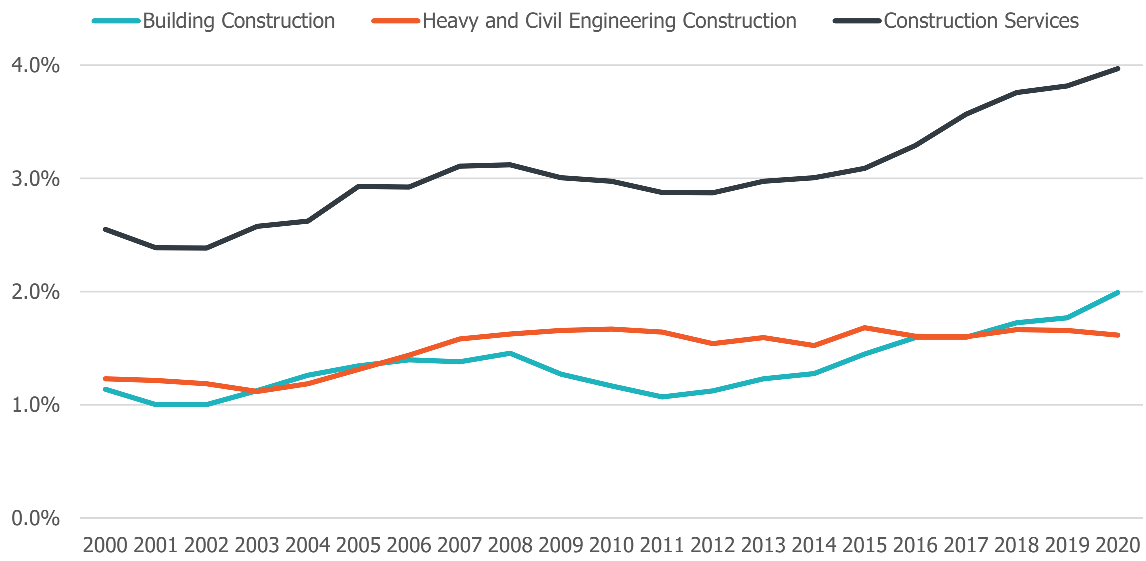
This data highlights the key role of subcontracting and specialist trades in the construction industry. Construction services account for half of the industry's contribution to GDP. They have grown at a similar rate to building construction between 2000 and 2020.

[6] During this time, there were significant changes to building methods, construction equipment and machinery, regulation of the construction industry, employment models and use of subcontracting, and the quality of construction outputs. Productivity indices attempt to adjust for these changes (Statistics New Zealand, 2014) but in doing so they condense and simplify the underlying trends.

[7] Construction firms appear to have responded by shedding staff and reducing investment. Firms' inputs contracted at a similar rate as firms' outputs, meaning that productivity did not change.

[8] Carson and Abbott (2012) summarise data from two studies that estimated construction productivity for the pre-1978 period. Chapple (1994) estimates construction total factor productivity for 1972-1991 and Orr (1989) provides estimates for 1961-1986. We use these sources to estimate pre-1978 construction productivity trends.

Figure 7: *Construction sub-sectors as a share of New Zealand's total economy*



Source: Te Waihanga analysis based on SNZ nominal GDP (production measure) for detailed industry groups

Construction prices are growing faster than prices elsewhere in the economy

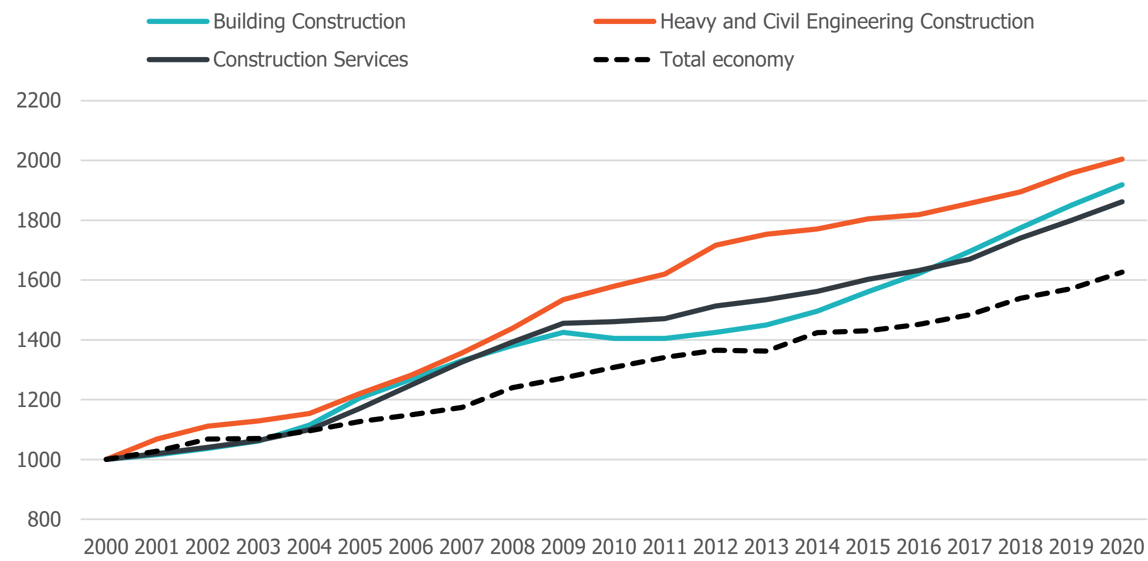
Construction's makes up an increasing share of our GDP due partly to an increase in the quantity and quality of construction outputs, and partly due to an increase in prices for construction outputs.

Figure 8 shows that prices for outputs from all three construction sub-sectors have grown more rapidly than economy-wide prices in recent decades. These price indices control for improvements in the quality of buildings and infrastructure.[9] From 2000 to 2020, building construction prices rose by 92%, construction services prices rose by 86%, and heavy and civil engineering construction prices rose by 100%. Economy-wide prices increased by only 63%.

Over the whole period, civil construction prices have grown more rapidly than building construction prices. This is because civil construction prices kept rising rapidly after the Global Financial Crisis, while building construction price growth flattened. In recent years, this relationship has reversed. Building construction prices have surged while civil construction price growth has slowed.

[9] Price indices that are used to convert nominal output and expenditure to real (inflation-adjusted) output are intended to control for changes in the composition and quality of outputs. For instance, if the average price of new-build houses increases by 10%, but the average quality of houses increases by 5% (eg due to increased house size or better insulation), then quality-adjusted prices would have increased by 5%. SNZ (2015) outlines the methodology for constructing New Zealand's producer price indices, while OECD (2011) compares methodologies used in different OECD countries.

Figure 8: Growth in output prices in construction industries, relative to the whole economy



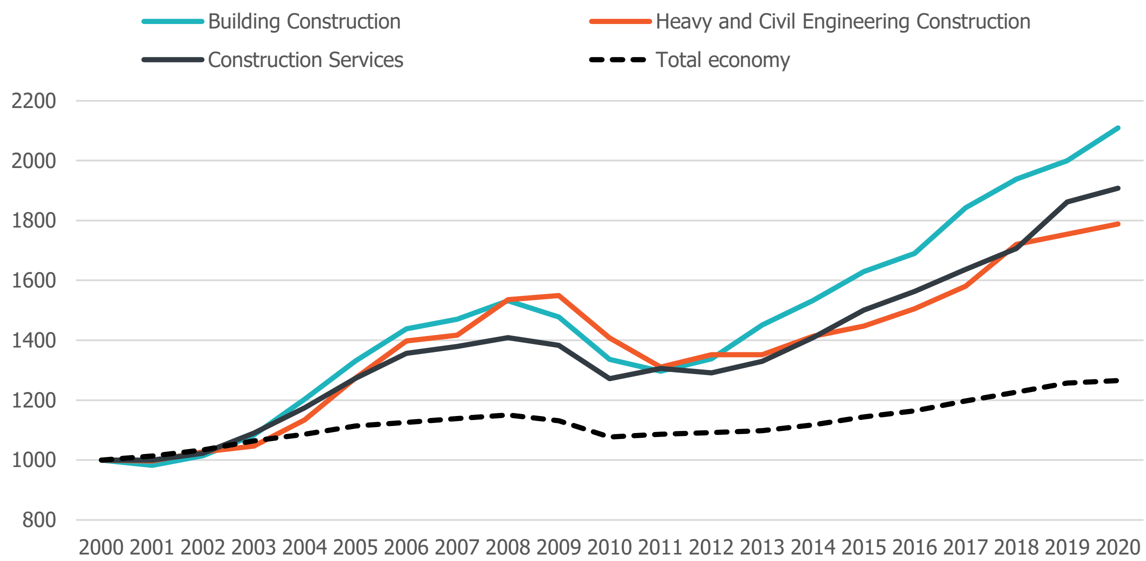
Source: Te Waihanga analysis based on SNZ producer price index output price indices for NZSIOC level 3 industries

The construction workforce has grown rapidly

Figure 9 shows that labour inputs to construction, measured based on total hours worked, increased faster than economy-wide labour inputs.[10] Labour inputs to construction have grown more rapidly than labour inputs elsewhere in the economy. From 2000 to 2020, building construction labour input rose by 111%, construction services labour input rose by 91%, and civil construction labour input rose by 79%. Economy-wide labour input increased by only 27%.

[10] OECD (2001) recommends measuring labour input based on total hours worked, including paid and unpaid time. Prior to 2021, New Zealand's industry productivity statistics used total paid hours as a measure of labour input.
In recent decades, New Zealand's construction employee headcount and total workforce (including working proprietors) have increased more rapidly than hours worked. The number of paid employees increased by 157% over the 2000-2020 period. The overall labour force, including working proprietors, expanded by 106%, and total paid hours worked increased by 94%. This means that annual paid hours per worker declined by around 6% between 2000 and 2020, presumably due to factors like increased leave allowances and reduced overtime.

Figure 9: Growth in labour inputs in construction industries, relative to the whole economy



Source: Te Waihanga labour input estimates for construction sub-sectors, based on methods and data outlined in Appendix 2. Labour input growth for the 'total economy' is estimated using the SNZ productivity statistics' labour input index for the 'measured sector', which excludes some public services where productivity is difficult to measure.

All parts of the construction industry have succeeded in scaling up their labour force during recent decades, in spite of a deep recession. Where did the new workers come from?

Schiff (2022) finds that both domestic recruitment and immigration have contributed to workforce growth in recent decades. Between 2012 and 2019, temporary and permanent migrants contributed 28% of the growth in the construction workforce, while citizens and long-term permanent residents contributed 72%. As a result, the share of immigrants in the workforce rose from 6.8% to 13.7%.

The construction workforce has also diversified significantly. Between 2004 and 2020, the share of construction workers who were female rose from 11% to 13, with further increases during the Covid-19 pandemic (Statistics New Zealand, 2022c). Between 2000 and 2018, the share of construction workers that are Māori, Pacific, and Asian increased while the proportion of people of European and other ethnicities declined from 79.4% to 66.5% (Schiff, 2022).

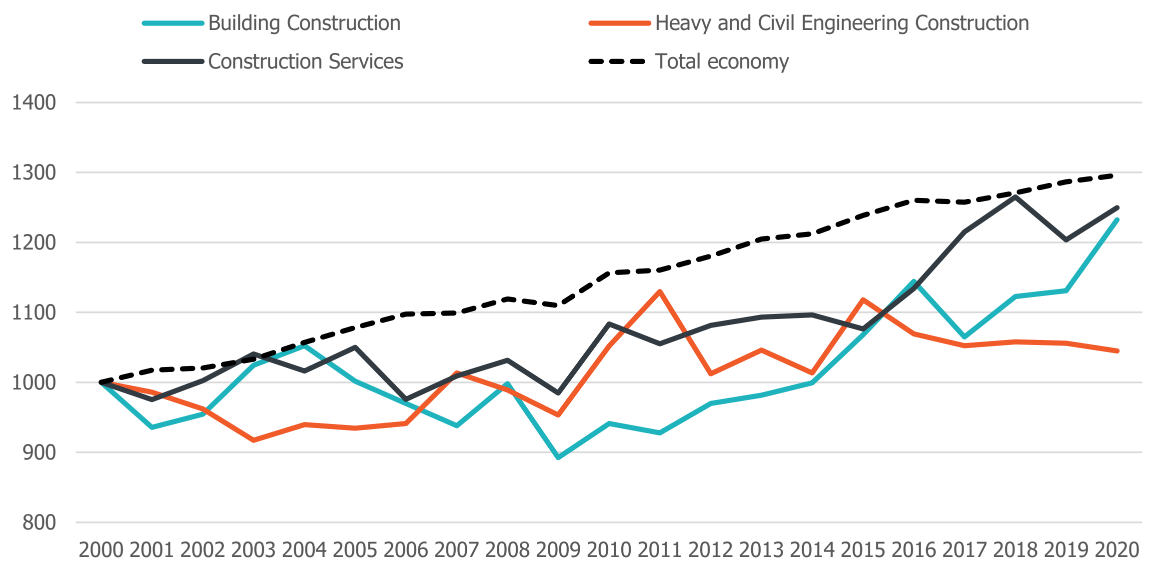
Labour productivity growth varies across construction sub-sectors

Figure 10 shows our estimates of labour productivity growth for three construction sub-sectors, relative to the whole 'measured sector' of the economy as defined in SNZ's productivity statistics. Appendix 2 describes how we developed these estimates.

Our key finding is that labour productivity is growing faster in 'vertical' construction than in 'horizontal' construction. Between 2000 and 2020, building construction labour productivity rose 23%, construction services labour productivity rose 25%, and heavy and civil engineering construction labour productivity rose 5%.[11] This compares to economy-wide labour productivity growth of 30%.

[11] Our estimates are qualitatively similar to Jaffe, Le, and Chappell (2016). They use firm microdata to estimate that, between 2001 and 2012, labour productivity rose by 22% in building construction firms, 2% in heavy and civil engineering construction, and 30% in construction services (see Appendix Table 4). Our corresponding estimates for this period are 4%, 3%, and 11%. We note that microdata-based labour productivity growth estimates appear to be higher than SNZ estimates for the overall construction industry.

Figure 10: *Labour productivity growth in construction industries, relative to the whole economy*

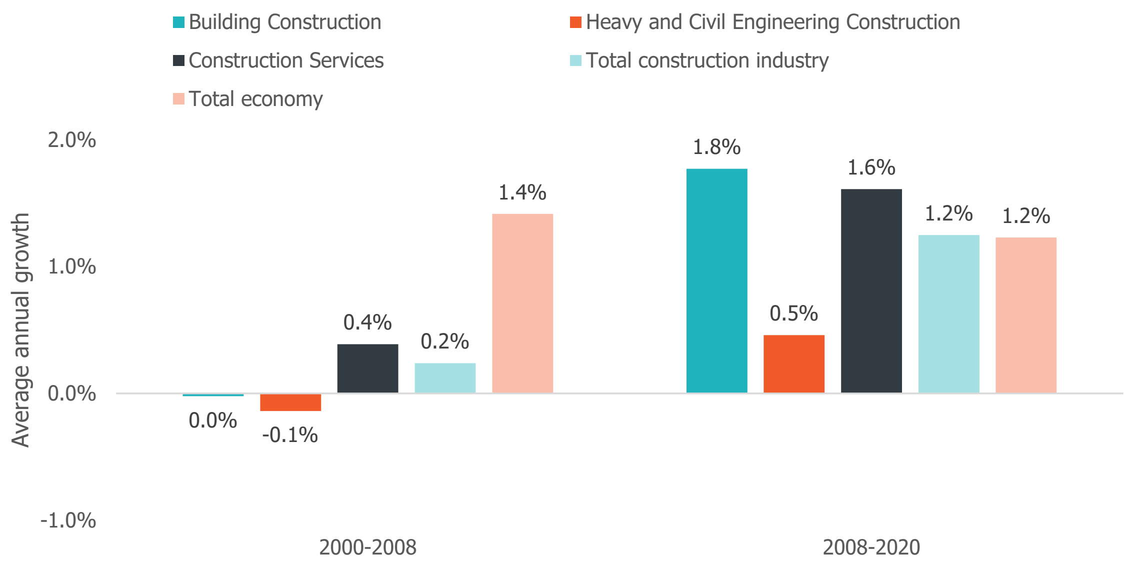


Source: Te Waihanga labour productivity estimates for construction sub-sectors, based on methods and data outlined in Appendix 2. Labour productivity growth for the 'total economy' is estimated using SNZ's labour productivity index for the 'measured sector', which excludes some public services where productivity is difficult to measure.

Figure 11 shows average annual growth in labour productivity over the last two business cycles. This highlights three key facts:

- First, labour productivity growth accelerated in all parts of the construction industry following the 2008 Global Financial Crisis.
- Second, since 2008 labour productivity growth has been faster in building construction and construction services than in the economy as a whole.
- Third, productivity growth has been consistently slower in heavy and civil engineering construction than in other parts of the construction industry.

Figure 11: Average annual construction labour productivity growth over recent business cycles



Source: Te Waihanga labour productivity estimates for construction sub-sectors, based on methods and data outlined in Appendix 2. Labour productivity growth for the overall construction sector and the 'total economy' is estimated using

SNZ's labour productivity index. 'Total economy' is defined as the 'measured sector', which excludes some public services where productivity is difficult to measure.

SNZ data for the aggregate construction industry suggests that faster labour productivity growth since 2008 is mostly due to increased multifactor productivity growth, rather than increased investment in construction equipment and machinery.[12]

It is unclear why construction productivity growth accelerated after the GFC. By contrast, recessions in the late 1970s and early 1990s damaged construction productivity (Figure 6). Some commentators have argued that the boom-bust cycle in construction depresses productivity growth by reducing incentives for investment and training. An alternative view is that recessions may catalyse faster productivity growth (Gordon, 2016), as falling demand causes firms to lift the quality of their management and explore new technologies and products (Kapelko & Abbott, 2017). Firms that survive recessions may emerge more productive and resilient as a result.[13]

The Canterbury Earthquake rebuild may have played a role in accelerating construction productivity growth. For instance, it may have encouraged firms to enter new markets, invest in capability-building, or recruit and train additional staff. The need to repair or rebuild the city's infrastructure and housing stock may have also encouraged innovation in construction methods.

What if civil construction productivity was growing faster?

Construction productivity growth has been uneven, with heavy and civil engineering construction lagging behind building construction and construction services. Civil construction output has grown more slowly, and prices have increased slightly more rapidly.

We apply our empirical estimates of reduced-form equations of Baumol's unbalanced growth model (Figure 5) to estimate what might have happened if civil construction had matched the productivity growth performance of other parts of the construction sector. Between 2000 and 2020, civil construction labour productivity rose by only 5%. But what if it had instead matched the performance of building construction and increased by 23%?

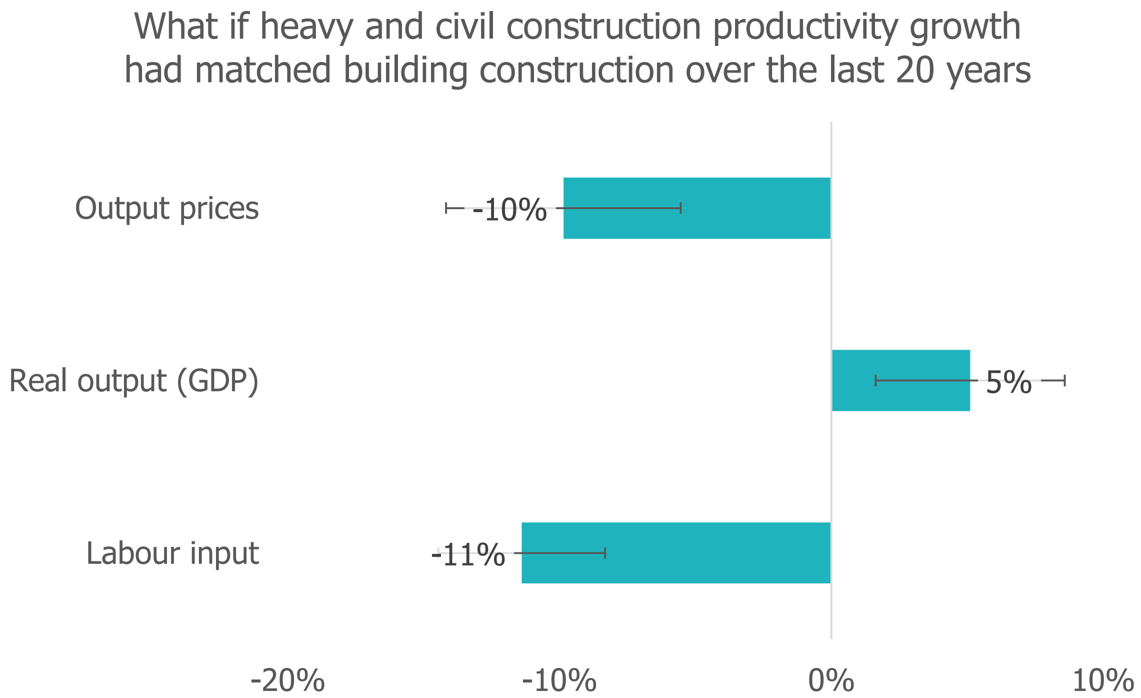
Figure 12 summarises estimated impacts on civil construction prices, real output, and employment. We estimate that matching the productivity growth performance of building construction would have reduced civil construction prices by 10%, increased the quantity and quality of civil construction output by 5%, and reduced labour requirements by 11%. This means that:

- We would be spending less on infrastructure construction but building more infrastructure for the money
- Fewer workers would be needed to deliver a higher level of output, easing our workforce capacity pressures.

[12] We observe contrasting trends in capital intensity in different parts of the construction industry. Building construction and construction services both became more capital-intensive over the 2000-2020 period, while capital intensity declined slightly in civil construction.

[13] There is little evidence about how these issues played out in the New Zealand construction industry. Jaffe, Le, and Chappell (2016) and Jaffe and Chappell (2018) find that firm entry and exit dynamics and reallocation of output and resources from low- to high-productivity firms increased construction productivity over the 2001-2012 period. It is unclear whether the GFC accelerated these dynamics.

Figure 12: Estimated impacts of faster civil construction productivity growth



Source: Te Waihanga estimates based on information in Figure 5 and Figure 10. Error bars indicate +/- one standard error.

International comparisons

This section explores New Zealand's *relative* construction productivity growth performance using data from SNZ and international statistics agencies. Previous attempts to benchmark New Zealand's construction sector have focused on whether we build at a cost-competitive rate relative to our peers (New Zealand Productivity Commission, 2012; NZIER, 2014). We focus on a different question - whether New Zealand's construction productivity is *catching up* with our peers over time.[14]

Many OECD countries are concerned about construction productivity (McKinsey Global Institute, 2013). There is a perception that the construction industry is slow to adopt productivity-improving innovations and building methods. Slow productivity growth in construction has been linked to rising costs to build homes and infrastructure (Borri & Reichlin, 2018; Swei, 2018).

Our cross-country comparisons build upon previous research comparing construction productivity growth trends between countries (Abdel-Wahab & Vogl, 2011; Nasir et al., 2014; Ruddock & Ruddock, 2011; Singapore Contractors Association & Singapore Chinese Chamber of Commerce & Industry, 2016) or critiquing attempts at comparison (Sezer & Bröchner, 2014; Vogl & Abdel-Wahab, 2015). Previous studies of New Zealand's comparative performance mostly focus on comparisons with Australia (Abbott & Carson, 2013; NZIER, 2013).

In the middle of the pack

Figure 13 shows that construction labour productivity growth has varied significantly across the OECD over the 2000-2008 and 2008-2020 business cycles. In some countries, construction productivity appears to be declining. In others, it appears to be improving rapidly.

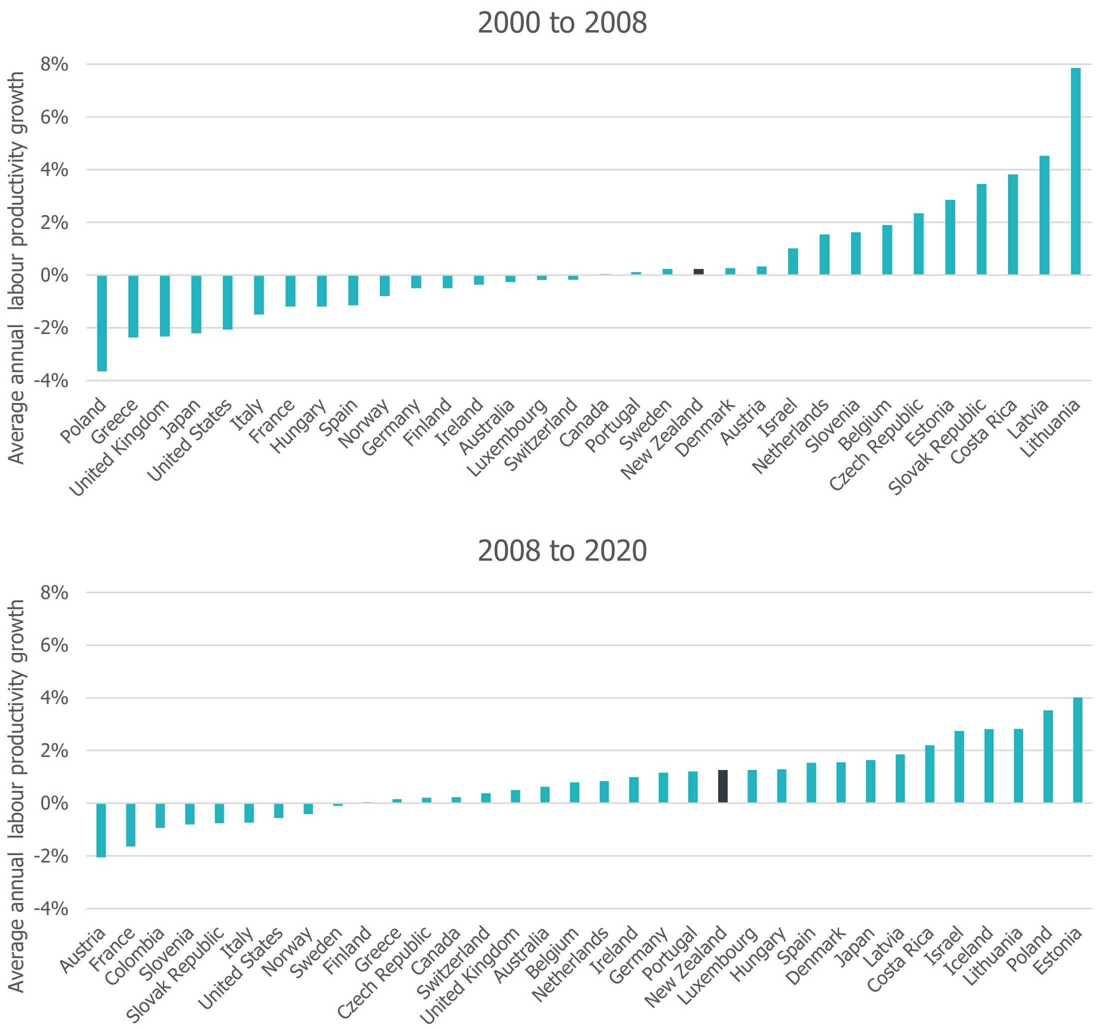
New Zealand's construction productivity growth performance was middling in both periods. Prior to the 2008 Global Financial Crisis, it grew at an average annual rate of 0.2% (ranked 13th in OECD). Between the GFC and the start of the Covid-19 pandemic, it accelerated to grow at an average annual rate of 1.2% (again ranked 13th).

Prior to the GFC, construction productivity was declining in 16 OECD countries, including Australia, the United States, United Kingdom, and Japan. After the GFC, it declined in nine OECD countries, again including the United States and Japan.

A small number of OECD countries have experienced sustained, rapid growth in construction labour productivity in recent decades. However, these are mainly lower-income OECD member states, such as Costa Rica, and Eastern European transition economies like Lithuania, Latvia, and Estonia.

[14] We focus on labour productivity as it is easier to compare across countries than multifactor productivity (New Zealand Productivity Commission, 2021). And we focus on labour productivity *growth* rather than labour productivity *levels* as we are interested in whether some countries are making faster progress than others. Vogl and Abdel-Wahab (2015) observe that cross-country comparisons of construction productivity growth rates are likely to be more robust than comparisons of productivity levels as they are "not affected by exchange rates and are less affected by differences in data definitions and capture". Langston (2016) highlights the need for construction-specific purchasing power parity adjustments when comparing construction productivity levels between countries. We hope to avoid the worst comparison challenges by focusing on cross-country differences in labour productivity growth, but highlight that methodological differences can still complicate comparisons.

Figure 13: Growth in construction labour productivity over recent business cycles



Source: Te Waihanga analysis based on data from OECD (2022), LUISS Lab (2022), ABS (2021) and SNZ (2022d)

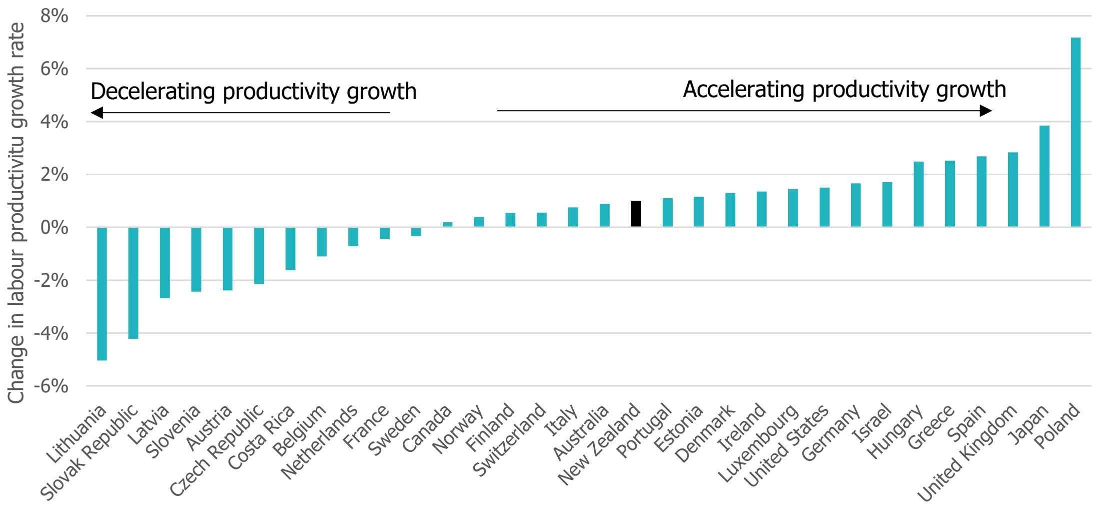
Accelerating productivity growth after the Global Financial Crisis

In the previous section, we noted the counterintuitive fact that New Zealand's construction labour productivity growth accelerated after the GFC, even as productivity growth was slowing elsewhere in the economy.

The international productivity data suggests that this was a common outcome. Figure 14 shows that two-thirds of OECD countries also experienced faster productivity growth during the 2008-2020 period than in the 2000-2008 period. The median OECD country experienced an 0.8 percentage point improvement to construction productivity growth after the GFC.

It's unclear why this happened. One possibility is that declining demand for construction, especially residential construction, after the GFC led to a period of 'creative destruction' that bankrupted low-productivity firms and incentivised other firms to reduce overheads, innovate, specialise and/or lift productivity to remain financially sustainable. It is notable that several of the countries with the fastest acceleration in labour productivity growth also experienced large, sustained declines in construction output after the GFC (eg Greece, Spain, United Kingdom).

Figure 14: Changes to labour productivity growth rates from 2000-2008 to 2008-2020



Source: Te Waihanga analysis based on data from OECD (2022), LUISS Lab (2022), ABS (2021) and SNZ (2022d)

Explaining differences in construction productivity growth

Why does construction labour productivity growth vary so drastically between OECD countries?

From a growth accounting perspective, labour productivity may increase due to improved labour quality (eg training), increased capital inputs (eg more equipment and machinery), or genuine improvements in efficiency (ie multifactor productivity growth). Here, we focus on factors that may affect the construction sector's incentives or ability to pursue any of these productivity-improving practices.

We undertake a cross-country econometric analysis to identify factors that are correlated with faster labour productivity growth in construction. We consider three types of explanations. First, we consider whether **market characteristics**, like income levels, population size, or regulation of construction activity, matter.[15] Second, we consider whether **market dynamics**, like shifts in the composition of construction output, boom and bust cycles, population growth rates, or house price inflation, matter. Third, we consider whether the **methods** used to measure productivity growth matter, focusing on methods for measuring price and quality changes over time.[16]

Table 1 summarises the results of our analysis. The first column reports a regression model for annual changes in country-level construction labour productivity (over the 2006-2020 period), the second column reports a regression model for changes over the 2000-2008 and 2008-2020

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[15] This is not an exhaustive investigation of possible causes. Other market characteristics that could be investigated include availability of capital, international mobility of construction firms and construction workers that results in sharing of best practices, and labour market regulations that affect flexibility in hiring and firing. With regards to labour market regulations, we note that measures of labour market regulations are debated (Lee et al., 2008), and the World Bank no longer produces a single labour market regulation index.

[16] To construct productivity growth statistics, it is necessary to account for changes to the composition and quality of industry outputs over time. Mis-measuring quality changes may cause analysts to confuse quality improvements (which indicate increased productivity) for price increases (which do not), or vice versa. Mis-measurement of quality changes is a perennial challenge for service industry productivity statistics. Previous analyses indicates that poor measurement of construction quality improvements can result in mis-estimation of productivity growth (Sezer & Bröchner, 2014; Sveikauskas et al., 2016; Yu, 2014).
All OECD countries compile productivity statistics using a broadly similar methodology, but different countries implement this methodology in slightly different ways (OECD, 2011). This could complicate attempts to compare productivity growth between countries. Discussions with SNZ suggest that differing methods for compiling input and output price indices are most likely to lead to spurious differences in measured labour productivity growth rates.

business cycle, and the third column reports a regression model for long-term changes over the 2000-2020 period. Appendix 3 outlines our methodology and data sources in more detail.

We find evidence that the following factors affect construction productivity growth:

- **Catch-up growth potential**: All else equal, countries with lower income levels tend to experience faster construction productivity growth. This could reflect opportunities to learn from other countries or improve training and equipment.
- **Construction regulation**: All else equal, countries with slower and more cumbersome construction permit processes tend to experience slower construction productivity growth.
- **Composition of construction output**: Countries that shifted construction output more towards infrastructure construction, and away from building construction, tended to experience slower productivity growth, although this was not always statistically significant. This suggests that other countries may share New Zealand's experience of slower civil construction productivity growth.[17]

On the other hand, we find that the following factors do not seem to matter:

- **Economies of scale**: All else equal, smaller countries tend to experience faster construction productivity growth than larger countries. This suggests that market size is not that important for achieving productivity growth.
- **Boom and bust dynamics**: We did not observe a statistically significant relationship between volatility in construction output growth (indicating larger booms and busts) and construction productivity growth.
- **Population and house price growth**: We did not observe a statistically significant relationship between population growth and construction productivity growth. Faster house price growth appeared to have a negative impact on construction productivity growth, although this was only statistically significant in one model.

Lastly, we found that **methodological issues** may affect measured construction productivity growth. All else equal, countries with price index methodologies that are more aligned with OECD best practice tend to have lower measured construction productivity growth.[18] A more in-depth analysis is needed to assess whether and how methodological issues affect international comparisons of price and productivity growth. However, this finding suggests that international comparisons of construction productivity growth could be complicated by relatively subtle methodological differences.

[17] For instance, Denmark and the United States have experienced stagnant or declining civil construction productivity and improving building construction productivity in recent decades (Statistics Denmark, 2022; Sveikauskas et al., 2016).

[18] Taking this finding at face value, it suggests that countries that are less aligned with OECD best practice methods tend to over-estimate quality improvements in construction outputs, and hence under-estimate price inflation. This results in faster estimates of construction output growth and hence faster estimates of construction productivity growth.

Table 1: Attempting to explain cross-country differences in construction labour productivity growth

Model		**Annual changes (2006-20)**	**Business cycle changes (2000-08; 2008-20)**	**Long run changes (2000-20)**
Outcome variable		**Annual change in labour productivity**	**Average annual change in labour productivity**	**Average annual change in labour productivity**
Explanatory variables				
Market characteristics	**Catch-up growth**: Per-capita GDP at start of period (natural log)	-0.027*** (0.006)	-0.021** (0.008)	-0.018** (0.008)
	Market size: Population at start of period (natural log)	-0.004*** (0.002)	-0.004*** (0.002)	-0.005*** (0.001)
	Construction regulation: World Bank construction permit score (0-100)	0.001*** (0.0002)	0.0007*** (0.0002)	0.0005 (0.0003)
Market dynamics	**Output composition**: Annual change in road investment share (%)	-0.159 (0.127)	-0.870*** (0.401)	-0.160 (0.563)
	Boom and bust: Construction output growth volatility (standard deviation)	0.004 (0.083)	-0.036 (0.090)	-0.044 (0.083)
	Growth: Annual population change (%)	0.217 (0.332)	-0.191 (0.322)	0.239 (0.288)
	House prices: Annual real house price inflation (%)	-0.029 (0.067)	-0.096 (0.072)	-0.122 (0.165)
Methods	**Price index methods**: Number of PPI methods in line with OECD preferred approach (0-8)	-0.004*** (0.001)	-0.003*** (0.001)	-0.002*** (0.001)
Constant		0.319*** (0.075)	0.263*** (0.089)	0.254*** (0.087)
Observations		394	56	31
R2		0.075	0.468	0.676

*Notes: (1) Panel model testing indicated a panel model with country random effects was preferred for the annual changes model, while a pooled model was preferred for the business cycle model (see Appendix 3 for test statistics). (2) See Appendix 3 for details of how variables were defined. (3) Standard errors are heteroskedasticity robust with a small sample size correction. (4) Statistical significant indicators *p<0.1; **p<0.05; ***p<0.01.*

The size of these impacts

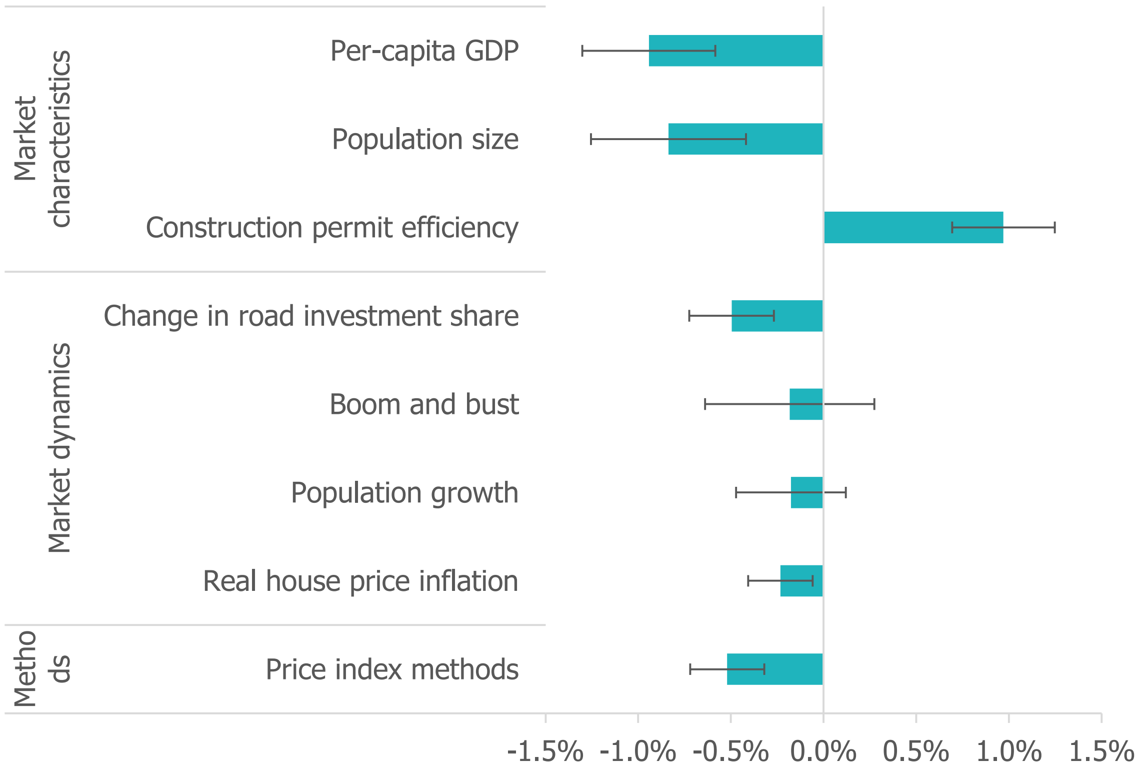
Because different variables are measured on different scales, regression results from Table 1 do not provide an intuitive sense of the size of the relationship between different factors and construction productivity growth. Figure 15 standardises the impact of different variables by estimating the impact of going from 25th to 75th percentile of OECD countries on each measure, holding all other factors constant.[19]

This suggests that per-capita GDP, population size, and construction permitting efficiency are the factors that have the largest impact on construction productivity growth. For instance, going from the bottom quartile of construction permitting efficiency to the top quartile is associated with a 1.0% increase in the rate of construction productivity growth.[20] This seems like a small difference, but it can add up rapidly.

[19] For instance, the point estimate of the coefficient on construction permit efficiency in the business cycle model is 0.0007. The 25th percentile OECD country has a permit efficiency score of 66.7, while the 75th percentile OECD country had a score of 80.5 (out of a total of 100). We therefore calculated the standardised impact of this variable as 0.0007*(80.5-66.7) = 1%.

[20] This is larger than Sveikauskas et al's (2016) estimate that restrictive land use regulation may subtract 0.1% from construction productivity growth in the United States.

Figure 15: Standardised impacts of different variables on construction labour productivity growth



Source: Te Waihanga analysis, based on first column in Table 1. The size of each bar indicates the impact of going from the 25th percentile to the 75th percentile on one variable, holding other variables constant. Error bars indicate +/- one standard error.

Current issues facing construction

In this section we examine short-term changes in economic and financial performance of the construction industry through the early stages of the Covid-19 pandemic. We summarise current pressures on the construction industry and present a firm-level analysis of how revenues, profits, and solvency and liquidity risk have changed for a sub-set of construction firms.

Factors affecting the construction sector over the past two years

Demand for new housing and new infrastructure has remained high through the early stages of the Covid-19 pandemic. From 2020 to 2022, new dwelling consents increased by 35% while investment in non-residential buildings and other construction fell by 6.8% and 6.3%, respectively (Statistics New Zealand, 2022a).

However, New Zealand's construction sector has faced several challenges through the Covid-19 pandemic, including significant cost escalations and delays in completing projects. Many other OECD countries, including Australia, are experiencing similar patterns of construction inflation.

Construction cost inflation is high, primarily driven by materials inflation

Table 2 summarises changes in input and output prices for the construction industry over the last year. This shows that:

- Costs for materials and others intermediate inputs are rising faster than labour costs
- Output prices are rising more rapidly than input prices
- Residential building prices have risen more than infrastructure construction prices and non-residential building prices (Statistics New Zealand, 2022b).

Table 2: Construction industry inflation for inputs and outputs, year ended June 2022

Producer Price Index - inputs (prices paid by producers for inputs)	
Labour cost inflation for all construction	4%
Producer price index – construction input index *(excludes labour and capital costs)*	14%
Capital Goods Price Index (changes in prices of new physical assets / outputs)	
Residential buildings	18%
Non-residential buildings	11%
Infrastructure-related construction	14%

Source: Statistics New Zealand (2022b)

Construction firms expect these pressures to continue. NZIER's December 2021 Business Opinion Survey found that 92% of firms reported an increase in costs, and feelings of pessimism as cost pressures continue to intensify (Ministry of Building, Innovation and Employment, 2022).

Construction cost inflation is expected to peak sometime in 2022, with the rate of inflation returning to a lower level in 2023. Inflation is expected to dampen as prices for raw materials and commodities return to levels at or below those before Russia's invasion of Ukraine. From December 2021 to July 2022, international timber prices have decreased 49%, and steel has fallen 16% (Pullar-Strecker, 2022). If demand for residential construction declines, it will tend to dampen inflation in the sector.

New Zealand's tight labour market is expected to continue into 2023, and possibly beyond

While construction inflation is expected to subside, labour cost inflation is expected to persist well into 2023. This is due to New Zealand's significant labour shortage. New Zealand is close to full employment, with an unemployment rate of 3.3% in the June 2022 quarter (Statistics New Zealand, 2022c).

Recent migration trends may be exacerbating labour market pressures in construction. SNZ's provisional estimate of net migration was an outflow of 7,300 people in the year ended March 2022. New Zealand relies on immigration to tap into the global labour market and fill skill gaps (Sense Partners, 2022). Recent changes to immigration policy may improve this outlook, depending upon how the sector agreement for construction worker access is implemented.

Colmar Brunton's most recent Construction Industry Survey found that 80% of respondents rated skills shortages as one of their top three challenges (May & Bryant, 2022).

Covid-19 delayed building projects, but construction firm liquidations have been limited thus far

In the June 2020 quarter, building projects were reported to be delayed by nearly seven weeks on average. This was early in the Covid-19 response, and delays were largely driven by Level 4 Lockdown. Since then, delays have mainly been driven by shortages in labour and materials, including exterior and interior cladding and gib board (Pointon, 2022).

Thus far, there are few signs of accelerating construction firm liquidations. Between January and May 2022, 120 construction firms were liquidated (Masters, 2022). This appears to be a pattern rather than a spike. For the same 6 months from 2019 to 2021, 123, 95, and 128 construction firms were liquidated respectively. However, Master Builders and the New Zealand Building Industry Federation have suggested that the sector is likely entering the down-turn phase of the boom-bust cycle as shortages in labour and materials combine with high costs and falling house prices (Cann, 2022).

A closer look at some of New Zealand's construction firms

To understand how construction firms' financial situations have changed during the early stages of the Covid-19 pandemic, we analyse firm-level data from the Ministry of Education's (MoE) Supplier Finance Tool. To ensure commercial sensitivity is upheld we do not present analysis or findings in a way that firms can be identified.

The Supplier Finance Tool summarises financial information from construction companies that tender for projects for Ministry of Education and several other central government agencies.[21] It provides information for the 2017 through 2021 financial years.

The MoE Tool is primarily used for due diligence in the procurement process by helping agencies to identify fit for purpose suppliers that have the financial health, capacity, and capability to successfully deliver contracts of different sizes. We use the underlying data to analyse the short- to medium-term financial performance of New Zealand's construction sector. Box 3 outlines key metrics we consider in this analysis.

[21] Te Waihanga has a Memorandum of Understanding with the Ministry of Education that outlines how we can use this data. This provides us with access to the financial records of every contractor who tenders for projects with the Ministry of Education and several other agencies, including Waka Kotahi, and allows us to collate anonymised and aggregated construction sector market benchmarking data for monitoring and reporting of industry trends and risks.

Box 3: Key metrics for firm financial performance

- **Gross profit:** This is equal to firm revenue minus wage/salary expenses and costs for intermediate inputs. It reflects the broad return on capital employed by the firm, including interest payments, shareholder profits, depreciation expenses, and taxes on profits.
- **Net profit:** This is equal to firm revenue minus wage/salary expenses, intermediate input costs, interest payments, depreciation expenses, and taxes on profits. It reflects the net returns to the firm's shareholders.
- **Solvency:** The ability of a firm to meet its long-term debts and obligations.
- **Liquidity:** The ability of a firm to use its current assets to meet its current or short-term liabilities.

The MoE Tool includes a small number of firms that represent a large share of market revenue

The Supplier Finance Tool includes around 150 firms in the vertical construction and civil construction space. Because these firms tend to be larger than average, they represent a large share of revenue in the non-residential construction and vertical construction space.

Table 3 presents key information on these firms. In 2021, the MoE Tool represented 41% of revenue but only 4.4% of all firms in the non-residential building and heavy and civil engineering construction market. These firms are around nine times larger, in terms of revenue, than the average construction firm. They play a significant role in delivering public infrastructure and hence it is important to monitor their performance. However, outcomes may differ for the broader construction market.

Throughout the analysis we focus on year-to-year changes in financial metrics as opposed to their absolute level. This helps to gauge the direction of trends in the market. As construction firms significantly vary in size, we focus on outcomes for the median firm.

Table 3: Comparison of firms in the MoE Supplier Finance Tool and all construction firms

	2017	2018	2019	2020	2021
Revenue comparison					
Total income - AES ($)	19.5b	21.5b	22.6b	23.4b	23.2b
Total revenue - MoE tool ($)	7.5b	9.6b	9.2b	9.7b	9.5b
Total revenue represented by the MoE supplier tool	38.5%	44.6%	40.7%	41.4%	40.9%
Number of firms and firm size					
Number of firms - AES	3,366	3,399	3,471	3,543	3,570
Number of firms – MoE tool	117	136	154	157	157
Total number of firms represented by the MoE supplier tool	3.5%	4.0%	4.4%	4.4%	4.4%
Average revenue of firms – AES ($)	5.8m	6.3m	6.5m	6.6m	6.5m
Average revenue of firms – MoE tool ($)	64.1m	70.6m	59.7m	61.8m	60.5m
Difference in firm size	11.1x	11.2x	9.2x	9.4x	9.3x

Source: Statistics New Zealand Annual Enterprise Survey data on non-residential construction and heavy and civil engineering construction firms; MoE Supplier Finance Tool.

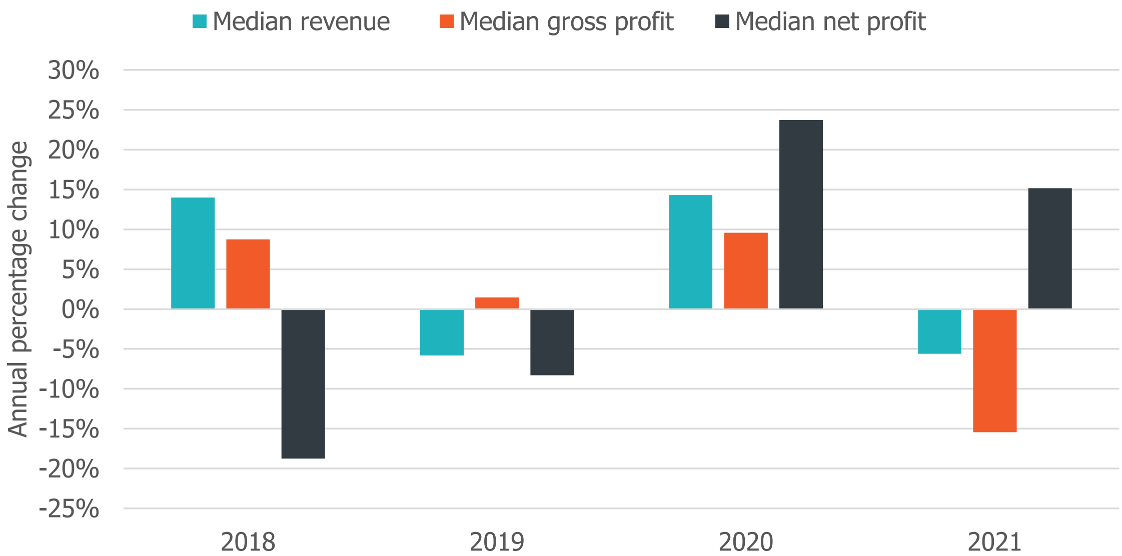
These firms maintained their profit margins through 2020 and 2021

Figure 16 shows that the median firm's revenue and profit were stable during the early stages of the Covid-19 pandemic. Between 2017 and 2021, the median firm's revenue increased by an average of 4% per year (a range of -6% to +14%).

The median firm's gross profit increased in 2018, 2019, and 2020 before decreasing by 15% in 2021. The median firm's net profit varied more over this period. Net profit increased by 24% in 2020 and increased by 15% in 2021.

This large increase in net profit was likely a function of the government's financial support for businesses during Covid-19, which would have lowered firms' expenses. For the median firm, operating expenses less decreased by 2% in 2020, reflecting reductions in activity during lockdowns. Firms appear to have paid down a large amount of debt in 2020, with average debt a cross firms declining by 29% between 2019 and 2020.

Figure 16: Annual change in the median firm's revenue, gross profit, and net profit

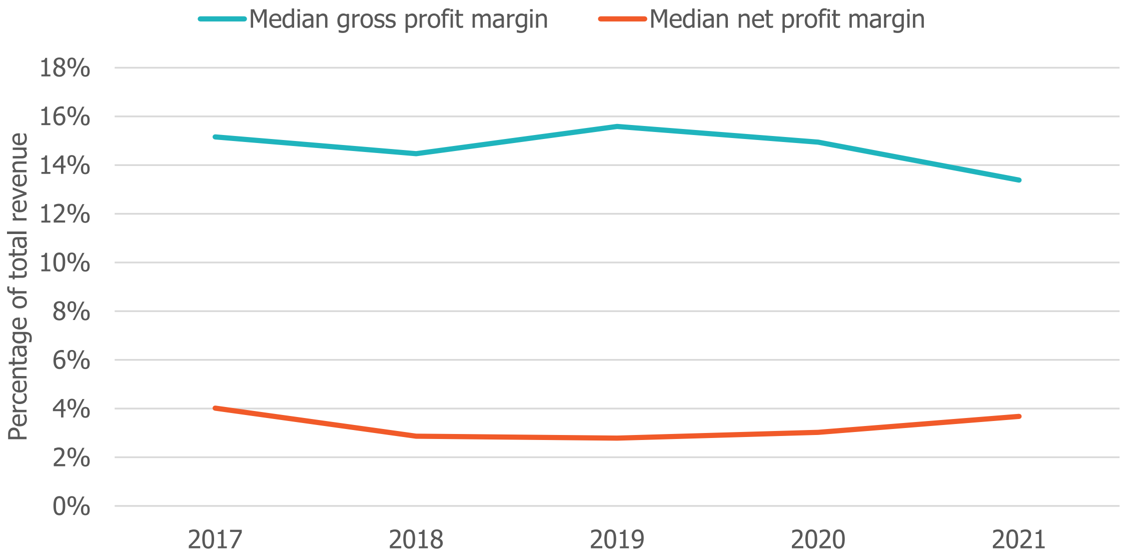


Source: Te Waihanga analysis of data from the MoE Supplier Tool. Figures are inflation-adjusted.

Figure 17 shows that construction firms' profit margins were stable during the early stages of the Covid-19 pandemic. Between 2017 to 2021, gross profit margins for the median firm ranged from around 13% to 16%. This figure reflects the difference between gross revenues and costs for labour, materials, and other intermediate inputs.

Net profit margins for the median firm ranged from 2.8% to 4.0%, rising in 2020 and 2021. This figure reflects the share of revenues that is ultimately returned to firms' shareholders, after accounting for interest payments, depreciation, taxes, and other allowances. We note that margins are likely to be higher for civil construction firms than for building construction firms.

Figure 17: Median firm's gross profit margin and net profit margin



Source: Te Waihanga analysis of data from the MoE Supplier Tool

Does increased revenues flow through to increased profits?

We used the MoE Supplier tool data to investigate whether firm profitability improves when firm revenues increase. This can help to understand whether increased revenues can assist construction firms to reach financial sustainability over time.

Table 4 presents panel regression models that relate changes in gross revenues with changes in net and gross profits, using firm-level data from 2017 to 2021. Based on our preferred models, which include year and firm-level fixed effects that control for underlying characteristics of firms that may make them more (or less) profitable, we estimate that:

- A $1 increase in gross revenue is expected to increase gross profit by 11 cents
- A $1 increase in gross revenue is expected to increase net profit by 2 cents.

This suggests that construction firms in the MoE Tool have, on average, managed to modestly lift profit when they have increased revenues.

Table 4: Profit-revenue regression results

Model	**Net profit Pooled OLS model**	**Net profit Fixed Effects model**	**Gross profit Pooled OLS**	**Gross profit Fixed Effects model**
Outcome variable	Change in net profit ($)	Change in net profit ($)	Change in gross profit ($)	Change in gross profit ($)
Explanatory variable				
Change in gross revenue	0.021*** (0.000)	0.017*** (0.000)	0.397*** (0.000)	0.113*** (0.000)
Firm fixed effects		Yes		Yes
Year fixed effects		Yes		Yes
R-Squared	0.8635	0.3654	0.8629	0.4585

Source: Te Waihanga analysis of data from the MoE Supplier Tool.

Notes: (1) Panel model testing indicated a panel model with fixed effects for year and firm was preferred for estimating both net and gross profit. We ran F-tests for both models to see if year and firm effects were significant. The null hypothesis is that the OLS model is preferred (ie year and firm are not statistically significant).

*The p-value for both tests was 0.000, which indicates that year and firm do have significant effects and that the fixed effects models are preferred. (2) Statistical significance indicators *p<0.1; **p<0.05; ***p<0.01.*

Solvency risks are widespread, but this is a pattern rather than a spike

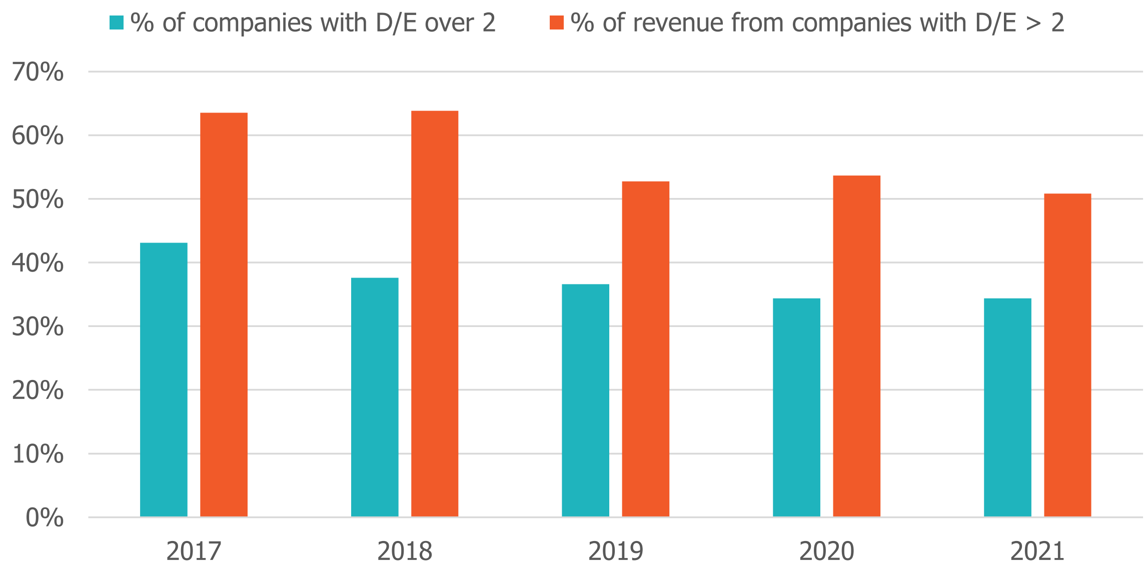
To assess solvency risks, we looked at firms' debt-to-equity ratios and interest coverage ratios. Both metrics are commonly used to measure a company's ability to meet its financial obligations.

The debt-to-equity ratio measures the proportion of a firm's operations that is funded by debt as opposed to equity. The 'optimal' ratio depends on the sector the firm is operating in. Capital intensive industries, including civil construction, tend to have slightly higher debt-to-equity-ratios. However, a common rule of thumb is that a ratio over two typically indicates that a company is in financial stress and may be unable to meet short- and/or long-term obligations to its creditors.

Figure 18 shows that 34% of construction firms in the MoE Tool, accounting for 51% of total revenue, had debt-to-equity ratios over two in 2021. These firms hold more than $2 of debt for every $1 of equity.[22]

While many firms have a high D/E ratio, the share of firms and the share of sector revenue exposed to a high D/E ratio are both decreasing. From 2017 to 2021 the proportion of firms with a D/E ratio over two dropped by 9% and revenue exposed dropped by 12%.

Figure 18: Proportion of firms and total firm revenue with debt-to-equity ratios over two



Source: Te Waihanga analysis of data from the MoE Supplier Tool

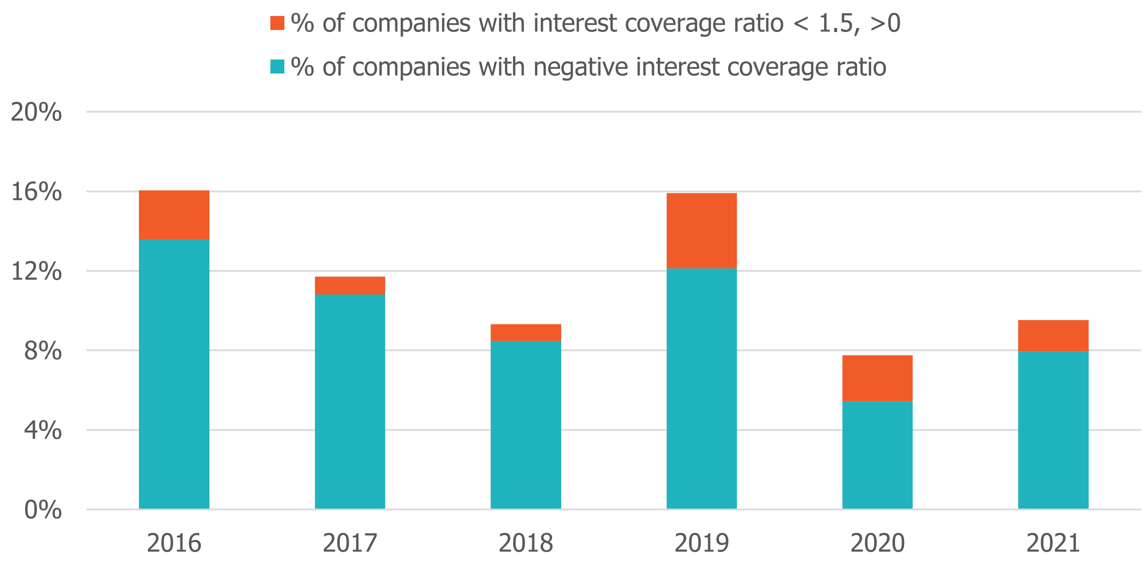
We also tested firm's solvency through the interest coverage ratio, which looks at how easily a company can pay interest on its debts. Like debt-to-equity, the 'optimal' ratio is largely dependent on the industry a firm operates in, but a higher ratio indicates that it will be easier to pay interest on loans and return profits to shareholders. Here, we identify firms with potential solvency risks as firms with interest coverage ratios below 1.5 and firms with negative profits.

[22] In addition, some firms appear to have negative debt-to-equity ratios, mainly due to negative shareholder equity. Between 2017 and 2021, between 8% to 12% of firms, accounting for between 1.2% and 3.8% of total revenue, had negative debt-to-equity ratios. It is unclear why this is the case, but it does not change our picture of firm solvency risk.

Figure 19 shows that in 2021, 8% of firms had a negative interest coverage ratio, indicating that they had negative Earnings Before Interest and Tax (EBIT). In addition, in 2021, 2% of firms had interest coverage ratios below 1.5 (but above 0). These firms are more likely to be exposed to dips in cashflow.

The share of firms with low interest coverage ratios has declined in recent years, although there was a modest increase in 2021.

Figure 19: Proportion of firms with an interest coverage ratio below 1.5



Source: Te Waihanga analysis of data from the MoE Supplier Tool

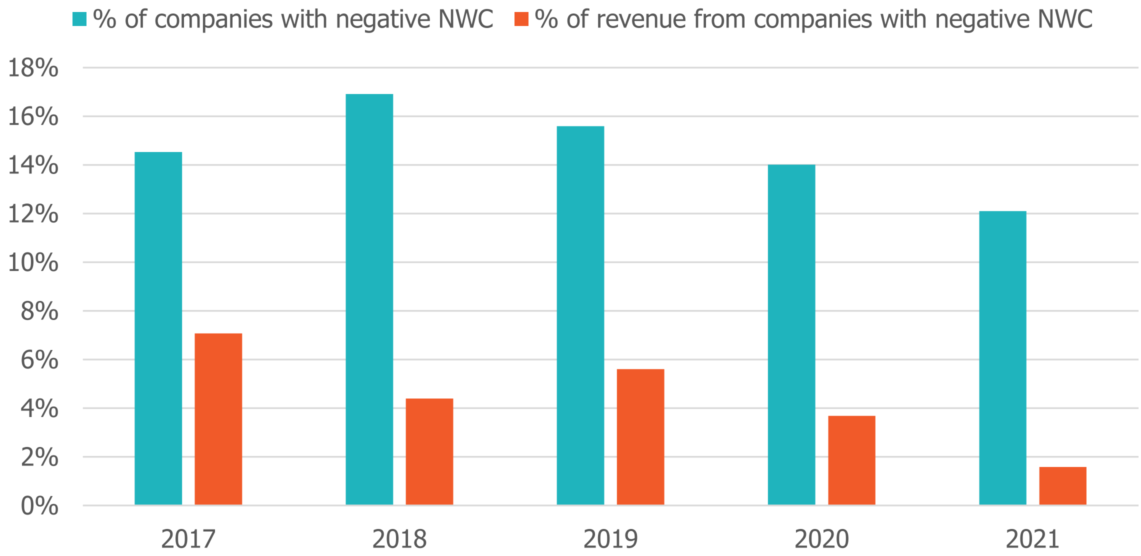
Some firms face liquidity risks, but liquidity risks did not increase in 2020 and 2021

To assess liquidity risk, we use net working capital, which is a firm's current assets minus its current liabilities. Negative net working capital indicates that a company may need to borrow or seek additional equity to meet its short-term obligations.

Figure 20 shows that around 15% of firms, accounting for around 6% of total revenue, had negative net working capital over the 2017-2021 period. Construction firms in the MoE Tool appear to be more exposed to solvency risk compared to liquidity risk.

Exposure to liquidity risk appears to have decreased through the early stages of the Covid-19 pandemic. The share of firms with negative net working capital declined from 16% in 2019 to 12% in 2021.

Figure 20: Proportion of firms and total firm revenue with negative net working capital



Source: Te Waihanga analysis of data from the MoE Supplier Tool

Conclusions

This Research Insights piece has investigated the economic performance of New Zealand's construction sector, with a particular focus on the civil construction sector due to its role in infrastructure delivery. Our analysis highlights some important considerations for the Section 7.5 of the *Infrastructure Strategy*, on building workforce capacity and capabilities. It also raises some important questions about how we can lift productivity in the civil construction sector.

Our key findings

Achieving faster construction productivity growth is important

New Zealand industries that have achieved faster productivity growth have experienced lower price inflation, faster increases in the quantity and quality of goods and services they produced, and less pressure on workforce capacity. In the long run, we estimate that a 1% increase in labour productivity leads to a 0.6% reduction in prices, a 0.3% increase in real output, and a 0.7% reduction in labour requirements.

Lifting construction productivity therefore plays a key role in addressing our infrastructure challenges. It can help us to contain infrastructure delivery cost inflation, increase infrastructure delivery, and moderate our workforce capacity pressures.

Overall construction productivity is improving

After a period of rapid productivity growth in the 1960s and early 1970s, New Zealand's construction sector experienced three decades of stagnant productivity. However, we have achieved sustained improvements in construction productivity since the late 2000s.

The New Zealand construction sector experienced booming output, employment, and productivity between 2008 and 2020. During this time, the construction sector reversed its historical productivity growth underperformance. Rather than lagging behind economy-wide productivity growth, construction as a whole matched the rest of the economy.

New Zealand's construction productivity growth is in the middle of the pack compared to other OECD countries. Over the last two business cycles (2000-2008 and 2008-2020) we had the thirteenth-fastest construction labour productivity growth in the OECD. Our performance lags behind some Eastern European transition economies experiencing 'catch-up' growth in productivity, but leads many other countries, including the likes of the United States and Japan.

Heavy and civil engineering construction lags behind

There is an important caveat to this finding: our improved construction productivity growth record is mainly due to 'vertical' construction of residential and non-residential buildings. 'Horizontal' construction, ie heavy and civil engineering construction, continues to experience slow productivity growth.

Between 2000 and 2020, labour productivity increased 23% in building construction, 25% in construction services, and only 5% in civil construction. Because heavy and civil engineering construction represents about 80% of the cost to build and maintain infrastructure, this represents a significant, ongoing challenge for New Zealand's infrastructure sector.

If civil construction had matched the productivity growth performance of building construction over the last 20 years, we estimate that infrastructure construction prices would be about 10% lower, the quantity and quality of new infrastructure construction would be about 5% higher, and workforce requirements would be about 11% lower.

International evidence highlights factors that can accelerate construction productivity

We identify several factors that are related to higher rates of construction productivity growth at the country level. First, we find that catch-up growth potential matters – countries with lower starting incomes tend to experience faster productivity growth. Second, we find that more efficient construction regulation is associated with faster productivity growth. Third, we find countries that shifted the composition of construction output towards road-building tended to experience slower productivity growth, possibly indicating a broader pattern of underperforming civil construction productivity growth.

However, some other factors do not appear to play a strong role. We find little evidence that economies of scale drive faster productivity growth – if anything, larger countries experience slower productivity growth than smaller ones. Construction market dynamics, like boom-and-bust cycles, population growth rates, and house price growth, seem to have little impact on construction productivity growth.

We also find some evidence that countries' choices about how to measure price indices (a key input into productivity statistics) may affect measured construction productivity growth, although this finding bears further investigation.

Construction firms have been resilient during early stages of the Covid-19 pandemic, but pressures are mounting

We use data from the Ministry of Education's Supplier Finance Tool to analyse the financial performance of around 150 large firms in the vertical construction and civil construction space. These firms represent around 40% of revenue in the non-residential construction and vertical construction space and play an important role in supplying public infrastructure.

These firms' profitability, solvency risk, and liquidity risk improved slightly through the early stages of the Covid-19 pandemic in 2020 and 2021. This highlights the resilience of the construction sector during this period and significant government financial support through measures like the Covid-19 wage subsidy.

However, our analysis also highlights that the construction sector face ongoing solvency risks, as reflected in high debt-to-equity ratios for a significant share of firms. In 2022, cost pressures have risen across the construction sector, primarily due to supply chain difficulties and increased prices for construction materials. To date, these have not caused an upsurge in firm liquidations – but this is a risk if pressures continue to mount.

How can we lift civil construction productivity?

Our analysis suggests that improving productivity growth in infrastructure construction can play an important role in addressing New Zealand's infrastructure challenges. However, the complexity of infrastructure projects can make it hard to achieve productivity gains. Infrastructure projects often involve working within or integrating with existing networks. They often face significant uncertainty about ground conditions that can result in scope or timeframe changes. Vertical construction projects, by contrast, tend to be more straightforward to plan and deliver.

With that in mind, what may be causing slow productivity growth in civil construction, and how can we lift the performance of the sector?

Some conventional stories about the causes of slow construction productivity growth in New Zealand don't seem to hold up.

International evidence suggests that our small size doesn't necessarily penalise us – if anything, smaller countries tend to experience faster construction productivity growth than larger countries. Similarly, while boom-bust cycles have damaged construction productivity in the past, our productivity growth record has *improved* since the 2008 Global Financial Crisis.

The evidence we have assembled suggests that we should ask some different questions instead.

First, what workforce capacity and capabilities do we need to lift productivity? Because infrastructure projects are complex and face multiple sources of uncertainty, they often rely on experienced professional and trades staff who can foresee and manage problems.[23] Better data on ground conditions and the condition and location of existing infrastructure can help to address this issue, but this is not necessarily a substitute for workforce capability.

Our analysis suggests that the civil construction sector has been able to increase the size of its workforce substantially in recent decades (Figure 9). However, industry bodies highlight that there is an ongoing need to address skill shortfalls (May & Bryant, 2022). As highlighted in Section 7.5 in the *Infrastructure Strategy*, we need to build the evidence base on the types of skills and occupations that are needed to address our infrastructure challenges.

Second, is there a link between competition and productivity in the construction sector? International evidence suggests that increased competition leads to higher productivity, as firms are incentivised to innovate and improve efficiency to avoid losing market share (Holmes & Schmitz, 2010; Zlatcu & Clodnitchi, 2018). Some analysts argue that weak competition in New Zealand's civil construction sector contributes to poor productivity growth (NZIER, 2013).

Maré and Fabling (2019) find that firms in the building construction and construction services industries face more competition than firms in the heavy and civil engineering construction industry.[24] We show that building construction and construction services are also experiencing faster labour productivity growth.

Third, do our systems for consenting and approving infrastructure projects reduce productivity growth by limiting innovation in design or construction methods? Our analysis indicates that countries with more inefficient construction permitting systems tend to experience slower construction productivity growth. Infrastructure construction may be more susceptible to these issues than building construction, as infrastructure projects tend to be larger, more complex, and require more permits and approvals to build.

[23] Management skills are likely to be particularly important for complex infrastructure projects. International evidence suggests that New Zealand's manufacturing sector performs poorly in terms of management quality (Green & Agarwal, 2011). Similar issues are likely to arise in other sectors. Sanderson (2022) finds that firm-level management practices have not changed significantly between 2005 and 2017, suggesting we may have ongoing deficits.

[24] Maré and Fabling (2019) estimate a suite of competition measures, including measures of industry concentration (eg share of sector revenue captured by a small number of large firms) and firms' ability to mark up prices above costs (an indicator of market power). They find that building construction and construction services are competitive on all measures, while heavy and civil engineering construction is highly concentrated but has reasonably low mark-ups. They find limited evidence of a link between competition and productivity, but this could be because competition intensity has not changed significantly over the period covered by their analysis.

This is not to say that stronger regulatory requirements are bad. They have many important benefits, including reducing environmental impacts of infrastructure development, improving health and safety performance, and alleviating impacts on nearby communities. However, research on infrastructure delivery costs in the US suggests that constantly *changing* regulatory requirements can lower construction productivity as a side effect of achieving these benefits (Brooks & Liscow, 2019; Eash-Gates et al., 2020).

Finally, are we mis-measuring changes in the quality of infrastructure we are building? In recent decades, design standards for infrastructure have changed, due to public demand for things like safer roads, cleaner water, improved energy performance, and better environmental mitigation.[25] If productivity measures do not capture the full value of these improvements, then they may under-state productivity growth in civil construction. However, it is unlikely that this would be large enough to fully eliminate the gap in productivity growth between 'horizontal' and 'vertical' construction.

These are not simple questions to answer, but they are important. Achieving faster infrastructure construction productivity growth is essential for addressing our infrastructure challenges. Understanding the factors driving our current performance is the first step to achieving that goal.

[25] Equally, we could over-estimate the value of infrastructure quality improvements. In some areas, there has been a longstanding trend towards selecting public infrastructure projects with lower value for money, which may indicate that the cost of quality improvements is greater than their value (Pickford, 2013).

Appendix 1: Econometric estimation of the Baumol model

Model setup

Our econometric analysis is based on the approach outlined by Nordhaus (2008). Nordhaus generalises Baumol's original two-industry unbalanced growth model to an economy with many industries. In this model, industry-level productivity growth is assumed to be exogenous, reflecting outside factors that are outside the control of firms in the industry. This theoretical model is used to identify a set of reduced-form equations that relate various endogenous outcomes (prices, real output, nominal output, labour input, and wages) to exogenous industry-level productivity growth.

Equation 1 shows the basic reduced-form equation for testing implications of the Baumol model. Δx_{it} is the percentage change in outcome variable x in industry i during time period t, while Δa_{it} is the corresponding percentage change in productivity. ε_{it} is an error term that could be further decomposed to include industry or time effects. β is the impact of productivity growth on the outcome variable, which is the effect that we are seeking to estimate econometrically.[26]

Equation 1: Reduced-form equations for testing implications of the Baumol model

$$\Delta x_{it} = \beta \Delta a_{it} + \varepsilon_{it}$$

Data sources

Table 5 summarises the data we used to estimate these reduced-form equations.

Table 5: Sources and summary statistics for long-run (2000-2020) industry productivity dataset

Variable	Source / notes	Number of industries	Mean	Standard deviation	Construction industry value
Labour productivity growth	SNZ Industry Productivity Statistics, labour productivity index	28	0.008	0.015	0.008
Multifactor productivity growth	SNZ Industry Productivity Statistics, multifactor productivity index	28	0.002	0.012	0.007
Output price growth	Implicit price deflators calculated from SNZ chain volume and nominal GDP (production measure) for ANZSIC industries	28	0.024	0.014	0.032
Real output growth	SNZ chain volume GDP (production measure) for ANZSIC industries	28	0.017	0.018	0.041
Nominal output growth	SNZ nominal GDP (production measure) for ANZSIC industries	28	0.041	0.022	0.073
Labour input growth	SNZ Industry Productivity Statistics, labour input industry	28	0.010	0.020	0.033
Wage growth	SNZ Quarterly Employment Survey, average hourly earnings	13	0.032	0.002	0.032

[26] Nordhaus (2008) observes that this parameter is related to the average price elasticity of demand for industry-level outputs.

Econometric model outputs

We estimated several permutations of the basic reduced-form model. We estimated models with both labour productivity growth and multifactor productivity growth as the explanatory variable. In addition, we estimated the model using annual changes in productivity, prices, etc; changes over the last two business cycles (2000-2008 and 2008-2020); and long-run changes from 2000 to 2020.

Table 6 summarises our resulting estimates. Annual and business cycle models were estimated using panel models with time and industry random effects, while long-run models were estimated using ordinary least squares regression. We ran standard panel model tests for each reduced-form regression to identify whether to include fixed or random effects.[27] Results generally, but not always, favoured random effects models over either pooled or fixed effects models. Where they did not, random effects estimates were generally similar to estimates from the preferred alternative (pooled or fixed effects) model. We therefore chose to report random effects estimates.

Each cell in the table reflects results from one econometric model. We obtain similar results when using either labour productivity (LP) growth or multifactor productivity (MFP) growth.

[27] We ran an F-test to compare a pooled model with an industry/time fixed effects model, a Lagrange multiplier test to compare a pooled model with an industry/time random effects model, and a Hausman test to compare fixed and random effects models.

Table 6: Testing the Baumol model using data on New Zealand industries

Time period	Productivity measure	Model type		Impact of industry productivity growth on:				
				Output price growth	Real GDP growth	Nominal GDP growth	Labour inputs	Average hourly wage
Annual	MFP	Random effects (time/industry)	Coeff	-0.595	0.978	0.350	-0.035	0.003
			Std err	0.282	0.053	0.316	0.048	0.038
			p-value	0.036**	0.000***	0.268	0.461	0.945
			N	540	540	540	540	260
Business cycle	MFP	Random effects (time/industry)	Coeff	-0.584	0.746	0.044	-0.293	0.051
			Std err	0.264	0.195	0.373	0.242	0.025
			p-value	0.031**	0.000***	0.907	0.231	0.055*
			N	54	54	54	54	26
Long difference	MFP	OLS	Coeff	-0.743	0.252	-0.491	-0.906	0.032
			Std err	0.286	0.284	0.349	0.332	0.029
			p-value	0.016**	0.384	0.171	0.012**	0.291
			N	27	27	27	27	13
Annual	LP	Random effects (time/industry)	Coeff	-0.560	0.840	0.242	-0.160	0.010
			Std err	0.251	0.057	0.269	0.057	0.036
			p-value	0.026**	0.000***	0.370	0.005***	0.783
			N	540	540	540	540	260
Business cycle	LP	Random effects (time/industry)	Coeff	-0.593	0.624	-0.100	-0.376	0.035
			Std err	0.163	0.106	0.175	0.106	0.021
			p-value	0.001***	0.000***	0.573	0.001***	0.104
			N	54	54	54	54	26
Long difference	LP	OLS	Coeff	-0.598	0.309	-0.289	-0.691	0.034
			Std err	0.262	0.211	0.186	0.211	0.031
			p-value	0.031**	0.155	0.133	0.003***	0.293
			N	27	27	27	27	13

*Notes: Statistical significant indicators *p<0.1; **p<0.05; ***p<0.01. Standard errors are heteroskedasticity robust with a small sample size correction*

Appendix 2: Labour productivity estimates for construction sub-sectors

This Appendix explains how we estimated labour productivity indices for 2-digit ANZSIC construction industries. To the extent possible, our estimates are calculated in a way that is consistent with SNZ's published methodology for productivity statistics and rely upon similar data (Statistics New Zealand, 2014).

Data sources

Labour productivity can be calculated as the ratio of real output to total labour input. To obtain estimates for 2-digit construction industries it was necessary to calculate or estimate output and labour input for 2-digit construction industries over time.

Real output indices were calculated as follows:

- We started with annual (March year) nominal 2-digit industry GDP(P) sourced from the National Accounts.
- Then, we used annual (March year) producer price indices for 2-digit industries to deflate nominal output to real output.[28] See below for further commentary on this issue.
- We converted real industry output (in constant New Zealand dollars) to real output indices with a base year of March 2000.
- We checked for consistency with official industry productivity data (Statistics New Zealand, 2022d) by summing real output for 2-digit industries and comparing the resulting output index with the published output index for the entire construction industry.

Calculating a labour input index was more complex and required several custom data requests. SNZ has historically measured labour input as the total paid hours worked in an industry, including both paid employees and working proprietors. As a result, we used the following data sources to estimate paid employee counts, working proprietor counts, and average weekly hours:

- We started with annual (March year) Linked Employer-Employee Dataset (LEED) data on paid employee counts for 2-digit industries.[29]
- We obtained annual (March year) LEED data on working proprietor counts for 2-digit ANZSIC industries from a custom data request to SNZ. We added working proprietor counts to paid employee counts to estimate total worker counts.
- We obtained annual (March year) Quarterly Employment Survey (QES) data on average weekly paid hours for people working in 2-digit industries from a custom data request to SNZ.[30]
- We multiplied total worker counts (from LEED data) by average weekly paid hours (from QES data) to estimate total weekly hours worked for 2-digit industries.
- To ensure consistency with official industry productivity data (Statistics New Zealand, 2022d), we summed estimated total weekly hours worked across all 2-digit ANZSIC industries, and the resulting labour input index with the published labour input index for

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[28] Producer price index output price indices are available on a quarterly basis. We averaged quarterly data to obtain estimated annual output price indices.

[29] LEED data on filled jobs by industry is available on a quarterly basis. We averaged quarterly data to obtain estimated annual employee counts.

[30] QES is available on a quarterly basis. We averaged quarterly data to obtain estimated annual average weekly paid hours. Note that sampling errors for 2-digit industry QES data are larger than sampling errors for 1-digit industry QES data, due to smaller sample sizes. A rough estimate suggests that sampling error will be up to 2 times as large for 2-digit ANZSIC industries. This should be considered as a source of error.

the entire construction industry. We used this to obtain a scaling factor that we then applied to 2-digit ANZSIC industries. This scaling factor appears to reflect changes to annual working days, eg from increased holiday and annual leave entitlements.

- We used the above estimates to derive labour input indices with a base year of March 2000.

Lastly, we estimated annual (March year) labour productivity indices for 2-digit construction industries by dividing real output indices by labour input indices.

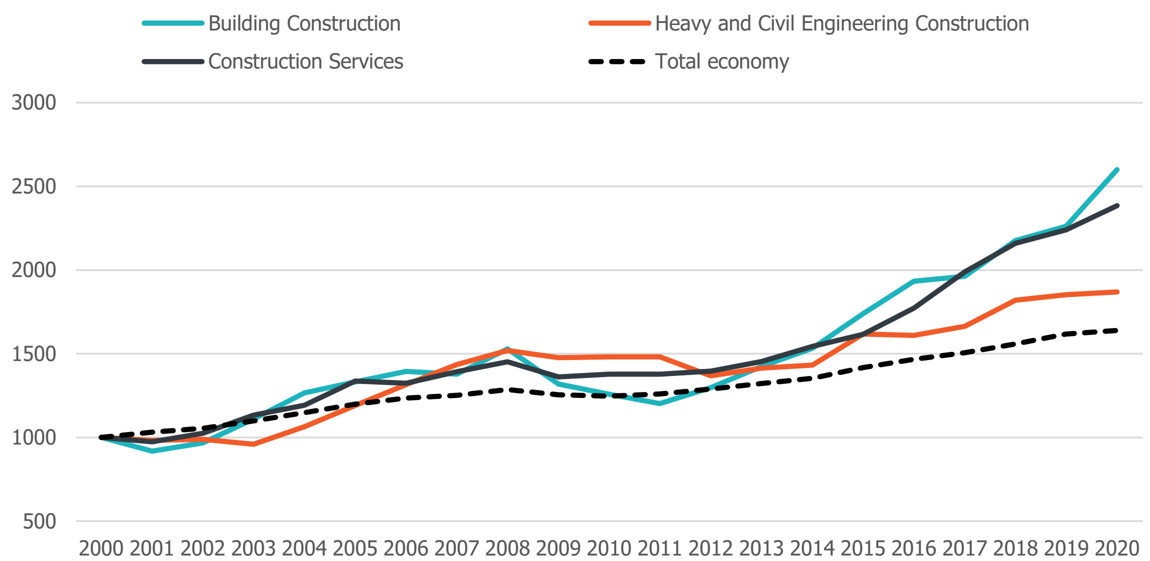
Summary of key data

Growth in real construction output

Figure 21 shows growth in real construction output for the three construction sub-sectors, relative to the whole or 'measured sector' of the economy as defined in SNZ's productivity statistics. This chart shows how rapidly the quantity and quality of construction sector outputs has increased in recent decades.

Construction output has grown more rapidly than the rest of the economy. From 2000 to 2020, building construction output rose by 160%, construction services output rose by 138%, and civil construction output rose by 87%. Economy-wide output increased by only 64%.

Figure 21: Growth in real output in construction industries, relative to the whole economy



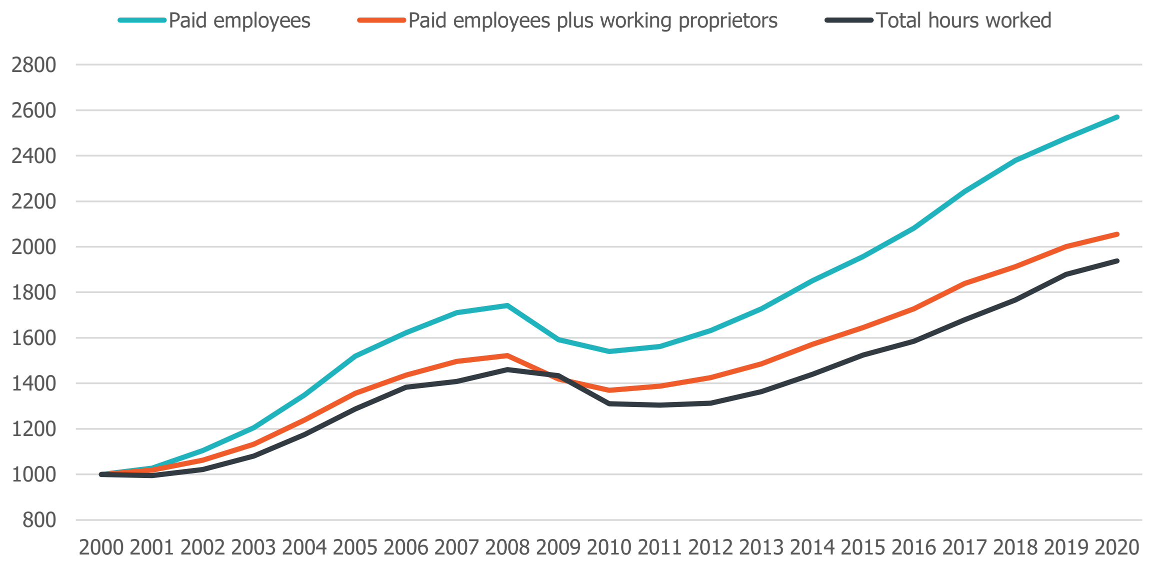
Source: Real output growth in construction sub-sectors is estimated using SNZ nominal GDP (production measure) for detailed industry groups and SNZ producer price index output price indices for NZSIOC level 3 industries. Real output growth for the 'total economy' is estimated using the SNZ productivity statistics' output index for the 'measured sector', which excludes some public services where productivity is difficult to measure.

Growth in construction labour inputs

Employment statistics are commonly used to estimate changes in construction labour inputs. However, paid employment is a partial measure that misses other important trends, such as growth in working proprietors and changing hours of work. Total hours worked by both paid employees and working proprietors is a better measure of labour inputs.

Figure 22 compares growth in the number of paid employees, the number of paid employees plus working proprietors, and total hours worked for the overall construction industry. While paid employment expanded by 157% over the 2000-2020 period, the overall labour force (including working proprietors) grew at a slower rate of 106%. Total hours worked grew by 94%, meaning that annual hours per worker declined by around 6% between 2000 and 2020. This reflects a range of factors, including reductions in the length of a typical workweek and increased leave allowances.

Figure 22: Changes to construction labour inputs, 2000-2020



Source: Te Waihanga estimates based on SNZ LEED data (for paid employee counts and paid employees plus working proprietors) and the SNZ industry productivity statistics' labour input index (for total hours worked).

Figure 9 in the body of the report shows growth in construction labour inputs, measured based on total hours worked, relative to the whole 'measured sector' of the economy as defined in SNZ's productivity statistics.

Labour productivity indices for construction sub-indices

Table 7 reports our annual labour productivity estimates for construction sub-sectors.

Table 7: Labour productivity estimates for 2-digit construction industries, 2000-2020

Year	Real output index			Labour input index			Labour productivity index		
	Building Construction	Heavy and Civil Engineering Construction	Construction Services	Building Construction	Heavy and Civil Engineering Construction	Construction Services	Building Construction	Heavy and Civil Engineering Construction	Construction Services
2000	1000	1000	1000	1000	1000	1000	1000	1000	1000
2001	919	983	975	982	997	1000	936	986	975
2002	968	988	1025	1014	1027	1022	954	962	1002
2003	1110	959	1134	1084	1046	1089	1024	917	1040
2004	1266	1065	1193	1203	1133	1174	1052	940	1016
2005	1333	1191	1337	1331	1274	1273	1002	934	1050
2006	1395	1315	1323	1438	1397	1356	970	941	976
2007	1379	1436	1393	1470	1417	1380	938	1014	1009
2008	1529	1519	1453	1532	1536	1408	998	989	1032
2009	1319	1477	1362	1478	1549	1383	892	953	985
2010	1258	1481	1378	1336	1408	1272	941	1052	1083
2011	1203	1481	1378	1297	1311	1306	928	1130	1055
2012	1297	1369	1396	1338	1352	1291	970	1012	1082
2013	1424	1414	1454	1451	1352	1330	981	1046	1093
2014	1532	1432	1544	1533	1413	1408	999	1013	1096
2015	1740	1618	1616	1629	1447	1501	1068	1118	1076
2016	1934	1610	1773	1690	1505	1563	1144	1069	1134
2017	1962	1664	1989	1843	1581	1637	1065	1052	1215
2018	2176	1820	2159	1938	1721	1707	1123	1058	1265
2019	2262	1853	2241	2000	1755	1862	1131	1056	1204
2020	2599	1869	2384	2109	1789	1908	1232	1045	1250

Source: Te Waihanga estimates based on SNZ data described above

A note on measurement

Price indices are an essential input into productivity estimates. Conceptually, productivity indices track whether we are able to produce more or better outputs over time, using a given quantity of inputs. However, national accounts statistics do not directly measure changes in the quantity and quality of industry outputs over time. Rather, they track changes in the current-price dollar value of industry output, and then use price indices to convert this to constant-price (real) output estimates. Separate price indices are calculated for each industry's inputs (ie the intermediate goods the industry purchases to use in production) and outputs (ie the goods and services that the industry produces and sells to customers).

In general, price indices attempt to adjust for changes in the quality of goods or services produced. This is necessary because firms often introduce new or improved products that are more expensive but also offers additional benefits for consumers. In addition, the composition of outputs produced by industries can shift over time. Failing to account for these quality improvements would mean over-estimating price inflation, and hence under-estimating productivity growth. Failing to account for compositional shifts could mean either over-estimating or under-estimating price inflation, depending upon circumstances.

To illustrate how price index methodology affects productivity growth estimates, consider a simple hypothetical example. Let's say that the current-price dollar value of residential construction increases by 10%, while the number of people employed in construction stays the same. Did productivity increase? It depends upon what happened to prices. Let's say that the average price of new-build homes increases by 10%, and that the average quality of these homes increases by 5% (eg due to increased house size or better insulation).

If price indices failed to adjust for changing home quality, we would estimate that there had been no increase in construction productivity. However, if price indices accurately adjusted for quality changes, then we would estimate that construction productivity had risen by 5%. Imperfect quality adjustment methods might result in an estimate somewhere in the middle.

By and large, New Zealand constructs producer price indices using methods that are consistent with OECD best practices or acceptable practices. SNZ (2015) outlines the methodology for constructing New Zealand's producer price indices, while OECD (2011) compares methodologies used in different OECD countries.

Based on discussions with SNZ, we understand that producer price indices for construction industries are built up from quantity surveyor estimates of the cost to build a reference set of standard construction designs. Price indices for individual items in the construction basket are re-weighted annually to reflect changes in the composition of construction output over time. However, we also understand that the underlying basket of goods tracked by SNZ has not been updated since around 2008. An update was planned for around 2016 but was deferred.

The composition of construction output and the quality of construction outputs has changed since 2008, due both to market demands and regulatory changes. This includes things like changes to health and safety regulation; initiatives like social procurement, sustainability, and carbon emission performance for public infrastructure projects; and a relative shift towards constructing more apartments and townhouses. It is possible that price indices built up from a 2008 basket of goods do not accurately account for quality changes or compositional shifts. This could in theory lead to biased estimates of output price growth and productivity growth, but we do not have sufficiently detailed information to quantify this issue.

Appendix 3: International comparisons of construction labour productivity growth

Industry labour productivity growth estimates

We use the following datasets to compare labour productivity growth rates in the construction industry:

- National statistics agencies (New Zealand and Australia)
- OECD.Stat industry productivity statistics (30 OECD countries)
- EU-KLEMS (2 additional OECD countries with poor coverage in OECD.Stat)

These sources define the construction industry in a similar way, with at most minor variations. OECD.Stat defines industries using the International Standard Industrial Classification (ISIC), revision 4. SNZ and the Australian Bureau of Statistics (ABS) use the Australia-New Zealand Standard Industry Classification (ANZSIC), 2006 revision, which corresponds to ISIC rev 4. EU-KLEMS uses the Statistical Classification of Economic Activities in the European Community (NACE), revision 2, which also corresponds to ISIC rev 4.

OECD statistics agencies prepares national accounts data and productivity indices using broadly similar methodologies (Organisation for Economic Co-operation and Development, 2001). Basic concepts, such as the definition of productivity, the definition of output, and the definition of labour input, are comparable across countries. However, there are variations in how standard methodologies are applied. These include things like:

- How labour input is measured: New Zealand historically measured labour input based on total paid hours, while most other OECD countries measure it using total hours worked (paid and unpaid). We would expect these differences to affect the estimated level of labour productivity, but not necessarily productivity growth rates.
- How price indices are calculated: OECD (2011) surveys differences in producer price index methodology at a point in time and assesses whether OECD countries employ preferred/best practice methods, methods that are in line with international guidelines, or other methods. Countries tend to adopt a common set of principles in slightly different ways. As noted in Appendix 2, different price index methodologies could lead to different estimates of productivity growth.

National statistics agencies provided annual labour productivity indices. For other OECD countries, it was necessary to calculate annual indices using data on real output and total hours worked for the construction industry. We did so by dividing total real output (in constant-price national currency units) by total hours worked, and then converting these estimates to indices with a base year of March 2000.

Variables that may be related to construction productivity growth

Table 8 summarises the data we used in our cross-country analysis.

Table 8: Data used for cross-country construction productivity growth regressions

Category	Variable	Source / notes
Market characteristics	**Catch-up growth**: Per-capita GDP at start of period (natural log)	Annual data on GDP per capita in constant price, PPP-adjusted US dollars was sourced from OECD.Stat.[31] Our measure was GDP per capita at the start of each period.
	Market size: Population at start of period (natural log)	Annual population estimates were sourced from the World Bank.[32] Our measure was population at the start of each period.
	Construction regulation: World Bank construction permit score (0-100)	Annual 'dealing with construction permits' scores were sourced from the World Bank.[33] Scores reflect procedures, time, and cost to build a standard building product (a warehouse). Higher values indicate more efficient permitting. This measure was available for 2006-2020, with a change in methodology in 2015. We spliced the 2006-2015 and 2015-2020 series together. Our measure for the business cycle model and long-run model was average permit score over each period, while our measure for the annual model was the annual permit score.[34]
Market dynamics	**Output composition**: Annual change in road investment share (%)	Annual data on total road investment, in current price national currency units, was sourced from OECD.Stat.[35] We calculated the ratio of total road investment to construction industry output (also in current price national currency units) for each year, and then calculated annualised changes in this ratio over different time periods.
	Boom and bust: Construction output growth volatility (standard deviation)	Annual data on construction sector output, in constant price national currency units, was sourced from national statistics agencies, OECD.Stat, or EU-KLEMS. We calculated annual growth in construction output and the standard deviation of annual construction output growth over periods.[36] For the business cycle model and long-run model, we calculated standard deviations over relevant periods (eg 2000-2008, 2008-2020). For the annual model, we calculated standard deviations over the five previous years (eg 2001-2005 for the 2006 year).
	Growth: Annual population change (%)	We calculated population growth rates (either annual or average annual over periods) using World Bank population data.[37]
	House prices: Annual real house price inflation (%)	Annual data on real (inflation-adjusted) house prices was sourced from OECD.Stat.[38] We used this data to calculate annual growth in house prices (either annual or average annual over periods).
Methods	**Price index methods**: Number of PPI methods in line with OECD preferred approach (0-8)	OECD (2011) provided data on different countries' methods for creating producer price indices as of 2011. This identifies eight different aspects of price index methodology (see Table 9). For each country, we calculated the number of aspects that are in line with the OECD's preferred or best practice methodology.

Table 9 summarises the OECD survey results for producer price index methodology, noting the OECD's preferred / best practice approach in each area (as of 2011). These cover a range of

[31] https://stats.oecd.org/index.aspx?queryid=61433#
[32] https://data.worldbank.org/indicator/SP.POP.TOTL
[33] https://subnational.doingbusiness.org/en/data/exploretopics/dealing-with-construction-permits/what-measured
[34] We considered using changes in construction permit score, but most countries experienced relatively small changes in permit efficiency over this period.
[35] https://stats.oecd.org/Index.aspx?DataSetCode=ITF_INV-MTN_DATA
[36] Other measures of boom and bust, such as the largest annual decline in construction output in a given period, performed similarly.
[37] https://data.worldbank.org/indicator/SP.POP.TOTL
[38] https://stats.oecd.org/viewhtml.aspx?datasetcode=HOUSE_PRICES&lang=en#

different issues, ranging from the type of prices that are collected, how indices are computed and aggregated at various level, how frequently weights are updated, and how quality adjustment is done. This is a snapshot of practices at a point in time, and countries are likely to have changed their approach since this survey was undertaken.

Table 9: Aspects of producer price index methodology surveyed by the OECD

Category	Preferred approach	NZ approach	Number of countries using preferred approach (n=34)
Type of prices	Basic prices	Basic prices	21
Activity Classification	ISIC Rev. 4	ANZSIC 2006 (corresponds to ISIC Rev. 4)	25
Domestic and export prices?	Both domestic and export	Total only	25
Computation of lowest level indices	Ratio of averages OR Geometric mean of prices	Geometric mean of prices	16
Aggregation formula	Chained Laspeyres	Fixed base Laspeyres	10
Frequency of weight updates	Annually	5-10 years	10
Imputation of missing prices	Yes	[Not reported]	21
Quality adjustment	Implicit OR explicit	Implicit	27

Table 10 provides summary statistics for the long-run OECD dataset used in this analysis.

Table 10: Summary statistics for long-run (2000-2020) country construction productivity dataset

Category	Variable	Number of countries represented	Mean	Standard deviation	New Zealand value
Outcome	**Average annual change in construction labour productivity**	35	0.0067	0.0140	0.0084
Market characteristics	**Catch-up growth**: Per-capita GDP at start of period (natural log)	35	10.30	0.53	10.29
	Market size: Population at start of period (natural log)	35	16.14	1.50	15.17
	Construction regulation: World Bank construction permit score (0-100)	35	72.5	8.8	83.0
Market dynamics	**Output composition**: Annual change in road investment share (%)	33	-0.0005	0.0045	-0.0002
	Boom and bust: Construction output growth volatility (standard deviation)	35	0.0770	0.0513	0.0450
	Growth: Annual population change (%)	35	0.0056	0.0071	0.0139
	House prices: Annual real house price inflation (%)	34	0.0228	0.0175	0.0550
Methods	**Price index methods**: Number of PPI methods in line with OECD preferred approach (0-8)	31	4.81	1.74	4

Econometric model testing

Table 1 in the body of the report presents our preferred estimates of three econometric models of annual, business cycle, and long-run changes in construction labour productivity. These models include the same explanatory variables but cover different time periods.

We ran standard panel model tests for the annual and business cycle models to identify whether to include fixed or random effects. These tests indicated that panel model with country random effects was preferred for the annual changes model, while a pooled model was preferred for the business cycle model. Table 11 reports key findings from this analysis.

Table 11: Panel model testing for cross-country construction productivity growth regressions

Test	**Annual changes model**	**Business cycle changes model**
F-test of twoway (country/time) fixed effects model vs pooled model	p-value = 0.992 Fail to reject null hypothesis of no fixed effects	p-value = 0.819 Fail to reject null hypothesis of no fixed effects
Lagrange multiplier test of twoway (country/time) random effects model vs pooled model	p-value = 0.005 Reject null hypothesis of no random effects at 1% level	p-value = 0.228 Fail to reject null hypothesis of no random effects *Note: Same results obtained for oneway random effects*
Hausman test of twoway fixed effects vs twoway random effects	N/A	N/A
Hausman test of oneway (country) random effects vs twoway (country/time) random effects	p-value = 1.00 Fail to reject null hypothesis of no time random effects	N/A
Preferred model	**Country random effects model**	**Pooled (OLS) model**

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