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CONCOVE TŪHURA

Report prepared for:
The Centre for Vocational Excellence (ConCoVE)

Characterising the prefabrication workforce

An analysis of the current supply of and demand for the prefabrication workforce

June 2023

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Executive summary

Introduction

One of the aims of the ConCoVE is to drive innovations in the construction and infrastructure workforce that will enable it to become more productive. One area the ConCoVE has identified in which it could create such an impact is in the offsite manufacturing industry. The ability to manufacture key elements of construction projects offsite is increasingly becoming an important part of New Zealand's construction and infrastructure ecosystem and is key to the future effectiveness of the industry.

The proportion of total construction builds sourcing one or more prefabricated elements from offsite manufacturers has increased from 3% to 9% between 2014 and 2021[1]. This share of the construction market is expected to accelerate in the coming years partially driven by the Government's commitment to "Drive the uptake of offsite manufacturing by Government agencies by a minimum of 10% year on year, to improve productivity and competition [for key building supplies]"[2]. As the Government and industry organisations increase their utilisation of offsite manufacturing, it becomes important to understand the offsite manufacturing workforce in more detail.

Current state of the prefabrication workforce

The current supply of the prefabrication workforce is estimated to be 2,325 FTEs in Q2 2023, while the demand for the workforce is estimated to be 3,999 FTEs (Figure 1). Rather than indicating a workforce shortage, the variance between the two estimates is an artefact of the modelling process. The confidence in these estimates will improve as the model's inputs are reviewed and updated. The occupations shown here are the same as traditional onsite occupations due to the prevailing business model in the prefabrication industry currently being labour intensive. We would expect that as construction-based technology becomes adopted across the industry, the composition of the prefabrication workforce would change, and more technology intensive roles will become relevant in time. This will be reviewed during future engagement with the industry – see recommendations.

A dynamic and interactive dashboard presenting the outputs from this work has been integrated with Waihanga Ara Rau's Workforce Information Platform (WIP) – click here to view the dashboard.

[1] According to a report commissioned by Offsite NZ in 2021 exploring residential and non-residential consent data from Statistics NZ for the frequency of prefabrication terminology in project descriptions.

[2] https://www.beehive.govt.nz/release/government-taking-action-improve-building-supply-competition. This statement was made in response to the Government's acceptance of the Commerce Commissions' recommendation to "Develop and implement an all-of-government strategy to coordinate and boost offsite manufacturing": (https://comcom.govt.nz/about-us/our-role/competition-studies/market-study-into-residential-building-supplies

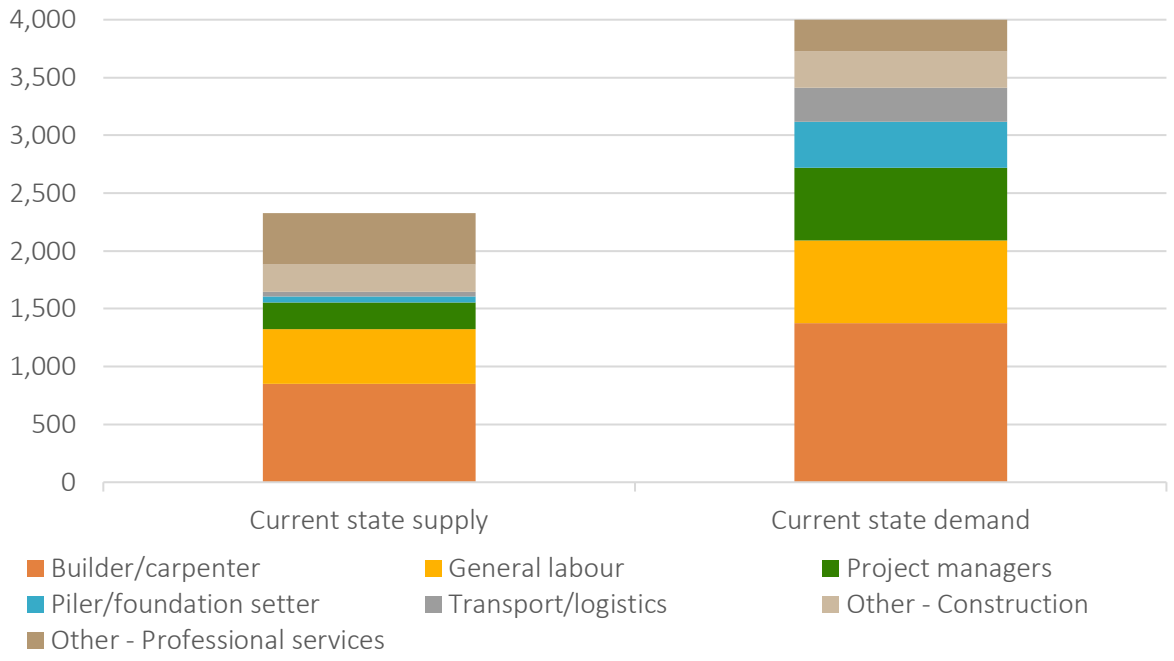

Figure 1: Current state estimate of the prefabrication workforce's supply and demand (Q2 2023).

Future demand for the prefabrication workforce

Figure 2 illustrates how the current state demand for the prefabrication workforce from Figure 1 is forecast to grow over time as the current market share of the prefabrication industry (i.e. the percentage of construction projects sourcing at least one prefabricated product) is maintained at the current 9%. This is considered the baseline analysis for which scenarios are imposed in the following sections. By the end of 2027, the model suggests the demand for the prefabrication workforce will be 4,567 FTEs – 569 more than the current demand.

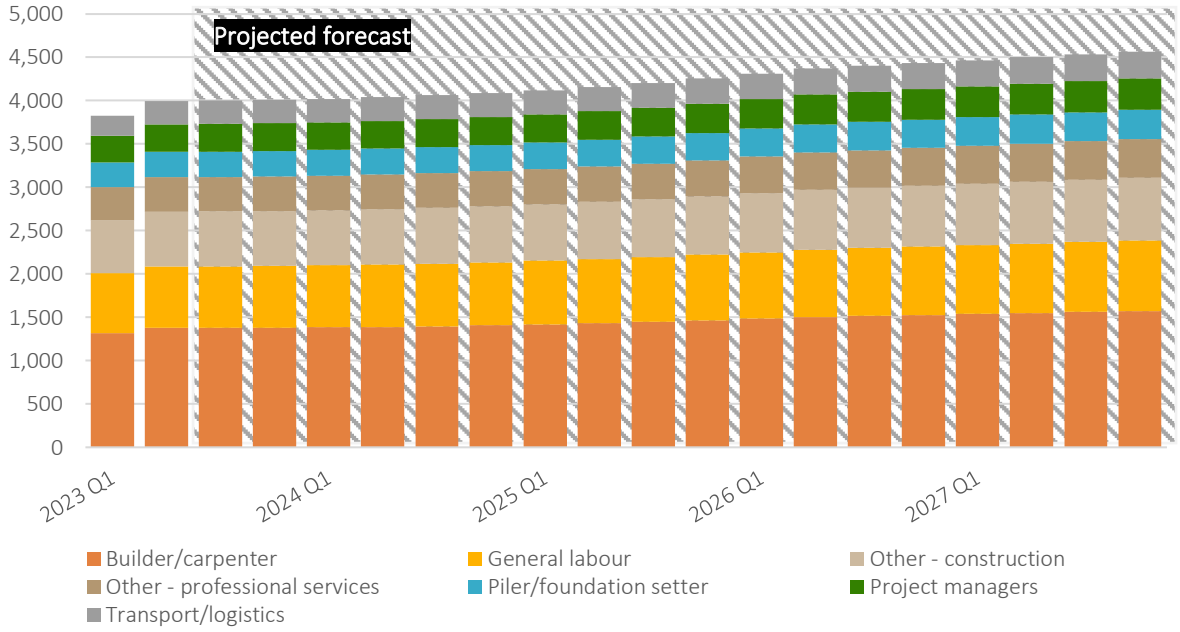

Figure 2: Demand (FTEs) for the prefabrication workforce by occupation – baseline analysis

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The modelling tests how the projected demand could be expected to change because of two anticipated trends in the industry; growth in the market share of the prefabrication industry and the adoption of construction-based technology reducing the number of builders/carpenters and general labourers required. The independent impact of these trends on the baseline workforce demand is presented below:

- Growth in industry market share. The projected demand in the baseline analysis assumes that the prefabrication industry will maintain its current market share as the wider construction industry grows. In reality, the commitment from the Government to increase their utilisation of offsite manufacturing will result in the prefabrication industry's market share (i.e. the proportion of total construction builds sourcing one or more prefabricated elements from offsite manufacturers) increasing. The modelling suggests that an increase in the industry's market share to 30% by Q2 2026 will increase the demand for the prefabrication workforce to 13,383 FTEs by the end of 2027 – 9,384 more than the current demand.
- Adoption of construction-based technology. The current assumptions characterising the number of people employed by prefabrication businesses are based on labour-intensive business models. It is expected that as the industry grows and its processes mature, businesses will look to adopt construction-based technologies for the efficiencies they can achieve – one being a reduction in the number of people required (e.g. substitution of people)[3]. The construction-based technologies modelled here assume a reduction in the number of builders/carpenters required. The modelling suggests that a 20% decrease in the number of these occupations required by Q2 2026 would increase demand to 4,100 FTEs by the end of 2027 – just 102 more than the current demand. Note that the annual industry growth of 3% increases the total workforce demand, while the demand for builders/carpenters and general labourers decreases because of the technology adopted.

An evaluation of the combined effect of the two trends on the baseline workforce is available on the WIP dashboard.

Findings and insights

The findings and insights to come from this work are as follows:

- The prefabrication industry will need to attract more people to meet the anticipated increase in demand. The market share of the prefabrication industry is expected to accelerate in the coming years driven by the commitment from the Government to improve its utilisation of the industry. The industry will need to attract between 4,800 (for a 20% market share) and 8,800 (for a 30% market share) more people to the workforce by Q2 2026 – a 120% to 220% increase on the current workforce demand.
- The occupations relevant to the prefabrication industry are currently homogenous with the occupations relevant to the traditional onsite construction workforce. The occupations and skills identified to be relevant to the construction of prefabricated products are understood to be homogenous with the occupations and skills of the traditional onsite workforce. Providing the prefabrication industry can provide a comparatively attractive employment opportunity

[3] This analysis focuses on evaluating the influence of construction-based technology which acts as a substitute for people (e.g. reduces the number of people required) rather than technology that is complimentary to people (e.g. improves the productivity of existing people without displacement).

(e.g. compensation packages, work hours, tidy facilities, shelter, etc.), it should be able to attract the people it needs from the traditional onsite workforce to meet demand.

- **There is, anecdotally, a high substitutability of people for construction-based technology.** Prefabrication businesses in New Zealand have nuanced business models. One nuance is their investment in construction-based technology as a substitute for people. For the most part, prefabrication businesses in New Zealand appear to be labour-intensive models which employ or contract the required occupations to produce prefabricated products. One reason for the current reliance on people is presumably due to the New Zealand industry being in its infancy. It would be expected that as the industry grows and matures its processes, the use of construction-based technology will become more widely used and the number of builders/carpenters and general labourers required will reduce.

- **Technology can be used to offset the increase in demand for the prefabrication workforce if the industry were to struggle to attract the required people.** The baseline analysis (Figure 2) illustrated that to maintain its current market share of 9%, the prefabrication industry would need to attract approximately 570 people to its workforce by the end of 2027. However, with the adoption of construction-based technology to reduce the number of builders/carpenters and general labourers required by 20%, the industry would only need to attract approximately 100 additional people to maintain its current market share by the end of 2027.

- **As the adoption of construction-based technology increases, the ability to embrace and interact with digital technology will emerge as a key skill required of the prefabrication workforce.** As construction-based technology becomes more widely adopted, it is expected that the substitutability of people between the traditional onsite and prefabrication workforces will reduce as the skills expected of the prefabrication workforce will change. An ability to embrace and interact with digital technology is widely regarded as one of the key emerging skills required of the prefabrication workforce.

Project recommendations

To accompany the above insights, the following recommendations have been proposed as the next steps for the ConCoVE to better understand the potential future trends in the prefabrication industry and to support the VET system to adapt qualifications as necessary. The recommendations include:

- **Integrating improvements in the inputs and assumptions used to model the supply of and demand for the prefabrication workforce into future work.** The approaches used to model the outputs in this document rely heavily on several assumptions and rules, particularly for the estimates of workforce supply. We would recommend the ConCoVE periodically update several of the inputs to the model via their engagement with industry and future RFPs. This work would improve confidence in the outputs from the model presented in this report.

- **Commissioning a research programme to characterise the implications of prefabrication businesses widely adopting construction-based technology.** Construction-based technology is arguably more disruptive to the prefabrication industry than the current prefabrication industry is to the traditional onsite construction industry. We recommend that the ConCoVE, therefore, look to commission a research programme that characterises the role of technology in the industry. Findings from this work would support the ongoing development of the modelling presented in this report and encourage prefabrication businesses to evaluate the opportunity for different types of technology to improve the productivity of their business.

- Commissioning a research programme evaluating the future skills required of New Zealand's prefabrication workforce. An ability to embrace and interact with digital technology has been highlighted as a key emerging skill required of the prefabrication workforce when technology is integrated into operations. It is therefore important that emerging skills are identified ahead of the industry need to allow the VET system time to adapt qualifications before it is required.
- Commissioning a research programme evaluating the future growth of the prefabrication industry. The prefabrication industry is poised to grow as a contributor to the construction of buildings across New Zealand. We recommend that the ConCoVE commission a research programme that evaluates realistic growth scenarios for the industry using international industries as case studies. This would help improve the outputs presented in this report and provide an indication of the role the prefabrication industry plays in the wider construction sector moving forward.

Introduction

Context

One of the aims of the ConCoVE is to drive innovations in the construction and infrastructure workforce that will enable it to become more productive. One area the ConCoVE has identified in which it could create such an impact is in the offsite manufacturing industry. The ability to manufacture key elements of construction projects (e.g. wooden panels, volumetrics and transportable homes) offsite is increasingly becoming an important part of New Zealand's construction and infrastructure ecosystem and is key to the future effectiveness of the industry.

The proportion of total construction builds sourcing one or more prefabricated elements from offsite manufacturers has increased from 3% to 9% between 2014 and 2021[4]. This share of the construction market is expected to accelerate in the coming years partially driven by the Government's commitment to "Drive the uptake of offsite manufacturing by Government agencies by a minimum of 10% year on year, to improve productivity and competition [for key building supplies]"[5].

Project overview

As the Government and industry organisations increase their utilisation of offsite manufacturing, it becomes important to understand the offsite manufacturing workforce in more detail. The ConCoVE has commissioned Scarlatti to:

1. Define and characterise the relevant offsite manufacturing occupations,
2. Estimate the current supply of the offsite manufacturing workforce,
3. Forecast the future demand for the offsite manufacturing workforce,
4. Evaluate how the future demand for the offsite manufacturing workforce could be influenced by future trends (e.g. industry growth and the adoption of construction-based technology),
5. Assess whether any gaps in the current workforce capacity or capability could cause problems for the industry in the future.

This report presents the outputs, findings and recommendations resulting from this work.

Project scope

Offsite manufactured products

Offsite manufacturing refers to a part of a building that is constructed away from its final site. There are five products generally considered to be part of New Zealand's offsite manufacturing sector (Table 1)[6]. We do not consider all products in scope for this work as indicated in Table 1.

[4] According to a report commissioned by Offsite NZ in 2021 exploring residential and non-residential consent data from Statistics NZ for the frequency of prefabrication terminology in project descriptions.
[5] https://www.beehive.govt.nz/release/government-taking-action-improve-building-supply-competition. This statement was made in response to the Government's acceptance of the Commerce Commissions' recommendation to "Develop and implement an all-of-government strategy to coordinate and boost offsite manufacturing; (https://comcom.govt.nz/about-us/our-role/competition-studies/market-study-into-residential-building-supplies
[6] https://www.offsitenz.com/about-us

Offsite products	In scope?	Reason for exclusion
Components (frame and truss, aluminium/wooden joinery, kitchens, glass, etc.)	Excluded	We have focused this work on products that are traditionally constructed onsite, but which offsite creates an alternative construction method. There are intentions for this work to be extended to include these products in the next 12 months.
Panels (wooden, concrete and steel)	Partially included (wooden panels only)	
Volumetrics/Modules	Included	n/a
Hybrids	Included	n/a
Transportables/Complete buildings	Included	n/a

Table 1: Products in New Zealand's offsite manufacturing industry

We will use the term *prefabrication industry* to collectively describe the products included in this work.

Building types

There are several types of buildings considered to be serviced by the prefabrication industry such as residential, secondary dwellings, commercial builds and infrastructure. This work considers all building types in scope except infrastructure as the baseline market share of the offsite industry (9%) refers only to prefabricated products in residential and commercial construction. This is due to prefabricated products being considered business as usual or a "normal" solution in the infrastructure sector.

Occupations

Through consultation with industry stakeholders, it is understood that the occupations relevant to the prefabrication workforce are currently homogenous with the occupations relevant to the traditional onsite workforce as the skills required for construction in both environments are similar. This includes both the direct (e.g. professional services, trades) and indirect (e.g. support roles, management) occupations. This is due to the prevailing business model in the prefabrication industry being labour-intensive. We would expect that as the industry grows and matures its processes, prefabrication businesses would look to construction-based technology for the efficiencies it creates. At this point, the substitutability of occupations from the traditional onsite workforce to the prefabrication workforce would reduce as existing skills become redundant or displaced, or new skills (e.g. general digital literacy) become required (Ginigaddara et al., 2021)[7] – this is discussed further in the Findings and Insights section (page 18).

The outputs from this work focus on the direct roles of the prefabrication industry as they are specifically relevant to the traditional onsite and prefabrication workforces while the indirect roles are transferable across economic sectors. The insights achieved from this report will therefore focus on the supply of and demand for the occupations specifically relevant to the construction sector (i.e. direct roles).

[7] Ginigaddara, B., Perera, S., Feng, Y. and Rahnamayiezekavat, P. (2021), "Offsite construction skills evolution: an Australian case study", Construction Innovation, Vol. 22 No. 1, pp. 41-56. https://doi.org/10.1108/CI-10-2019-0109

Outputs

The outputs of this work have been integrated as a dashboard on Waihanga Ara Rau's Workforce Information Platform (WIP) as an independent analysis. The analysis in WIP is dynamic allowing the user to:

1. Review the estimate of the prefabrication workforce supply by occupation, region and product produced,
2. Review the current and projected estimate of demand for the prefabrication workforce by occupation, region and product produced, and
3. Evaluate how the projected demand could be influenced by growth in the prefabrication market share (from the current 9%) and the amount of labour saved via the adoption of construction-based technologies.

Caveats of outputs

The outputs produced from this work rely on a series of assumptions in the absence of readily available data to calibrate the model's inputs and outputs. Where possible, we have engaged with industry stakeholders and businesses to test the assumptions and inputs of the model. However, we expect there will still be sample errors in the inputs which will be reflected in the outputs.

For this reason, we consider the outputs from this work a first iteration which will be improved and updated over time. The dashboard for this work on WIP (see above) includes a feedback loop for businesses producing prefabricated products to review their business' modelled workforce by occupation and provide feedback where there are variances.

About this document

This document has the following sections:

1. Supply of the prefabrication workforce. An introduction to the approach used to model the current *supply* of the prefabrication workforce and its limitations, and a static view of the current estimate of supply by occupation.
2. Demand for the prefabrication workforce. An introduction to the approach used to model the current and projected demand for the prefabrication workforce and its limitations, as well as static views of projected demand under the industry growth and construction-based technology scenarios.
3. Insights and recommendations. While this project was centred on estimating the current supply and demand for the prefabrication workforce, we also synthesise some findings from the work and make a series of recommendations to the ConCoVE (and wider industry) relating to future projects which would complement this work.
4. Appendix. More detail on the approaches used to model the supply and demand estimates for the prefabrication workforce are included as an appendix.

Supply of the prefabrication workforce

Approach to estimating supply

Introduction

The model used to estimate the supply of the prefabrication workforce follows a bottom-up approach where we consider the following attributes of businesses producing prefabricated products:

1. The primary product they produce and where they produce it,
2. The number of people they employ and/or contract to produce the product,
3. The breakdown of the total people by the roles they perform to produce the product, and
4. The number of people who work part-time and full-time.

For the most part, we have been able to identify the businesses producing the in-scope products by name via industry member associations. For these businesses, identifying the first of the above two attributes can be done via secondary sources (e.g. online), whereas the third and fourth attributes are more difficult to identify. Our modelling uses a series of rules and assumptions to model the third attribute for each business which are informed by several interviews with prefabrication businesses on the breakdown of their workforce.

Once attributes had been collected and modelled for each business, we converted this information to a database of virtual employees. Each virtual employee in the database is assigned a series of attributes according to the data collected for each business in the industry (e.g. region, occupation, product produced, and FTE). The database of virtual employees is used to produce supply estimates of the prefabrication workforce supply split by the employee's attributes.

A more detailed description of the approach used to estimate the current supply of the prefabrication workforce is included in Appendix 1 (page 21).

Limitations

Some limitations of the approach taken to estimate the supply of the prefabrication workforce include:

- **There is an absence of useful data available to calibrate the model's supply estimates against.** The modelling to estimate the supply of the traditional onsite construction workforce has used data from the IDI as a point of calibration. However, the prefabrication industry is not defined enough in the IDI to be a useful point of calibration. Therefore, the supply estimates in this work rely heavily on the assumptions and rules used to model the size and occupational breakdown for approximately 140 prefabrication businesses.
- There are many permutations to what a prefabrication business model could look like. **Where required, we have generalised the assumptions and rules according to what we have perceived to be the most common business models in the industry.** For example, the assumptions informing the breakdown of roles were based on people-intensive models as opposed to technology-based business models.
- In response to the anticipated growth, it is expected that the number of businesses producing prefabricated products will increase and/or the number of people employed by existing

businesses will increase. **In both cases, the supply of the industry's workforce will increase. The rate at which this occurs will dictate how quickly the outputs from this work become outdated.**

Estimates of the current prefabrication workforce supply

The current supply of the prefabrication workforce is modelled to be 2,325 FTEs. This number is estimated as the midpoint of a modelled range given the uncertainty in the inputs used to model it – see *Limitations* on the previous page. As the inputs collected are reviewed and updated (see recommendations – page 19), the confidence in the outputs will improve.

The breakdown of the supply estimate by the occupations considered in scope for this work is presented in Figure 3 below. Additional breakdowns of this number by region and product type can be viewed in the offsite manufacturing dashboard in WIP by using the available filters.

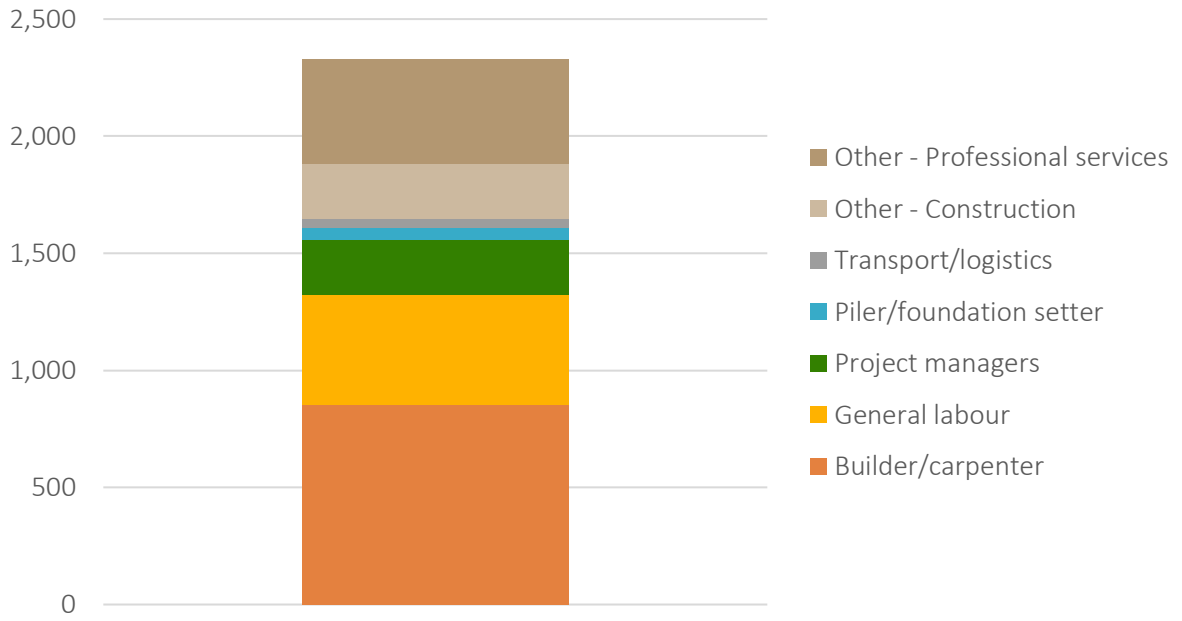

Figure 3:Supply estimates broken down by occupation

Demand for the prefabrication workforce

Approach to estimating demand

Introduction

The approach taken to estimate the current and future demand for the prefabrication workforce follows a QS approach where a construction project's value is broken down by the occupations required to undertake the project's activities. The approach is based on the following logic where we make quantitative assumptions at each stage to breakdown the project's value:

- There are a total number of residential and commercial projects planned to be undertaken in the future. We have used a variation on Pacfiecon's project pipeline as an indication of this number, as we have with previous modelling of demand for a workforce.
- Some proportion of the projects in the pipeline will source at least one of the prefabricated products considered in scope for this work. Depending on the product, a certain proportion of the project's total value will be attributed to sourcing the product.
- The value of the product to the project will be split by the materials required, the workforce required, and a margin covering overhead costs and profit margins.
- The total labour costs required to produce the product will have been determined by considering the different activities involved in producing the product, and the occupations/roles required to undertake those activities.
- The cost allocated to each occupation across the different activities can then be translated into the number of FTEs required to construct the product for the project by considering the average charge-out rate ($/hour) for each occupation.
- The FTE requirements to produce prefabricated products in each project can be aggregated across the pipeline to estimate the total demand for the prefabrication workforce.

The approach uses Pacifecon's project pipeline, which captured the value of construction and infrastructure projects across New Zealand, as its starting point. The model then breaks down the projects' values using the logic above. The total pipeline value is split out by quarters according to when the projects are expected to start and finish – the total pipeline value is available on WIP here.

This approach is similar to the modelling used to estimate the demand for the traditional onsite workforce (also in WIP). A more detailed description of the methodology to estimate the current demand for the prefabrication workforce is included in Appendix 2 (page 24).

Limitations

One limitation of the approach taken to estimate the demand of the prefabrication workforce is regarding the use of Pacifecon's project pipeline. The pipeline tends to *over*estimate the total project's value in the short term and *under*estimate the total project's value in the long term. The reasons for these variances and our mitigations are discussed below:

- Short-term overestimation. This is due to the frequency at which the pipeline is updated for project delays and cancellations. We use an adjusted pipeline for this work which removes projects which have not recently been updated.

- **Long-term underestimation.** The pipeline is underestimated in the long term due to the short-term forecasting of construction projects. The pipeline has a steep decline in its total value from about two years (illustrated in WIP here). In reality, we would expect the actual pipeline value to increase in the future as more construction projects are added to the pipeline. For this reason, the pipeline is not a good source of truth for forecasting demand. We, therefore, model the demand for the prefabrication workforce in two parts:

    1. The **past and current demand** using the current Pacifecon pipeline value with the short-term correction as previously discussed (up to 2023 Q2),

    2. **Future demand** where the future pipeline value is extrapolated from its current peak with an imposed annual growth rate of 3% to represent industry growth and inflation.

Demand for the prefabrication workforce – 5 year forecast

The current demand for the prefabrication workforce in 2023 Q2 is modelled to be 3,999 FTEs[8]. Again, this number is estimated as the midpoint of a modelled range given the uncertainty in the inputs used to model it. Figure 4 presents how the current demand for the prefabrication workforce is expected to grow over time as the current market share of the prefabrication industry (i.e. the percentage of construction projects sourcing at least one prefabricated product) is maintained at the current 9%. This is considered the baseline analysis for which scenarios are imposed in the following sections.

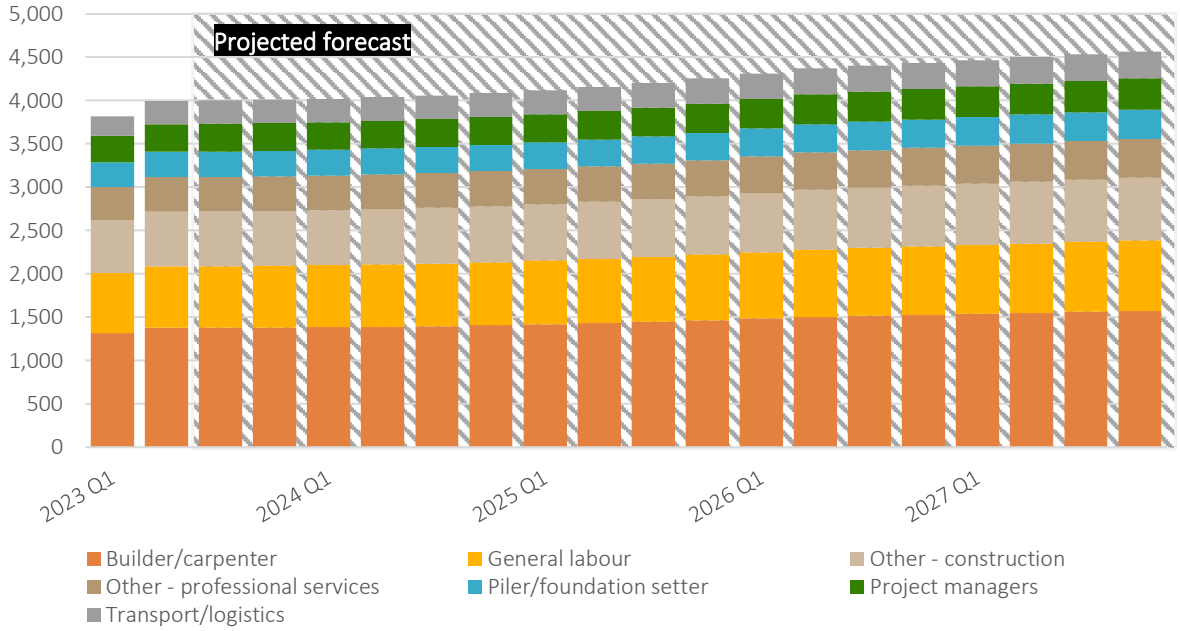

Figure 4: Demand (FTEs) for the prefabrication workforce by occupation – baseline analysis

It is important to note that even by maintaining its current market share in the future, the prefabrication industry would require more people over time as the wider construction industry is modelled to grow

[8] Rather than indicating a workforce shortage, the variance between the modelled midpoints of supply (Figure 3) and demand estimates (~1,500 FTEs) is mostly attributed to the different approaches and the uncertainty in the inputs used to model the supply and demand estimates. As the supply inputs collected are reviewed and updated (see recommendations – page 15), the confidence in the outputs will improve.

at 3% annually. If the prefabrication industry were unable to attract the additional demand, the industry would see a progressive decline in its current market share unless productivity improved – see below.

Demand for the prefabrication workforce – increased market share

The proportion of the total construction projects sourcing at least one product from the prefabrication industry has grown from 3% to 9% between 2014 and 2021. The industry's market share is expected to continue increasing in the coming years partially driven by a commitment from the Government to improve utilisation of offsite manufacturing at a "minimum of 10% year on year"[9]. The following hypothetical scenarios have been modelled to evaluate how different rates of industry growth could be expected to increase the prefabrication workforce demand:

1. The prefabrication industry's market share increases from 9% to 20% by 2026 Q2,
2. The prefabrication industry's market share increases from 9% to 30% by 2026 Q2.

The future demand for the prefabrication workforce, if the industry were to increase its market share from 9% (Figure 4) to 30%, is presented in Figure 5 below. The effect is achieved over three years to 2026 Q2. The dashboard for this work on WIP will allow you to explore how industry growth to 20% is modelled to increase future demand for the prefabrication workforce.

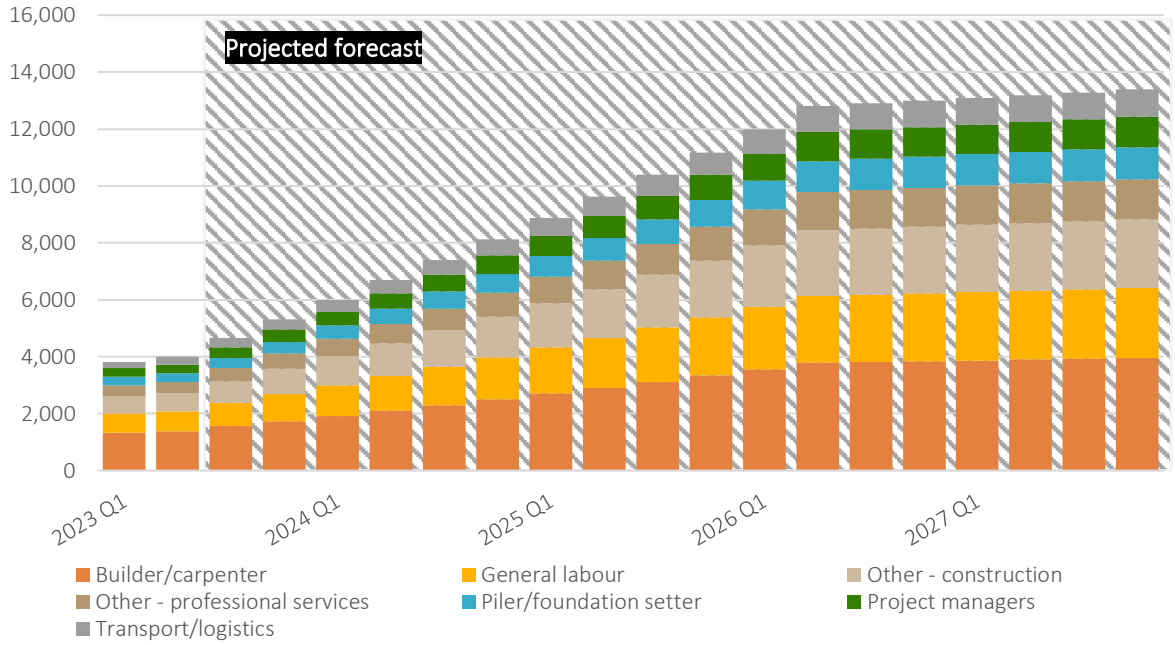

Figure 5: Demand (FTEs) for the prefabrication workforce by occupation– market share increases to 30%

As the occupations required to produce prefabricated products are currently homogenous with the occupations required for traditional onsite construction (i.e. high transferability), the industry will be able to pull from the traditional onsite industry to meet the modelled increase in demand. The number of people required to produce the prefabricated products is believed to be less than the number of

[9] As per the statement made by Government in response to their acceptance of the Commerce Commission's recommendation to develop an 'all of government' strategy to better utilise offsite manufacturing which is referenced in the introduction on page 5 - https://www.beehive.govt.nz/release/government-taking-action-improve-building-supply-competition

people required to produce the equivalent product onsite traditionally. Therefore the increase in demand for the prefabrication workforce is expected to be proportionately less than the reduction in demand for the traditional onsite workforce. The rate of efficiency is unclear although anecdotally could be in the order of 20%. For example, if demand for the prefabrication workforce increased by 100 people, then the decrease in the demand for the traditional onsite workforce would be approximately 125 people. The movement of people from the traditional onsite workforce to the prefabrication workforce would not be expected to worsen the persisting shortage in the wider construction workforce as the construction of products moves in the same direction, the difference being where the people are required to construct the products (i.e. physically on a construction site, or at an offsite facility where it is later transported to the site for installation).

Demand for the prefabrication workforce – adopting construction-based technology

The current assumptions characterising the number of people employed by prefabrication businesses are based on labour-intensive business models. It is expected that as the industry grows and its processes mature, businesses will look to adopt construction-based technologies for the efficiencies they can achieve – one being a reduction in the number of people required (e.g. substitution of people)[10]. At the time of writing, the rate of substitution achieved by technology (e.g. technology for people) is unknown as it is dependent on several factors (e.g. product produced, type of technology adopted)[11]. The following hypothetical scenarios have been modelled to evaluate how different rates of substitution could be expected to reduce demand for the prefabrication workforce:

1. Technology reduces the number of people required reduces by **10%**,
2. Technology reduces the number of people required reduces by **20%**,
3. Technology reduces the number of people required reduces by **30%**,

The model assumes that the 'people' or occupations affected by the adoption of technology are builders/carpenters and general labourers as the technology modelled is construction-based with a substitution effect. The future demand for the workforce, if the industry were able to reduce the number of builders/carpenters and general labourers it needed by 20%, is presented in Figure 6 on the following page. The effect is achieved over three years through to 2026 Q2. The dashboard on WIP will allow you to explore how the other scenarios are modelled to reduce future demand for the prefabrication workforce.

[10] This analysis focuses on evaluating the influence of construction-based technology which acts as a substitute for people (e.g. reduces the number of people required) rather than technology that is complimentary to people (e.g. improves the productivity of existing people without displacement).
[11] An opportunity to explore the rate of substitution achieved by technology is proposed in this report's recommendations.

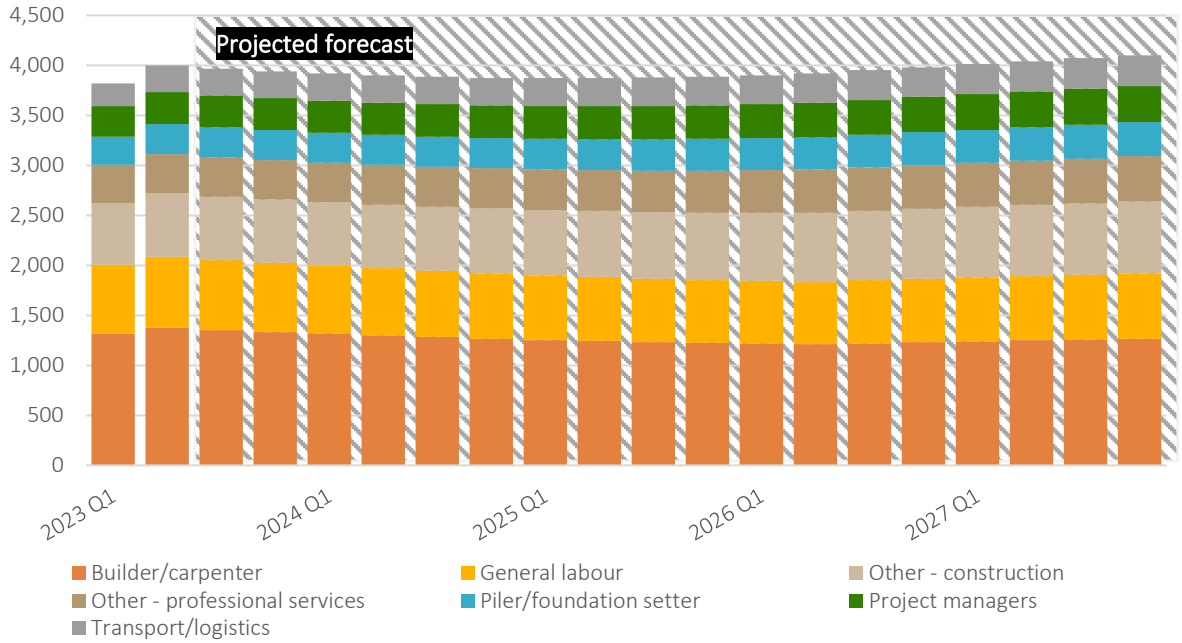

Figure 6: Demand (FTEs) for the prefabrication workforce by occupation– technology reducing the number of people required by 20%

Table 2 below illustrates the effect of the construction-based technology from Figure 6 on reducing projected workforce demand compared to its current level (Q2 2023). The adoption of technology does not necessarily reduce the demand for builders/carpenters and general labourers by 20% as the annual industry growth rate (3%) offsets the construction-based effect. Therefore, the technology reduces the rate at which builders/carpenters and general labourers are required to maintain the industry's current market share.

Occupations	Current demand (Q2 2023)	Projected demand (Q2 2026)	Net change in demand
Builders/carpenters	1,376	1,213	-163 (12% reduction)
General labourers	712	623	-90 (13% reduction)
Other occupations	1,910	2,087	177 (9% increase)
Total demand	3,999	3,923	-76 (2% reduction)

Table 2: Effect of construction-based technology on the demand for prefabrication occupations

Insights and recommendations

Findings and insights

The prefabrication industry will need to attract more people to meet the anticipated increase in demand

The prefabrication industry's market share is expected to increase in the coming years driven by the Government's commitment to better utilise offsite manufacturing by 10% year on year. What this means for the total growth in the industry is unclear as the Government's commitment will contribute to the industry's growth but will not be the sole determinant. This work has forecast how the demand for the workforce could be expected to increase from the current 9% to 20% and 30% over 3 years to Q2 2026 (Page 14). The modelling suggests that to service the increased demand, the industry would need to attract between approximately 4,800 (for a 20% market share) and 8,800 (for a 30% market share) more people to the workforce by Q2 2026 – a 120% to 220% increase on the current workforce demand.

The occupations relevant to the prefabrication industry are currently homogenous with the occupations relevant to the traditional onsite construction workforce.

The occupations and skills identified to be relevant to the construction of prefabricated products are understood to be homogenous with the occupations and skills of the traditional onsite workforce. Therefore, people are currently substitutable between the two workforces. Assuming the prefabrication workforce can provide a comparatively attractive employment environment (e.g. compensation packages, work hours, tidy facilities, shelter, etc.), the industry should be able to attract people from the traditional onsite workforce to fill the demand. The high substitutability of people between the traditional onsite and prefabrication workforce is not sustainable due to, as a later finding highlights, the required skills of the prefabrication workforce will likely change as the industry grows.

There is, anecdotally, a high substitutability of people for construction-based technology

New Zealand prefabrication businesses have nuanced business models. One nuance is their investment in construction-based technology as a substitute for people, particularly builders/carpenters and general labourers. For the most part, prefabrication businesses in New Zealand appear to be labour-intensive models which employ or contract the required occupations to produce prefabricated products. By comparison, the few businesses that had invested in construction-based technology employed or contracted smaller construction teams. One reason for the current reliance on people is presumably due to the New Zealand industry being in its infancy. It would be expected that as the industry grows and matures its processes, the use of construction-based technology will become more widely used. The rate at which construction-based technology would substitute the need for people, and what occupations it could substitute, is unclear at the time of writing but is addressed by one of the following recommendations.

Technology can be used to offset the increase in demand for the prefabrication workforce if the industry were to struggle to attract the required people

The baseline analysis (Figure 4) illustrated that to maintain its current market share of 9%, the prefabrication industry would need to attract approximately 570 people to its workforce over the next 5 years to Q4 2027 (Table 3). Over 50% of these (close to 300) will need to be builders/carpenters and general labourers. However, with the adoption of construction-based technology to reduce the number of builders/carpenters and general labourers required by 20%, the industry would only need to attract approximately 100 additional people to maintain its current market share. This mostly comes from the increase in demand for other occupations as the technology modelled only targets a reduction in builders/carpenters and general labourers which the demand for reduces by 108 and 61 respectively[12].

Occupations (variance from current demand in brackets)	Current demand (Q2 2023)	Projected demand – baseline scenario (Q4 2027)	Projected demand – Tech scenario (Q4 2027)
Builders/carpenters	1,376	1,572 (+196)	1,268 (-108)
General labourers	712	814 (+101)	651 (-61)
Other occupations	1,910	2,182 (+272)	2,182 (+272)
Total demand	3,999	4,567 (+569)	4,100 (+102)

Table 3: Comparison of workforce demand required to maintain the current 9% market share in the baseline and technology adoption scenarios

While we wouldn't expect the prefabrication industry to have trouble attracting staff to service the workforce demand required to maintain its current 9% market share (given the current homogeneity of occupations between the traditional onsite workforce and the prefabrication workforce), construction-based technology would positively impact the productivity of the prefabrication sector when the industry starts to grow its market share. The combined effect of market share growth and the adoption of technology can be tested in the dashboard on WIP.

As the adoption of construction-based technology increases, the ability to embrace and interact with digital technology will emerge as a key skill required of the prefabrication workforce.

As construction-based technology becomes more widely adopted in the prefabrication industry, it is expected that the substitutability of people between the traditional onsite and prefabrication workforces will reduce as the skills expected of the prefabrication workforce will change. Publications

[12] Note these findings are based on the modelling presented in this report and are subject to change as the inputs to the model are updated and improved.

from the United States of America[13], Australia[14] and the United Kingdom[15] all highlight the emergence of technology and digital skills as being key in the construction of prefabricated products with Ginigaddara et al. (2019) stating that "knowledge, interpersonal skills, and the ability to embrace digital technology are the key skill categories needed for future smart and modern construction". The New Zealand VET system will therefore need to develop general literacy material and adapt relevant qualifications to ensure opportunities for the workforce to learn the emerging skills are available. This is addressed by one of the following recommendations.

Recommendations

To accompany the above findings and insights, the following recommendations to the ConCoVE have been proposed as the next steps to further the ConCoVE's understanding of future trends in the prefabrication industry, improve the model with up to date insights, and support the VET system to adapt qualifications as necessary. The recommendations include:

- **Integrating improvements in the inputs and assumptions used to model the supply of and demand for the prefabrication workforce into future work.** The approaches used to model the outputs in this document rely heavily on several assumptions and rules, particularly for the estimates of workforce supply. We would recommend the ConCoVE periodically update several of the inputs to the model to keep the outputs up to date. Examples of the inputs to be updated could include:
  - The business level information on the number of people businesses employ and contract to undertake different activities,
  - The composition of businesses at an industry level with labour-intensive and technology-intensive business models,
  - The natural rate of industry growth (currently 3%) used to forecast the value of Pacifecon's project pipeline which informs the demand estimates.

  The ConCoVE could leverage industry engagement (e.g. conferences) and future RFPs to review these inputs and collect information for them to be updated.
- **Commissioning a research programme to characterise the implications of prefabrication businesses widely adopting construction-based technology.** Construction-based technology is arguably more disruptive to the prefabrication industry than the current prefabrication industry is to the traditional onsite construction industry. We recommend that the ConCoVE, therefore, consider commissioning a research programme that characterises the role of technology in the industry. In part, the programme could aim to address the following research questions:

[13] Assaad, R. H., El-adaway, I. H., Hastak, M., & Needy, K. (2022). The impact of Offsite Construction on the Workforce: Required Skillset and Prioritisation of Training Needs. *Journal of Construction and Engineering Management, 148*(7). https://www.researchgate.net/publication/360845318_The_Impact_of_Offsite_Construction_on_the_Workforce_Required_Skillset_and_Prioritization_of_Training_Needs

[14] Ginigaddara, B., Perera, S., Feng, Y. and Rahnamayiezekavat, P. (2019), "Skills Required for Offsite Construction". *Proceedings of the CIB World Building Congress conference.* https://www.researchgate.net/publication/333990891_Skills_Required_for_Offsite_Construction

[15] The Construction Industry Training Board. (2017). *Faster, Smarter, More Efficient: Building Skills for Offsite Construction.* https://www.citb.co.uk/media/5sbjolfx/offsite_construction_full_report_20170410.pdf

- What construction-based technology is available for prefabrication businesses to adopt?
- How quickly could the available technology be adopted across the prefabrication industry?
- Which occupations will be substituted by the adoption of technology?
- To what extent could the available technologies be expected to reduce the number of people required?

The benefits of this research programme to the ConCoVE and the prefabrication industry will be twofold. First, it would help with improving the forecasting of demand for the prefabrication workforce and evaluating how the gap between future demand and current supply can be reduced. Second, it will provide prefabrication businesses with a case study for better utilising different types of construction technology to improve the productivity of their business.

- **Commissioning a research programme evaluating the future growth of the prefabrication industry.** The prefabrication industry is poised to grow as a contributor to the construction of buildings across New Zealand. We recommend that the ConCoVE commission a research programme that evaluates realistic growth scenarios for the industry using international industries as case studies. In part, the programme could aim to address the following research questions:
  - At what rate could the prefabrication industry be expected to grow in the future?
  - What characteristics of the prefabrication industry could foster and/or implicate future growth?
  - What trends could the prefabrication industry expect to experience as it grows?

  The benefits of this work would help inform the inputs to the modelling of the supply and demand for the prefabrication workforce but also provide insight to industry stakeholders on the role the prefabrication industry could play in the wider construction sector moving forward.

- **Commissioning a research programme evaluating the future skills required of New Zealand's prefabrication workforce.** An ability to embrace and interact with digital technology has been highlighted as a key emerging skill required of the prefabrication workforce when technology is integrated into prefabrication operations. It is therefore important that emerging skills are identified ahead of the industry need to allow the VET system time to adapt qualifications as required before it is required. In part, the programme could aim to address the following research questions:
  - What skills will be required of the prefabrication workforce in response to the anticipated industry trends?
  - How will the VET system need to adapt to support the current or potential workforce with opportunities to upskill in the relevant areas?

  This recommendation would benefit from involving the relevant WDCs as characterising and managing future industry needs, in terms of workforce capacity and capability (skills), is an objective of both the ConCoVE and WDCs.

Appendices

Appendix 1: Supply modelling methodology

Model framework

The supply model is built using a bottom-up approach looking at the number of businesses in the prefabrication industry and the number of people they employ and contract who perform different roles. The input to the supply model is a table where each row is a separate business or group of businesses (Table 4).

Company name	Product produced	Turnover	Employees (FTEs)	Subcontractors (FTEs)	Occupational breakdown
ABC company	Transportables	$1 - $5 million	18	3	Multiple columns →
…	…	…	…	…	…

Table 4: Example of the supply input table

Inputs to the framework

The columns in the inputs table (Table 4) are the inputs to the supply model and can be grouped into three types of inputs:

1. The number of businesses (e.g. the number of rows) primarily producing each prefabricated product by turnover, by region (e.g. business attributes in columns),
2. The number of people each business employs directly and contracts, and
3. The breakdown of employees and contractors by the occupations relevant to the production of prefabricated products.

Figure 7 illustrates how these inputs fit in the approach to fill the input table (Table 4).

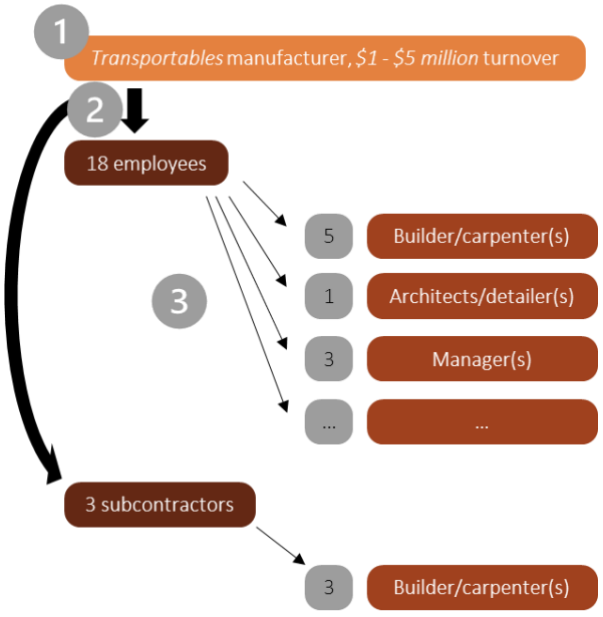

Figure 7: Breakdown of supply model inputs

Collection of inputs

For this work, the businesses in the prefabrication industry can be split into three groups. The approach taken to collect the inputs for the businesses in each group varies. The groups, and how the inputs are collected for them, are presented below:

1. **The businesses we know and can contract.** Where we were able to identify individual businesses producing different products and access their contact details are available, we contacted them to schedule an online interview to collect the inputs for their business. We interviewed seven businesses that were a part of this group.
2. **The businesses we know but cannot contact.** Where we can identify individual businesses producing the relevant products but are unable to engage with them directly (e.g. contact details not available, not enough resources to interview them all), we will use a combination of secondary resources, industry stakeholders and assumptions to estimate the appropriate inputs for them.
3. **The businesses we do not know and cannot contact**. Where we are unable to identify individual businesses producing the relevant products, we will engage with industry stakeholders to estimate how many firms there are in total of different sizes using pre-set ranges. Inputs such as region are not considered for these groups of businesses, so we will use a combination of secondary resources, industry stakeholders and assumptions to estimate the appropriate inputs for them.

The above bullet points are summarised in the table below with an indication of the confidence in the inputs used in the supply model.

<table>
<tr><th>Types of Businesses</th><th>Group 1
(n=7)</th><th>Group 2
(n=43)</th><th>Group 3
(n=99)</th></tr>
<tr><td>Confidence level</td><td>Highest</td><td>Moderate</td><td>Lowest</td></tr>
<tr><td>Business name</td><td rowspan="9">Collected directly from the businesses via interview (6 interviewed so far)</td><td rowspan="4">Collected from secondary sources (e.g. website, member organisations)</td><td>Not considered</td></tr>
<tr><td>Primary product produced</td><td rowspan="2">Secondary sources</td></tr>
<tr><td>Region located</td><td rowspan="2">Not considered</td></tr>
<tr><td>Region supplied</td></tr>
<tr><td>Turnover/firm size</td><td>Secondary sources (using size brackets)</td></tr>
<tr><td>Occupational breakdown</td><td colspan="2" rowspan="3">Modelled from a combination of assumptions, rules, and information collected from interviews – see the following section</td></tr>
<tr><td>Full-time/part-time splits</td></tr>
<tr><td>Employee/contractor splits</td></tr>
</table>

Table 5: Approach to collecting inputs for different types of prefabrication businesses

Modelling inputs

For the second two groups of businesses, we intend to model the inputs using the following approaches and data:

- **Business size and region.** The approach varies for the two groups. For the businesses we know we can use secondary sources (internet, industry experts) to make estimates on the number of people involved in their business. For the businesses we do not know, we establish size brackets based on company turnover and estimate how many businesses in the industry fit within each.
- **Occupational breakdown**. The approach varied depending on the product being produced. The occupational breakdown is modelled using estimates from the interviewed businesses. The proportions we used were based on labour-intensive business models.
- **Employee/contractor splits.** This varied substantially between the businesses interviewed. However, one trend emerged that as the number of people employed increased, the number of subcontractors decreased. The employer/contractor split is modelled using estimates from the interviewed businesses.
- **Full-time/part-time splits.** For the most part, employees were employed full-time. There were instances where some people in specific roles worked part-time hours. This split was also informed using information collected from the businesses directly.

The rules and assumptions used to model these inputs for the second two groups of businesses are included in an accompanying spreadsheet.

Limitations of approach

As highlighted in the body of this document

Some limitations of the approach taken to estimate the supply of the prefabrication workforce include:

- **There is an absence of useful data available to calibrate the model's supply estimates against**. Previous iterations of this modelling estimating the supply of the traditional onsite construction workforce have used the IDI as a point of calibration. However, the prefabrication industry is not represented enough in this dataset to calibrate the outputs from this work. Therefore, the supply estimates rely heavily on the assumptions and rules used to model several attributes of prefabrication businesses.
- There are seemingly endless permutations to what a prefabrication business model could look like. **Where required, we have generalised the assumptions and rules according to the most common business models in the industry.** For example, the assumptions informing the breakdown of roles were based on labour-intensive models as opposed to technology-based business models.
- In response to the anticipated growth, it is expected that the number of businesses producing prefabricated products will increase and/or the number of people employed by existing businesses will increase. **In both cases, the supply of the industry's workforce will increase. The rate at which this occurs will dictate how quickly the outputs from this work become outdated.**

Appendix 2: Demand modelling methodology

Model framework

The approach taken to estimate the demand for the prefabrication workforce takes a bottom-up approach, like a QS approach, where a project's value is broken down by the different occupations required to undertake the project's activities, however, logically flows top-down. There is little to add to the logic communicated in the body of this document (page 12) but is illustrated in Figure 8 below.

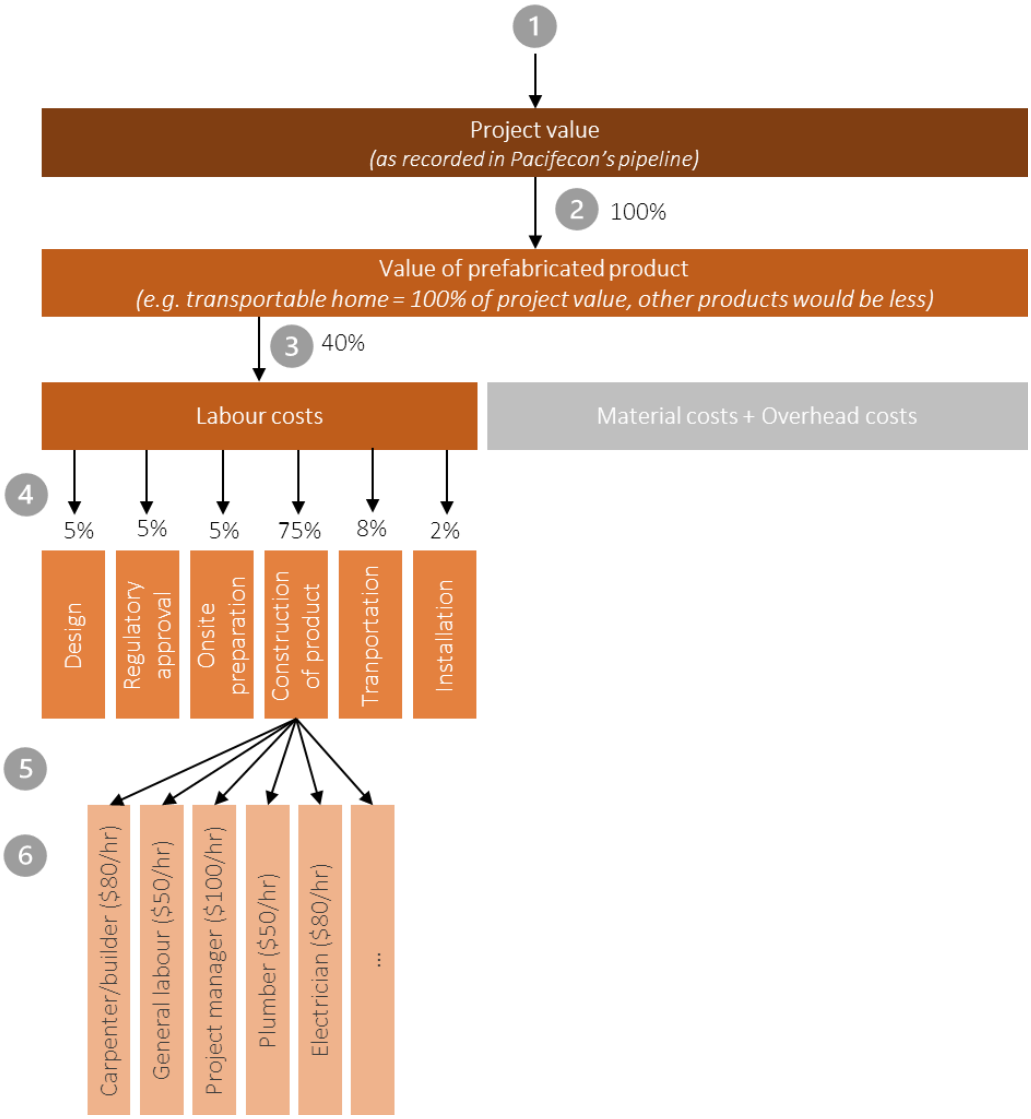

Figure 8: Illustration of the demand model framework using transportable homes as a case study

Inputs to framework

The inputs required for the above demand model framework include (note that the inputs below correspond to the numbers and examples in Figure 8):

1. The proportion (%) of total industry builds that source each of the prefabricated products from offsite businesses,

2. The proportion (%) of the project's value attributed to sourcing the prefabricated product (e.g. a transportable home might be 100% of the project's value, however, a wooden panel will be considerably less),
3. The value of the prefabricated product as a proportion (%) of the value of the project sourcing it (e.g. wooden panels would only be a small proportion of the total project value, while a transportable home would be the whole value of the project),
4. The proportion (%) of the prefabricated products' value that would be allocated to labour costs (as opposed to material or overhead costs),
5. The breakdown (%) of the prefabricated product's labour costs between the activities required to complete the project (e.g. design, regulatory approval, onsite preparation, construction, transport and installation – note that not all activities will be relevant to all prefabricated products),
6. The breakdown (%) of an activity's value to each of the occupations required to undertake that activity,
7. An average hourly charge-out rate for each occupation to translate the cost attributed to each occupation across all six activities into FTEs.

The value of construction projects planned across New Zealand is captured in Pacifecon's project pipeline. The framework presented above in Figure 8 is applied to each of the relevant projects in this pipeline to estimate the workforce demand for that project by quarter. This process is replicated for all projects in the pipeline and the results are aggregated by occupation across all projects to model the demand for the workforce.

The total pipeline value is split out by quarters according to when the projects are expected to start and finish – the total pipeline value is available on WIP here.

Collection of inputs

The above inputs have primarily been collected by engaging with prefabrication industry stakeholders and experts and calibrated using industry reports and data.

Limitations of approach

As highlighted in the body of this document

One limitation of the approach taken to estimate the demand of the prefabrication workforce is regarding the use of Pacifecon's project pipeline. The pipeline tends to *over*estimate the total project's value in the short term and *under*estimate the total project's value in the long term. The reasons for these variances and our mitigations are discussed below:

- Short-term overestimation. This is due to the frequency at which the pipeline is updated for project delays and cancellations. We use an adjusted pipeline for this work which removes projects which have not recently been updated.
- Long-term underestimation. The pipeline is underestimated in the long term due to the short-term forecasting of construction projects. The pipeline has a steep decline in its total value from about two years (illustrated in WIP here). In reality, we would expect the actual pipeline value to increase in the future as more construction projects are added to the pipeline. For this

reason, the pipeline is not a good source of truth for forecasting demand. We, therefore, model the demand for the prefabrication workforce in two parts:

1. The past and current demand using the current Pacifecon pipeline value with the short-term correction as previously highlighted,
2. Future demand where the future pipeline value is extrapolated from the pipeline's current peak with a 3% annual growth rate to represent a combination of industry growth and inflation.