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Productivity distribution and drivers of productivity growth in the construction industry

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The results in this study are not official statistics, they have been created for research purposes from the Integrated Data Infrastructure (IDI) managed by Statistics New Zealand. The opinions, findings, recommendations and conclusions expressed in this study are those of the authors not Statistics New Zealand, the New Zealand Productivity Commission, BRANZ, or Motu Economic & Public Policy Research.

Access to the anonymised data used in this study was provided by Statistics New Zealand in accordance with security and confidentiality provisions of the Statistics Act 1975. Only people authorised by the Statistics Act 1975 are allowed to see data about a particular person, household, business or organisation and the results in this study have been confidentialised to protect these groups from identification. Careful consideration has been given to the privacy, security and confidentiality issues associated with using administrative and survey data in the IDI. Further detail can be found in the privacy impact assessment for the IDI available from www.stats.govt.nz.

The results are based in part on tax data supplied by Inland Revenue to Statistics New Zealand under the Tax Administration Act 1994. This tax data must be used only for statistical purposes, and no individual information may be published or disclosed in any other form, or provided to Inland Revenue for administrative or regulatory purposes. Any person who has had access to the unit-record data has certified that they have been shown, have read, and have understood section 81 of the Tax Administration Act 1994, which relates to secrecy. Any discussion of data limitations or weaknesses is in the context of using the IDI for statistical purposes, and is not related to the data's ability to support Inland Revenue's core operational requirements.

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Abstract

This study draws on firm-level data from the Longitudinal Business Database to examine productivity in the New Zealand construction industry. It finds that over the period 2001–2012, on average labour productivity in this industry grew by 1.7 percent annually and multi-factor productivity by 0.5 percent annually, compared with 0.5 and 0.1 percent annually respectively for firms in the overall measured sector. Within the construction industry, productivity growth rates vary markedly by sub-industry and other firm characteristics. Labour productivity is more widely dispersed across the construction industry than is multi-factor productivity. High-productivity firms tend to be younger, more likely to be a new start-up, to belong to a business group, and to locate in Auckland than low-productivity firms. Working-proprietor-only firms are slightly less productive on average than employing firms, and also exhibit much greater productivity variation. Overall, however, productivity variation or dispersion is no greater in construction than in other industries. We decompose productivity changes over time into that due to changes at continuing firms, to reallocation of output from low- to high-productivity firms, and to entry and exit. In the 'Building construction' and 'Heavy and civil engineering and construction' industries, productivity was enhanced by net entry and reallocation, but reduced by an overall decline in the productivity of continuing firms. In the 'Construction services' industry, net entry, reallocation, and productivity improvement of continuing firms all contributed to positive productivity growth.

JEL codes

D24, L74

Keywords

Construction industry, labour productivity, multi-factor productivity

Summary haiku

Productivity
has risen. Thank entry and
reallocation.

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1 Introduction

It is widely reported that the construction industry has poor productivity performance. For example, official statistics show that over the period 1978–2012, labour productivity for this industry grew by 0.6 percent annually, compared with 1.5 percent for all goods-producing industries (including manufacturing, electricity, gas, and water supply, and construction) and 2.1 percent for the former measured sector (roughly the business sector) of the economy (Statistics New Zealand, 2014). Over 2008–2012, labour productivity for the construction industry fell by 0.1 percent annually, while it still increased by 1.8 percent annually for all goods-producing industries and by 1.4 percent annually for the former measured sector. Similar patterns are seen with respect to multi-factor productivity (MFP), where the annual growth rate over 1978–2012 was 0.2 percent for the construction industry, compared with 0.9 percent for the former measured sector.

Since the construction industry contributes a large share to the New Zealand economy, accounting for 8 percent of total employment and 5.9 percent of the country's total GDP in 2010 (Statistics New Zealand, 2013), poor productivity growth in this industry is a drag on the economy's productivity performance.

Recognising the significance of poor productivity performance in such an important industry, in recent years several studies have examined the issue of productivity in the construction industry (e.g. Tran, 2010; PWC, 2011; BRANZ, 2011; NZIER, 2013; Page and Norman, 2014). However, reliance on macro, published data means that those studies can merely compare industry-level statistics across industries in terms of input factors (e.g. number of firms, number of hours worked, level of capital) and output factors (e.g. GDP, sales, value added).

New Zealand is not alone in experiencing poor productivity growth in the construction industry. The US (Rojas and Aramvareekul, 2003), Canada (Harrison, 2007), Singapore (Lee, 2014), Europe and Japan (Abdel-Wahab and Vogl, 2011) also share the experience. By contrast, in Australia and the UK (Li and Liue, 2012 and Abdel-Wahab and Vogl, 2011), the construction industry is a productivity outperformer. However, the lack of firm-level data has shed little light into what makes a firm in this industry more productive than others.

The current study seeks to fill the gaps in the literature by addressing the following questions related to firm-level productivity in the New Zealand construction industry:

1. What does the distribution of productivity in the construction industry look like?
2. What are the characteristics of high-productivity firms, e.g. are they large or small, are they established firms or new start-ups, which sub-industry are they in, where are they located, and do they have employees (as distinct from firms whose only labour is the proprietor)?
3. Do the answers to (1) and (2) differ by productivity measure (i.e. labour productivity vs. MFP)?
4. Do the answers to (1) and (2) differ from those observed in other industries?
5. What drives productivity growth over time in this industry?

In order to address those questions, this study will draw on firm-level data from the Longitudinal Business Database (LBD), a linked longitudinal database that contains tax- and survey-based financial data, merchandise and services trade data, a variety of sample surveys on business practices and outcomes, and government programme participation lists (Fabling, 2009), providing comprehensive information on firms' demographic characteristics, business activity and performance. Only when we have comprehensive economic data on firms' production can we have a good understanding of what is important to firms' productivity. Because New Zealand has relatively rich firm-level data available for research, the current study is also a potentially significant addition to the international evidence on productivity in the construction industry.

The study proceeds as follows. Section 2 briefly discusses the concepts and measurement issues of productivity. Section 3 reviews international evidence on productivity in the construction industry, while Section 4 reviews New Zealand studies related to the topic. Sections 5 and 6 respectively describe the production function and the data. Section 7 presents summary statistics on production measures and labour productivity, followed by MFP estimation results in Section 8. Section 9 identifies characteristics associated with high-productivity firms. Section 10 then decomposes MFP growth. Section 11 summarises and concludes.

2 Productivity: concepts and measurement

2.1 Concepts of productivity

Productivity is a measure of the efficiency with which a production unit converts inputs into outputs. Productivity can be expressed as the ratio of output to inputs used in the production process. A productivity measure that accounts for all input factors is called total factor productivity (TFP). TFP is often referred to as MFP, as strictly speaking, this measure includes multiple, but unlikely all possible, inputs. MFP takes into account substitution between different types of input, and is thus not directly affected by changes in the composition of total inputs. However, measuring MFP is a challenge due to the significant data requirements and especially the difficulty in standardising input quantities across different types of input.

When only one type of input is included, the measure is called partial factor productivity (PFP). Compared to MFP, PFP is easier to calculate and comprehend. PFP reflects the amount of output generated per unit of one specific input, such as labour or capital. As such, it is useful in understanding the effect of changes in the utilisation of that input on the level of output. However, inputs generally contribute to output in a complementary way, so that PFP measures for a given input are increased by higher utilisation of other inputs. For example, a substitution of capital for labour will improve labour productivity but not necessarily total productivity. Thus, PFP measures do not capture efficiency per se and so are less useful in talking about productivity, as that word is normally used.

2.2 Approaches to productivity measurement

There are several approaches to measuring productivity, the most common ones being the growth accounting approach, the index number approach, the production frontier approach, and the econometric approach (Mawson et al, 2003).

Growth accounting specifies a production function that relates a *level* of output to levels of inputs and MFP. This makes it possible to decompose output *growth* into the growth of inputs and MFP. It can be shown mathematically that MFP growth is a residual of the production function. That is, it captures the part of the growth in output that cannot be explained by growth in inputs. While the growth accounting approach is relatively simple to implement, the disadvantage of this approach is that it rests crucially on several assumptions, the most important being that the production function exhibits constant returns to scale. Relaxing these assumptions or changing the form of the production function can yield markedly different results. Furthermore, this approach can only measure productivity growth but not productivity levels.

The index number approach measures productivity by dividing an output quantity index by an input quantity index to give a productivity index. It is then straightforward to calculate productivity growth rates based on the index obtained. This is the approach used by most statistical agencies, including Statistics New Zealand (Mai and Warmke, 2012), to produce official productivity statistics.

Since a production unit often uses many types of input and produces many types of output, each of which has its own measurement scale, it is necessary to determine an appropriate way to aggregate the different inputs and outputs. Further, the mix of inputs and outputs changes over time, raising the issue of how the weights used to combine multiple outputs or multiple inputs into indices should change over time. There are different index formulations using prices or shares to weight the different kinds of input or output and adjusting the weights in different ways over time. Using the index number approach to measure productivity necessitates making a choice of which index formulation to use.

The production frontier approach uses an output distance function that measures the distance of a production unit from its production frontier. This function measures how close a level of output is to the maximum level that can be obtained from the same level of inputs if production is efficient. A change in MFP can be decomposed into changes resulting from a movement towards the production frontier and shifts in the frontier. This approach is particularly useful in identifying and quantifying the sources of inefficiency. However, it requires knowledge of the production technology or production frontier of all production units at all time periods in question, which is not easy obtain.

The econometric approach measures productivity via estimating the parameters of a production function. As in the growth accounting approach, if a production function is specified in growth rate form, the estimated residual captures the residual growth, which is often interpreted as a measure of productivity growth.

The main advantage of the econometric approach is that it enables testing the assumptions underlying the growth accounting and index number approaches. For example, it is possible to test whether the production function exhibits constant returns to scale, an assumption that is often used in the growth accounting approach. However, as with the growth accounting approach, results from the econometric approach are also sensitive to the form of the production function. Some functional forms or data samples might yield implausible parameter estimates. Moreover, this approach is not intuitive to a general audience. It is also not straightforward to compare productivity estimates obtained from this approach across different studies. Hulten (2000) suggests that the econometric approach be used as complementary to the growth accounting and index number approaches, as the relative simplicity of the latter can be used to help interpret the richer results of the former.

2.3 Interpreting productivity measures

In interpreting productivity measures, it is important to keep in mind how the specific data that are used in constructing those measures relate to the underlying concepts of outputs, inputs, and efficiency. We want to be able to interpret observed differences in productivity across firms or industries, and trends in productivity over time, as indicative of differences or trends in the efficiency of conversion of inputs to outputs. But in important circumstances they may reflect instead differences or trends in the relationship between our data and the underlying concepts of inputs and output.

In particular, because real firms use multiple inputs to produce multiple outputs, we almost never measure either inputs or outputs in fundamental homogeneous units. We typically measure labour input in numbers of employees or employee-days, but a day's work from an engineer is not the same input as a day's work from a mason. We measure output in dollars (correcting over time for inflation), but a million dollars' worth of single-family home is not, in fact, the same output as a million dollars' worth of apartment buildings, and a million dollars' worth of houses today is not the same output as a million dollars' worth of 1990 houses, even *after* adjusting for the effects of overall inflation between then and now. This means that the fundamental level of inputs or outputs can change without the measured level changing, and conversely there can be changes in the measured levels that do not correspond to actual changes in the fundamental levels. These gaps between measurement and fundamental concepts can lead to apparent differences or trends in productivity that are not economically meaningful.

The limitations of revenue as the measure of output are particularly important. A higher quality structure represents more output for the firm that built it, as appropriately measured, than a lower quality structure. If, on average, we are constructing higher (or lower) quality structures than we used to, there is no reason to believe that the operation of competitive market forces will cause the revenue received by builders to rise (or fall) in proportion to such quality changes. If for example, quality is gradually improving, while prices have been rising only at the rate of overall inflation, this represents a gradual increase in industry output that will not be reflected in industry revenues. Hence reported productivity growth in this scenario systematically understates true productivity growth.

Just as there may be output differences or trends over time that are not reflected in revenue, there can be differences or trends in revenue that do not reflect any change in output. For example, if some parts of the country have more intense price competition among builders, firms in that region will receive less revenue for any given outputs than firms in less competitive regions. Our standard productivity measures will interpret this lower revenue as lower output, and so will infer incorrectly that these firms have lower productivity.

Analogously misleading differences or trends can be generated by differences in input levels that are not captured by our input measures. Some firms, sectors or regions may specialise in products that require a higher proportion of engineers or architects. These workers are more expensive than other labourers, and hence such firms probably have higher revenue per worker. But this does not truly represent higher productivity—their quality-adjusted use of labour input is higher. They are not more efficient, they are just producing more output with more input.

These possibly spurious results generated by mismeasurement of inputs and outputs are particularly severe when comparing productivity *levels* across different industries. Since different industries by definition produce different outputs, and frequently use inputs that differ qualitatively as well, comparing productivity levels across industries relies heavily on the validity of standardised input and output measures. Comparing output per worker (i.e. labour productivity) or MFP in different industries is the ultimate comparison of 'apples and oranges'.

This fact is concealed by the use of revenue as a supposedly consistent output measure across industries, but there really is no basis to believe that it is, in fact, meaningful of productivity when compared across industries. In contrast, when examining changes or growth rates for productivity within an industry, there may still be non-comparabilities (e.g. from quality improvement over time), but there is somewhat more of a basis to believe that output and input measures are roughly comparable. In other words, a house-builder in 2012 may use somewhat different inputs and build somewhat different houses than did a house-builder in 2000, but those differences are likely much smaller than the differences between a house-builder and an electric utility company.

A somewhat different kind of measurement problem arises from external shocks to the demand for a firm's products. The whole productivity framework is predicated on a model of a firm in which the firm continuously and optimally chooses how much to produce and how much of each input to consume. But real firms are not like that. While they may in some sense be able to choose how much to produce, they cannot necessarily sell everything they produce, and we measure output as sales, not production. Further, over some time horizon they can adjust how much labour, capital and other inputs to buy, but at any given moment they are constrained by existing configurations and contracts. This means that a firm hit with a decline in the demand for its products will generally reduce its output more than it reduces its measured use of inputs. This represents, formulaically, a decline in measured productivity. Indeed, productivity statistics for most industries around the world routinely show a decline when a recession hits. From one perspective this makes sense—a firm that has a bunch of workers who are to some extent hanging around not doing much is, in a sense, using those inputs inefficiently. But to the extent we interpret productivity numbers to convey the technical capability of firms or industries to convert inputs to outputs, it is silly to think that such capability has somehow deteriorated simply because they cannot sell their wares. More generally, as we try to understand the implications of measured differences or trends in productivity, it behoves us to understand how shocks to the demand for firms' products are affecting the numbers.

Another issue of interpretation is the relationship of productivity levels or trends at the level of firms to statistics for industries, regions, or countries. This will be discussed in more detail in Section 10, but we simply note here that the average change in productivity for the firms in an industry is not equal to the overall industry productivity change. To illustrate, consider a hypothetical industry with 10 firms. In the first period, 9 of these firms have 1 employee and $100,000 in sales each; the last firm as 10 employees and $1 million in sales. Now suppose in the second period, all of the firms have the same employment; the first 9 firms see sales increase to $110,000 (after adjustment for inflation), while the last firm continues at $1 million. Thus 9 firms enjoyed a productivity increase of 10 percent (10 percent more output using exactly the same inputs) and one firm had no change in productivity. The average firm therefore enjoyed a productivity increase of about 9 percent. But for the industry as a whole, output increased by about 4.7 percent ($90,000 increase divided by base total sales of $1.9 million). The difference between the 9 percent average improvement across firms and the 4.7 percent increase for the industry is that the latter is, in effect, the *weighted* average of the increase for each firm, while the former is the simple average. In real industries, the situation is even more complicated, as the industry change is also affected by the entry and exit of firms. Section 10 will discuss in more detail how the overall change in industry productivity can be related to changes occurring at the firm level.

3 International evidence on productivity in the construction industry

Research on productivity in the construction industry has addressed two main questions: what have the trends in productivity in this industry looked like and what determines productivity in this industry. Research in this area can be divided into three strands. The first strand, which draws on published statistics on productivity at the industry level, suggests that productivity growth in the construction industry has been declining. For example, Abdel-Wahab and Vogl (2011) use growth accounting to show the decline across major OECD countries over the period 1971–2005, with the exception of the United Kingdom.

The second strand of research focuses on measuring construction productivity at the activity level. For example, Herbsman and Ellis (1990) develop a statistical model to estimate the productivity of specific items (such as man hours per square metre for tiles). Goodrum and Haas (2004) examine 200 construction activities and find that labour productivity has improved.

The apparent contradiction between industry-level statistics, which show poor productivity performance in the construction industry, and activity-level evidence, which shows the opposite, has led several researchers to question the reliability of the former. For example, Rojas and Aramvareekul (2003) argue that productivity should be measured at the sub-industry level because of the amount of variation in the type of work done within the broad construction industry. Borg and Song (2013) find that construction productivity growth in Sweden has been understated by an average of 0.8 percentage points per year, because aggregate statistics do not adequately capture quality improvements in the construction industry. Relatedly, Harrison (2007) finds evidence of a downward bias in aggregate productivity estimates from the use input-cost-based deflators, and argues that this bias may account for up to half of the gap in productivity growth compared with the overall business sector.

However, activity-level studies are not without limitations. Activity-based productivity measures are highly specific, making cross-activity comparisons difficult. There are also channels through which firm-level productivity could decrease even as activity-level productivity increases. For example, Goodrum et al. (2002) note that projects may have become more complex over time, which could result in activity improvements not necessarily translating into broader progress.

The last strand of research reports managers', contractors' and workers' views on the factors that drive construction productivity, based on primary surveys and interviews. This research suggests that construction productivity is driven by internal factors, in particular management and worker skill and experience (Rojas and Aramvareekul 2003b, Kadir et al. 2005, Kazaz et al. 2008), rather than external factors such as recessions, labour market conditions and the like. That is, construction industry practitioners believe that it is within their power to improve productivity. We have found no studies that use firm-level data to estimate productivity in the construction industry.[1]

4 Studies related to productivity in the New Zealand construction industry

The interest in New Zealand construction productivity has increased considerably over the last few years, especially since Statistics New Zealand (2010) first published productivity statistics at the industry level which indicate that the construction industry has underperformed other industries in the last few decades, both in terms of productivity levels and productivity growth. The research questions asked in the New Zealand context are similar to those asked overseas.

As in the international literature, most New Zealand studies on this topic have used aggregate productivity statistics as their starting point. For example, Page (2010) reports that construction labour productivity has been decreasing on average by around 0.1 percent annually since 1988, and MFP has been decreasing by around 1 percent annually, though the decline stopped in the mid-1990s. Conway and Meehan (2013) further document this reversal, showing that construction experienced stronger growth in the 2000s. There are significant differences across sub-industries within the construction industry; the areas with the highest value added per person (i.e. labour productivity) include non-residential buildings and civil construction, while housing construction and various services have lower value added (Page and Curtis, 2011).

Some studies use survey questions to identify drivers of New Zealand construction productivity. In particular, Durdyev and Mbachu (2011) and Curtis and Page (2014) report that internal factors such as worker skill and competent management are the most important, while external factors are either not asked about, or not considered as important. Unlike the international literature, no New Zealand studies have examined productivity in the construction industry at the activity level.

[1] Appendix Table 1 summarises existing international studies on productivity in the construction industry.

Some studies indirectly examine productivity in the New Zealand construction industry by analysing macro-economic factors. For example, NZIER (2013) notes that the level of competition a firm faces could either hurt or help productivity; when competition is intense the returns to innovation may be less, which can decrease the incentive to innovate. Alternatively, competition may give firms an incentive to innovate in order to escape the pack of other firms and gain more profit. Similarly, there is reason to think firm size matters, as larger firms may reap economies of scale advantages. The report notes that firm sizes vary within construction sub-industries, but it cannot infer an effect on productivity due to the lack of firm-level data. Abbot and Carson (2012) highlight the effect of business cycles on the construction industry; construction growth is highly cyclical, and so the authors argue that longer time frames must be considered to get accurate findings that go beyond a short-term boom or bust. Curtis and Norman (2011) develop a link between this volatility and poor productivity; because it takes time to change the number of workers, there is a surge of labour productivity at the start of a construction boom when the firm has not yet hired more staff. Similarly, there is a drop in labour productivity at the start of a downturn as firms hoard labour, even while total output is declining. Relatedly, PWC (2011) recommends that the government build counter-cyclically and remove any bias toward speculative residential investment, in order to reduce volatility in the construction industry.

Again, no New Zealand studies have used firm-level data to estimate productivity in the construction industry.[2] Measuring productivity at the firm level is broad enough to allow solid comparisons across practitioners, which activity measures struggle with. At the same time, firm-level data are disaggregated enough to identify patterns at the micro level which cannot be seen at the industry level. The current study seeks to fill that gap.

5 The production function

This study will focus on two measures of productivity: labour productivity and MFP. Labour productivity is important as construction is a highly labour-intensive industry and one of the largest employers in New Zealand. In this study, labour productivity is defined as the ratio of value added relative to total labour input.

$$lp = VA/L \tag{1}$$

MFP captures the extent to which a given firm is more or less efficient than other firms in converting inputs into outputs. If all inputs are accounted for, then MFP growth can be taken as a measure of an economy's long-term technological change or technological dynamism.

[2] Appendix Table 2 summarises studies related to productivity in the New Zealand construction industry.

This study estimates MFP using the econometric approach. As discussed in Section 2.2, MFP cannot be calculated directly and will be estimated as a residual from a production function. The starting point is an equation that relates the quantity of inputs used by a firm (i) in a given period (t) to the quantity of outputs produced:

$$Output_{it} = A_{it} * f_{it}(Inputs_{it}) \tag{2}$$

The function $f(*)$ captures the technology used by the firm, and A_{it} is a measure of MFP. $f(*)$ is indexed by firm and time period.

It would be possible to estimate the technology parameters and MFP separately if the changing functional form of the technology were known. In practice, both of these are generally estimated jointly, necessitating some constraints on the technology parameters. Technology is often assumed to be stable over time and constant for firms in the same industry (j), so $f(*) = f_j(*)$. As such, MFP is estimated relative to an industry-specific reference technology. A firm with high MFP is one that produces more output than other firms in its industry, given the inputs used for production.

According to Griffin et al. (1987), there are 20 different functional forms for equation (2). The functions differ with respect to the constraints they impose on marginal productivity (the extent to which marginal product varies with respect to input quantities), input factor substitutability (how easy it is to substitute one input for another), output elasticities (the extent to which output increases as one input is increased while holding other factors constant) and returns to scale (the extent to which output increases as all inputs are increased proportionally). In the literature, the most common functional form for equation (2) is the Cobb-Douglas production function:

$$Y_{it} = A_{it} * \prod_n (X_{nit})^{\beta_{nj}} \tag{3}$$

where Y is output and X_n is the n-th input factor. Even though the Cobb-Douglas function is relatively restrictive with respect to the constraints mentioned above, it is parsimonious (requiring only N+1 parameters to be estimated, where N is the number of input factors), and can be estimated (in log form) using linear regression. When expressed in logs (with lower-case letters denoting logged variables), (3) is equivalent to:

$$y_{it} = a_{it} + \sum_n \beta_{nj} x_{nit} \tag{4}$$

Several variants of equation (4) will be estimated, which will enable us to assess the robustness of the results. An example of (4) is:

$$y_{it} = a_{it} + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} \tag{5}$$

where y is gross output, k is capital input, l is labour input and m is intermediate inputs. Other determinants of productivity can be added as controls in equation (5). Equation (5) also shows that the econometric approach is conceptually equivalent to the index number approach discussed in Section 2.2; the weights in the index number approach are prices or shares, whereas in the econometric approach they are the β parameters.

Once labour productivity and MFP are estimated, the study will then compare how each measure of productivity varies by firm characteristics, over time, and so on.

6 Data

6.1 Data sources

The next paragraphs describe the major LBD data sets used in this study.[3]

6.1.1 Annual Enterprise Survey (AES)

AES is New Zealand's most comprehensive source of financial statistics. It provides annual information on the financial performance and financial position for industry and sector groups operating within New Zealand and is the primary source of information for the estimation of national accounts.

According to Fabling and Maré (2015), the term 'AES' is used by Statistics New Zealand to refer to both a postal sample survey of firms, and a compiled data set of business information that includes data from this survey as well as from administrative sources. With increased reliance on alternative data sources, the size of the sample survey has declined over time, reflecting Statistics New Zealand's commitment to reducing respondent burden. The postal survey is stratified by industry and size, with full coverage of enterprises in the largest-size stratum within each industry. Sampled units are predominantly large units.

In this study, AES is the preferred data source for deriving firm-level gross output, value of capital services flows and intermediate inputs, as the concepts and measures used in the AES are designed for the purposes of production measurement.

6.1.2 IR10

IR10 is a two-page summary of financial statements provided for tax purposes to Inland Revenue. The IR10 form has two parts, with the 'income statement' covering the firm's financial performance (profit and loss) and the 'balance sheet' covering its financial position. In this study, IR10 data are used when AES data are not available.

[3] Most of these data sets suffer from 'discontinuities', e.g. AES questionnaire redesign in 2009; IR10 form redesign in 2012/2013 and change in the tax treatment of depreciation in 2011, affecting IR10 data on depreciation, see Fabling and Maré (2015) for more details. These discontinuities might have implications for temporal analysis.

6.1.3 Linked Employer-Employee Data (LEED)

LEED contains data from tax and statistical sources. Each month all employers file an Employer Monthly Schedule record with Inland Revenue, which lists all employees at that firm in the month, the amount of income they received, and the amount of tax that was deducted at source. In this study, LEED data are used to derive firm-level labour input.

6.2 Key variables

Construction firms are defined as those whose Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006 division code is E, as listed in Appendix Table 3. Analyses can be disaggregated at the 2-, 3- and 4-digit level.

Table 1: LBD production function data

Variable	Definition	Price deflation
Gross output (GO)	-From AES: GO=gros_out_amt -From IR10: $GO = sales + other\ income + stock\ change = i10\_salesserv\ + (i10\_rent\_rcvd + i10\_otherinc) + (i10\_clgstock - i10\_opgstock)$ To be comparable with AES measure, IR10 measure is adjusted for purchases of goods for resale, for interest payments in financial industries, and for road user charges	Deflated at the NZSIOC industry level[4] using the Producer Price Index for outputs
Value of capital services (K)	$K = depreciation + rental\ and\ leasing\ costs + cost\ of\ borrowing$	Deflated at the aggregate level using the Capital Goods Price Index
Labour input (L)	L= working proprietors + employees Where -'Working proprietors' is a headcount of individuals who receive self-employed income (identified from annual tax return information) -Employees' labour input is adjusted to approximate a full-time equivalent measure, derived from LEED data	n/a, as this is a headcount-based measure
Intermediate inputs (M)	-From AES: $M = ic\_adj\_amt - (estimated\ rental\ and\ leasing\ )$ -From IR10: $M = i10_{purchases} + i10_{totexp} - i10_{salwages} - i10_{baddebts} - i10_{intpd} - i10_{deprec} - goods\ for\ resale - road\ user\ charges - (rental\ leasing\ and\ rates\ if\ \text{RLR}\ is\ missing)$ Where RLR is rental and leasing costs	Deflated at the NZSIOC industry level using the Producer Price Index for Inputs
Value added (VA)	$VA = GO - M$	

Source: Summarised from Fabling and Maré (2015)
Note: The base year for price deflation is 2007 for all variables.

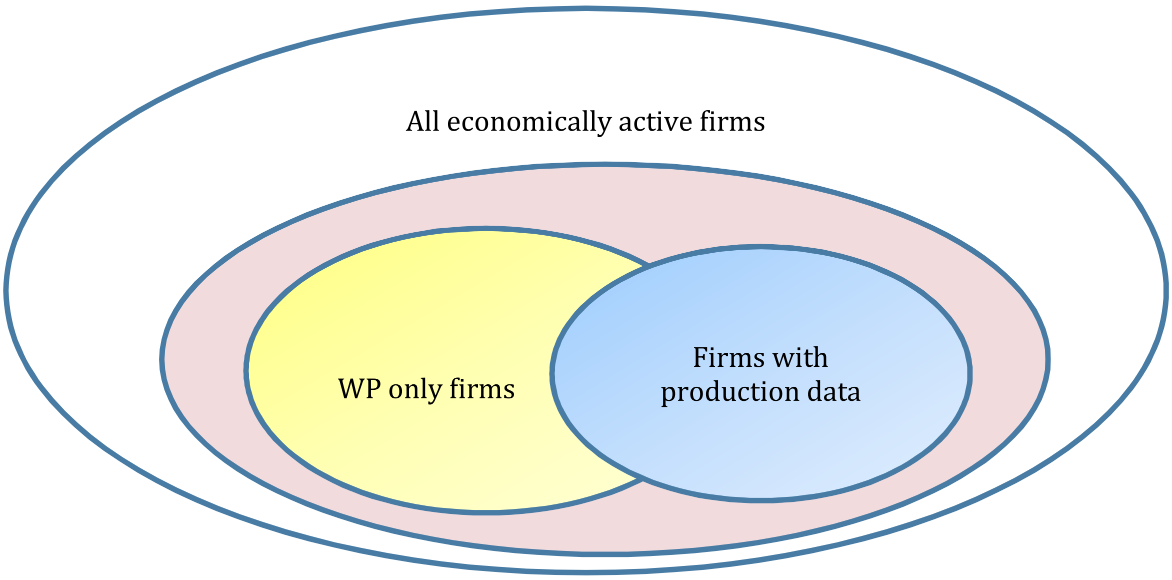
[4] NZSIOC (New Zealand Standard Industry Output Categories) is an industry classification system that Statistics New Zealand developed based on ANZSIC 2006, with level of disaggregation adapted specifically to the New Zealand situation, see http://www.stats.govt.nz/browse_for_stats/industry_sectors/anzsic06-industry-classification/background-info/nzsioc.aspx

The 'production function' variables (i.e. the variables necessary for estimating a production function, as described in Section 5) are drawn from the work of Fabling and Maré (2015). A production function, such as (5), can only be reliably estimated when the input and output variables are well measured. In practice, measurement is a challenging issue, as a firm often uses more than one input and produces more than one output, and the types of input and output differ greatly across firms and especially industries. Data on inputs and outputs are usually available in (nominal) monetary terms. Table 1 summarises how Fabling and Maré (2015) derive the production function variables so that they can reasonably capture quantities of input and output.

6.3 Estimation samples

The primary analytical sample used in this study is all economically active firms in the private, for-profit sector[5] that appeared in the LBD during 2001–2012.[6] Not all economically active firms have labour input, and among those which do, some have no employees other than the proprietors. Besides, full production data are not available to some firms with labour input. Figure 1 illustrates how the different data samples relate to one another.

Figure 1: Relations between data samples



Note: Graph is not to scale.

[5] This is the restriction that Statistics New Zealand uses in defining the target population for the business sector (see, for example, Statistics New Zealand, 2007) and has been adopted by many studies using LBD data. Around 500,000 firms meet this definition each year during 2000–2012. These firms are collectively referred to as the 'measured sector' in this study.

[6] The LBD currently covers the period 2000–2013. However, data for 2013 are incomplete and there are some data issues for 2000 (e.g. imputation flag for AES data is missing and entry status cannot be reliably defined for 2000).

Analyses related to productivity measures are further restricted to firms with production data only. Our general LBD data set has over six million firm-year observations of around 947,000 firms, including 749,000 firm-year observations of 124,000 firms in the construction industry. Our working production data set is smaller, with about 2.3 million observations of 487,000 firms, including 358,000 observations of 78,000 firms in the construction industry. Because firms come and go, the number of firms active in any one year is less than this total. For example, even though 947,000 economically active firms were recorded during 2001–2012, the number of firms active in each year was less than half a million, see Table 3.

7 Descriptive statistics

7.1 Comparing the construction industry with other industries

Table 2 shows the contribution of the construction industry in the New Zealand economy. In 2012, the number of construction firms with any labour input made up around 14 percent of the measured sector. The share of employment was 9.9 percent, while the shares of gross output and value added were 10.7 and 8.8 percent respectively. These numbers show that Construction accounts for a substantial part in the New Zealand economy and that its relative contribution increased strongly between 2001 and 2012.

Table 2: Share (%) of the construction industry in the measured sector

	2001	2012
Number of firms with any labour input	12.2	14.3
Firms with production data only:		
Employment	7.5	9.9
Gross output	8.1	10.7
Value added	5.6	8.8

Source: Longitudinal Business Database
Note: Numbers of underlying observations have been randomly rounded to base 3 to protect confidentiality.

Table 3 compares Construction to other industries. Across the measured sector there was an increase of 2.1 percent in the number of economically active firms between 2001 and 2012; from 476,000 to 485,000. Pushing against this increase was the decline in the primary and manufacturing industries, where firm numbers decreased by 20 percent and 6 percent, respectively. In contrast, the number of construction firms increased by 15 percent (from 54,000 to 62,000). This proportional increase is greater than for other services (7.4 percent), and is only lower than in the utilities industry (18 percent).

Table 3: Summary statistics by industry

		Primary	Manu-facturing	Utilities	Construc-tion	Other services	Total
2001							
All economically active firms							
Number of firms		94,611	28,350	981	54,381	297,174	475,500
% with no labour input		17.7	21.5	25.7	24.7	34.6	29.3
% with no labour in all years		10.5	10.3	16.2	13.7	22.1	18.1
% with WP only		71.1	54.0	59.9	73.6	73.7	72.0
% with WP only in all years		58.1	40.4	44.6	57.8	63.6	60.4
Firms with production data:							
% with WP only		64.8	45.0	46.9	65.2	54.8	58.0
% with WP only in all years		49.9	28.9	29.9	45.6	39.5	42.2
Employment	Mean	2.4	11.6	12.6	2.8	5.9	5.1
	25th percentile	1.0	1.0	1.0	1.0	1.0	1.0
	Median	2.0	2.0	2.0	1.3	2.0	2.0
	75th percentile	2.3	5.8	4.3	2.1	3.4	3.0
Gross output ($)	Mean	305,600	3,977,100	18,141,700	561,300	803,800	948,200
	25th percentile	30,600	70,900	109,900	56,900	48,300	47,300
	Median	121,800	214,300	200,100	119,800	119,500	125,100
	75th percentile	309,400	704,800	556,900	300,100	303,800	324,200
Value added ($)	Mean	121,800	1,369,900	8,338,500	164,600	403,600	398,500
	25th percentile	4,400	32,500	48,100	23,500	23,000	18,600
	Median	41,700	91,500	101,400	48,600	64,500	57,700
	75th percentile	119,400	308,400	277,500	106,300	164,800	148,700
Labour productivity ($)[a]							
	25th percentile	59,500	70,800	667,900	62,300	60,100	68,000
	Median	105,500	138,000	1,525,100	84,500	104,300	118,000
	75th percentile	185,200	386,200	1,890,900	157,800	170,100	299,100
	P75:P25 ratio	3.11	5.46	2.83	2.53	2.83	4.40
2012							
All economically active firms							
Number of firms		76,077	26,649	1,161	62,406	319,041	485,337
% with no labour input		26.6	26.7	33.1	26.7	37.7	34.0
% with no labour in all years		9.9	7.7	17.6	8.4	18.2	15.1
% with WP only		70.3	55.8	64.6	71.2	72.7	71.2
% with WP only in all years		50.5	36.0	47.3	50.3	58.6	55.0
Firms with production data:							
% with WP only		60.4	43.0	46.9	60.3	53.0	54.9
% with WP only in all years		41.3	25.6	32.5	40.3	37.6	37.9
Employment	Mean	2.8	12.4	23.1	3.6	6.7	5.9
	25th percentile	1.0	1.0	1.0	1.0	1.0	1.0
	Median	2.0	2.0	2.0	1.5	2.0	2.0
	75th percentile	2.6	6.2	4.9	2.7	3.6	3.2
Gross output ($)	Mean	459,500	4,459,300	21,686,100	740,600	937,300	1,131,200
	25th percentile	27,400	82,500	90,700	61,000	55,700	53,100
	Median	122,200	247,100	171,300	131,900	134,200	137,200
	75th percentile	367,100	806,500	670,600	365,000	352,300	380,100
Value added ($)	Mean	174,700	1,335,400	6,410,000	271,400	552,000	506,100
	25th percentile	3,100	38,400	39,300	32,700	30,500	25,300
	Median	41,700	104,000	86,000	66,000	80,100	71,600
	75th percentile	131,300	333,500	270,700	161,100	203,800	187,000
Labour productivity ($)[a]							
	25th percentile	68,500	68,700	215,300	72,100	72,600	73,500
	Median	124,800	139,600	398,600	101,400	111,200	124,000
	75th percentile	256,200	371,000	606,900	157,600	203,500	284,300
	P75:P25 ratio	3.74	5.40	2.82	2.19	2.80	3.87

Source: Longitudinal Business Database

Notes: Numbers of observations have been randomly rounded to base 3 to protect confidentiality. Dollar values are in 2007 prices and have been rounded to the nearest hundred. [a]Weighted by gross output.

Across the measured sector, the share of firms with no labour input (i.e., 'shell' companies) increased from 29 percent in 2001 to 34 percent in 2012. The proportion of shell companies in Construction is lower than in the overall measured sector in both 2001 and 2012. A substantial number of shell companies are persistently so: around 48 to 64 percent (row 3 divided by row 2) of firms with no labour input in 2001 remained so throughout their LBD history, but many firms also make the transition into production and activity.

Across the measured sector, the share of working-proprietor-only firms (i.e., those with no employees other than the proprietors) stabilised at just over 70 percent and Construction has one of the highest shares. The vast majority of such firms are persistently so: about 74–86 percent (row 5 divided by row 4) of working-proprietor-only firms in 2001 remained so throughout their LBD history. Working-proprietor-only firms are less likely than employing firms to have production data as they tend to be less economically significant. As a result, working-proprietor-only firms are under-represented in the production data set. In 2012, just over half of firms with production data are working-proprietor-only, compared with the corresponding share of 71 percent among all economically active firms.

In terms of size, construction firms tend to be relatively small, with around three workers on average compared with the overall measured sector average of over five. The only smaller industry is Primary, while Manufacturing and Utilities have much larger firms on average. Within Construction, the upper quartile of employment is lower than the mean, indicating that a few large firms account for most of the employment in this industry.

Labour productivity in construction firms tends to be lower than in other industries. In 2001, the median labour productivity in Construction was $84,500 of value added per worker, compared with $118,000 for the overall measured sector. The pattern is not much different in 2012, with median labour productivity in Construction of $101,400, compared with $124,000 for the overall measured sector. Relatively low labour productivity in the construction industry is likely to be a combination of lower average skill and lower capital intensity in construction compared to other industries, as will be noted Section 8.1.

There is wide dispersion in labour productivity. For example, in 2012 the firm at the 75th percentile of labour productivity distribution for Construction had 2.2 times the value-added output per worker as the 25th percentile firm. This ratio of the productivity of the 75th percentile firm to that of the 25th percentile firm is a convenient summary measure of the extent of dispersion, and can be roughly compared across industries or sub-industries to get a sense of the importance of such dispersion. Interestingly, this ratio is actually smaller in the construction industry than in other industries, e.g. the corresponding ratio is 5.4 for Manufacturing and 3.7 for Primary. Thus, there is no evidence to support a conjecture that relatively poor average productivity performance in Construction is due to having a greater proportion of firms that significantly lag behind the best performers. Indeed, while Construction has similar lower quartile labour productivity to that of other industries (except for Utilities, a high capital intensive industry, with only a small number of firms), its median and upper quartile are much lower than in other industries. This suggests that the top performers in Construction are not as productive as the top performers in other industries, but the poorer performers in Construction do not fare worse than the underperformers in other industries. (Nevertheless, for the reasons noted in Section 2.3, these cross-industry comparisons should be taken with a grain of salt because of the non-comparability of inputs and outputs across industries.)

7.2 Disaggregating the construction industry

Page and Curtis (2011) highlight the differences between the sub-industries of Construction. With the LBD, we can examine these differences with even finer detail. Table 4 disaggregates the construction industry at the 4-digit level. The most significant 4-digit industry is 'House construction' (E3011), accounting for 29 percent of Construction's total firm count and 16 percent of employment in 2012. The second most significant 4-digit industry is 'Electrical services' (E3232), accounting for 11 percent of the total firm count and employment in 2012. The composition of the construction industry was fairly similar between 2001 and 2012.

Table 5 shows that 'Land development and subdivision' (E3211) stands out as having remarkably high shares of zero-labour firms and working-proprietor-only firms. While only 27 percent of all construction firms had no labour input in 2012, the corresponding share for 'Land development and subdivision' was 82 percent. Moreover, almost all (95 percent) of this sub-industry's firms were working-proprietor-only in 2012, compared with 71 percent across the construction industry.

Of particular interest in the construction industry is the prevalence of firms that take in contracts and sub-contract others to undertake work. This 'contract out' status is reported on IR10 returns. Overall, three quarters of construction firms have a 'complete' IR10 front page, thus providing a reliable measure of sub-contracting.[7] For these firms, the share of contracting out increased from 20 percent in 2001 to 26 percent in 2012. Industries with contracting-out rates of over 30 percent in 2012 include 'Concreting services' (E3221), 'Bricklaying services' (E3222) and 'Plumbing services' (E3231). The rate of contracting out is noticeably low (5.7 percent) for 'Land development and subdivision' (E3211), which is also the sub-industry with the highest share of working-proprietor-only firms.

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[7] Firms have the option of attaching a set of financial statements to their tax return instead of filing an IR10 return. Firms that file an IR10 return tend to be smaller than those that attach financial statements. Statistics New Zealand classifies whether the information provided on the front page and back page respectively of IR10 returns have passed some basic quality checks for consistency and completeness. 'Contractor and sub-contractor payments' is on the front page of the IR10 form. While the AES, the alternative, and more reliable, source of financial data in the LBD, collects information on 'payments to contractors', this particular information is not included in the data available to researchers.

Table 4: Composition of the construction industry by 4-digit industry

ANZSIC 2006	Industry description	Share in total construction industry in: Firm count	Employment[a]	Gross output[a]	Value added[a]
2001					
E3011	House construction	28.3	17.8	18.8	17.0
E3019	Other residential building construction	0.5	0.2	0.3	0.4
E3020	Non-residential building construction	2.8	8.1	23.2	14.9
E3101	Road and bridge construction	1.0	7.0	8.4	9.1
E3109	Other heavy and civil engineering construction	2.2	8.1	8.1	10.6
E3211	Land development and subdivision	6.4	1.3	1.9	1.2
E3212	Site preparation services	3.7	5.4	5.0	6.3
E3221	Concreting services	1.8	1.8	1.3	1.6
E3222	Bricklaying services	2.5	2.1	1.1	1.3
E3223	Roofing services	2.1	1.6	1.5	1.1
E3224	Structural steel erection services	0.4	0.3	0.2	0.3
E3231	Plumbing services	7.0	7.3	5.2	5.5
E3232	Electrical services	10.2	12.5	8.8	10.6
E3233	Air conditioning and heating services	1.1	1.8	2.3	1.9
E3234	Fire and security alarm installation services	1.3	1.3	1.0	1.0
E3239	Other building installation services	0.3	0.4	0.3	0.4
E3241	Plastering and ceiling services	3.8	2.8	1.5	2.0
E3242	Carpentry services	6.3	3.4	2.1	2.1
E3243	Tiling and carpeting services	3.8	2.7	1.3	1.6
E3244	Painting and decorating services	8.9	7.6	3.5	5.4
E3245	Glazing services	0.9	1.2	0.8	0.9
E3291	Landscape construction services	2.6	2.3	1.2	1.7
E3292	Hire of construction machinery with operator	0.3	0.4	0.4	0.8
E3299	Other construction services n.e.c.	2.0	2.6	1.9	2.6
2012					
E3011	House construction	28.9	16.4	18.5	15.7
E3019	Other residential building construction	3.3	1.2	1.0	0.9
E3020	Non-residential building construction	2.7	7.7	19.7	14.3
E3101	Road and bridge construction	0.9	9.3	11.8	10.7
E3109	Other heavy and civil engineering construction	1.9	9.6	9.8	9.0
E3211	Land development and subdivision	3.0	0.3	0.5	0.5
E3212	Site preparation services	4.2	5.8	5.2	7.2
E3221	Concreting services	1.9	1.8	1.3	1.6
E3222	Bricklaying services	2.0	1.4	0.6	0.9
E3223	Roofing services	2.0	1.7	1.4	1.4
E3224	Structural steel erection services	0.5	0.3	0.2	0.3
E3231	Plumbing services	6.4	6.5	4.6	5.6
E3232	Electrical services	10.5	10.9	7.4	9.3
E3233	Air conditioning and heating services	1.7	3.1	3.1	3.2
E3234	Fire and security alarm installation services	1.0	1.8	1.3	1.5
E3239	Other building installation services	0.8	1.1	0.7	0.9
E3241	Plastering and ceiling services	3.5	2.1	1.2	1.6
E3242	Carpentry services	3.3	1.7	1.2	1.3
E3243	Tiling and carpeting services	4.0	2.2	1.1	1.4
E3244	Painting and decorating services	8.3	6.1	3.1	4.4
E3245	Glazing services	1.0	1.0	0.6	0.8
E3291	Landscape construction services	4.5	3.7	1.8	2.3
E3292	Hire of construction machinery with operator	0.4	0.7	0.9	1.5
E3299	Other construction services n.e.c.	3.1	3.7	2.8	3.9

Source: Longitudinal Business Database

Notes: Entries are percentages. Shares of firm counts are constructed from firm counts that have been randomly rounded to base 3. Shares of employment are constructed from employment counts that have had graduated random rounding applied. Shaded rows are discussed in text. [a]For firms with production data only.

Table 5: Descriptive statistics of the construction industry by 4-digit industry

ANZSIC 2006	Total firm count	% with no labour input		% with WP only		% with 'complete' IR10	% contract out
		In this year	In all years	In this year	In all years		
2001							
E3011	15,369	23.5	11.7	77.4	60.1	77.0	21.0
E3019	246	46.3	15.9	86.6	67.1	73.2	13.4
E3020	1,503	25.9	14.2	62.5	47.3	75.6	22.0
E3101	531	22.6	11.3	46.3	32.2	76.3	25.4
E3109	1,185	20.0	10.6	57.7	42.5	77.7	21.8
E3211	3,501	68.5	55.6	94.2	88.8	70.8	6.0
E3212	2,013	20.7	10.7	63.3	46.6	79.3	22.4
E3221	954	22.3	9.7	56.9	37.4	71.1	25.2
E3222	1,350	14.7	8.2	68.7	49.6	78.7	27.1
E3223	1,131	30.8	15.1	65.0	44.6	67.6	19.4
E3224	225	24.0	12.0	73.3	58.7	70.7	14.7
E3231	3,795	17.3	8.4	67.8	51.3	79.8	25.6
E3232	5,535	17.7	9.2	72.2	59.1	79.4	18.5
E3233	576	21.9	9.4	62.0	44.8	77.1	20.8
E3234	702	26.5	15.8	67.9	56.4	69.7	16.2
E3239	189	27.0	12.7	63.5	47.6	76.2	17.5
E3241	2,070	23.3	11.7	71.9	54.5	70.4	22.0
E3242	3,444	23.8	12.2	85.0	72.7	75.8	16.9
E3243	2,046	18.8	8.9	76.1	58.9	76.4	16.4
E3244	4,833	19.6	9.4	72.2	54.7	76.6	22.3
E3245	516	20.3	8.7	65.1	47.1	77.9	18.0
E3291	1,440	20.2	7.7	69.0	46.0	75.8	21.7
E3292	150	26.0	12.0	62.0	40.0	80.0	18.0
E3299	1,074	25.1	13.4	62.3	48.6	73.2	17.9
Total	**54,381**	**24.7**	**13.7**	**73.6**	**57.8**	**76.2**	**19.9**
2012							
E3011	18,051	28.1	7.8	74.5	51.8	74.3	26.5
E3019	2,088	33.6	17.8	85.9	73.6	72.0	20.7
E3020	1,716	36.7	14.7	63.5	41.3	70.8	23.1
E3101	531	27.7	10.2	46.3	26.0	69.5	26.0
E3109	1,200	26.0	9.0	58.5	39.8	72.5	26.3
E3211	1,887	81.7	59.9	95.1	84.9	72.0	5.7
E3212	2,616	26.6	6.3	63.3	40.7	76.9	27.6
E3221	1,194	25.1	5.5	58.8	30.4	73.1	32.7
E3222	1,230	20.7	3.2	69.3	41.0	74.4	30.5
E3223	1,266	26.1	6.4	58.1	32.5	68.5	28.2
E3224	309	26.2	6.8	74.8	61.2	68.9	16.5
E3231	4,020	18.0	3.3	63.6	44.0	77.9	31.8
E3232	6,543	19.3	4.3	71.4	55.1	77.9	24.5
E3233	1,074	26.0	6.7	59.8	42.2	75.4	27.4
E3234	642	27.1	7.0	63.1	45.3	72.9	26.6
E3239	507	24.3	8.9	58.6	43.8	72.8	23.7
E3241	2,199	24.1	4.5	74.1	47.5	69.0	24.1
E3242	2,046	24.9	5.4	83.6	65.7	73.6	19.1
E3243	2,478	21.4	4.0	75.9	54.5	74.0	21.5
E3244	5,154	20.5	4.7	70.8	47.6	73.7	28.2
E3245	648	21.3	4.2	59.3	39.8	76.4	23.6
E3291	2,820	22.3	5.2	69.3	46.1	77.2	27.9
E3292	246	31.7	11.0	69.5	42.7	75.6	23.2
E3299	1,941	29.1	9.6	64.5	45.0	74.0	24.9
Total	**62,406**	**26.7**	**8.4**	**71.2**	**50.3**	**74.4**	**25.5**

Source: Longitudinal Business Database
Notes: Numbers of observations have been randomly rounded to base 3 to protect confidentiality. Industry description can be found in Table 4 or Appendix Table 3. Shaded rows are discussed in text.

Table 6: Distribution of employment and labour productivity by 4-digit industry

ANZSIC 2006	Employment				Labour productivity[a] ($)			
	Mean	25th pctile	Median	75th pctile	25th pctile	Median	75th pctile	P75:P25 ratio
2001								
E3011	1.8	1.0	1.0	2.0	73,600	112,800	220,300	2.99
E3019	2.0	0.8	1.0	2.0	50,800	110,500	144,600	2.85
E3020	8.6	1.0	2.0	4.6	89,800	181,500	188,400	2.10
E3101	18.5	1.0	2.9	9.0	74,700	78,000	81,400	1.09
E3109	9.6	1.0	2.0	4.3	69,800	80,500	115,600	1.66
E3211	1.9	1.0	2.0	2.0	65,600	224,900	665,500	10.15
E3212	3.6	1.0	2.0	3.0	64,800	86,500	137,700	2.12
E3221	2.7	1.0	2.0	3.2	49,300	65,200	81,500	1.65
E3222	2.1	1.0	1.2	2.1	41,700	55,700	69,400	1.66
E3223	2.5	1.0	1.7	2.7	38,900	49,700	68,500	1.76
E3224	2.3	1.0	2.0	2.3	54,200	74,100	106,200	1.96
E3231	2.4	1.0	2.0	2.5	47,500	60,300	86,000	1.81
E3232	3.0	1.0	2.0	2.4	52,300	67,700	92,200	1.76
E3233	4.2	1.0	2.0	3.3	50,300	76,600	117,400	2.34
E3234	3.1	1.0	2.0	2.8	45,500	56,800	107,900	2.37
E3239	2.9	1.0	2.0	3.7	43,400	68,600	91,000	2.10
E3241	2.1	1.0	1.0	2.1	43,300	53,900	75,700	1.75
E3242	1.7	1.0	1.0	2.0	47,700	64,400	89,900	1.89
E3243	1.8	1.0	1.2	2.0	41,000	59,600	87,300	2.13
E3244	2.2	1.0	1.0	2.0	43,800	58,100	85,200	1.95
E3245	2.7	1.0	2.0	3.0	45,500	59,000	74,400	1.64
E3291	2.1	1.0	1.1	2.0	42,100	57,100	74,900	1.78
E3292	3.8	1.0	2.0	3.8	91,100	137,300	137,300	1.51
E3299	3.7	1.0	2.0	3.8	56,300	71,500	109,300	1.94
2012								
E3011	2.1	1.0	1.0	2.1	79,600	122,000	230,000	2.89
E3019	1.7	1.0	1.0	2.0	71,800	150,100	232,000	3.23
E3020	11.2	1.0	2.0	5.8	124,800	166,400	235,900	1.89
E3101	38.7	2.0	3.9	11.9	94,700	94,700	112,800	1.19
E3109	18.0	1.0	2.0	5.1	69,500	72,100	100,100	1.44
E3211	2.1	1.0	2.0	2.0	138,900	465,000	1,089,300	7.84
E3212	4.7	1.0	2.0	4.0	90,500	119,300	156,100	1.72
E3221	3.2	1.0	2.0	3.8	62,400	80,600	108,400	1.74
E3222	2.2	1.0	1.2	2.3	49,600	63,600	83,000	1.68
E3223	2.9	1.0	2.0	3.4	62,200	93,500	130,100	2.09
E3224	2.7	1.0	1.0	2.0	77,900	95,800	127,100	1.63
E3231	3.0	1.0	2.0	3.0	63,800	78,500	101,200	1.59
E3232	3.3	1.0	2.0	2.8	67,000	82,200	110,500	1.65
E3233	6.5	1.0	2.0	6.3	63,100	99,200	117,600	1.86
E3234	6.4	1.0	2.0	4.1	41,400	64,700	90,700	2.19
E3239	4.8	1.0	2.0	4.3	58,000	73,100	102,100	1.76
E3241	2.1	1.0	1.0	2.0	56,900	75,700	131,500	2.31
E3242	1.8	1.0	1.0	2.0	69,200	85,700	135,500	1.96
E3243	1.8	1.0	1.0	2.0	60,200	84,200	122,000	2.03
E3244	2.4	1.0	1.0	2.0	55,100	77,100	115,600	2.10
E3245	3.0	1.0	2.0	3.4	57,400	71,900	104,300	1.82
E3291	2.7	1.0	1.4	2.3	52,400	66,900	88,800	1.70
E3292	7.1	1.0	2.0	4.0	138,200	203,900	308,900	2.24
E3299	4.5	1.0	2.0	4.0	67,900	94,700	138,500	2.04

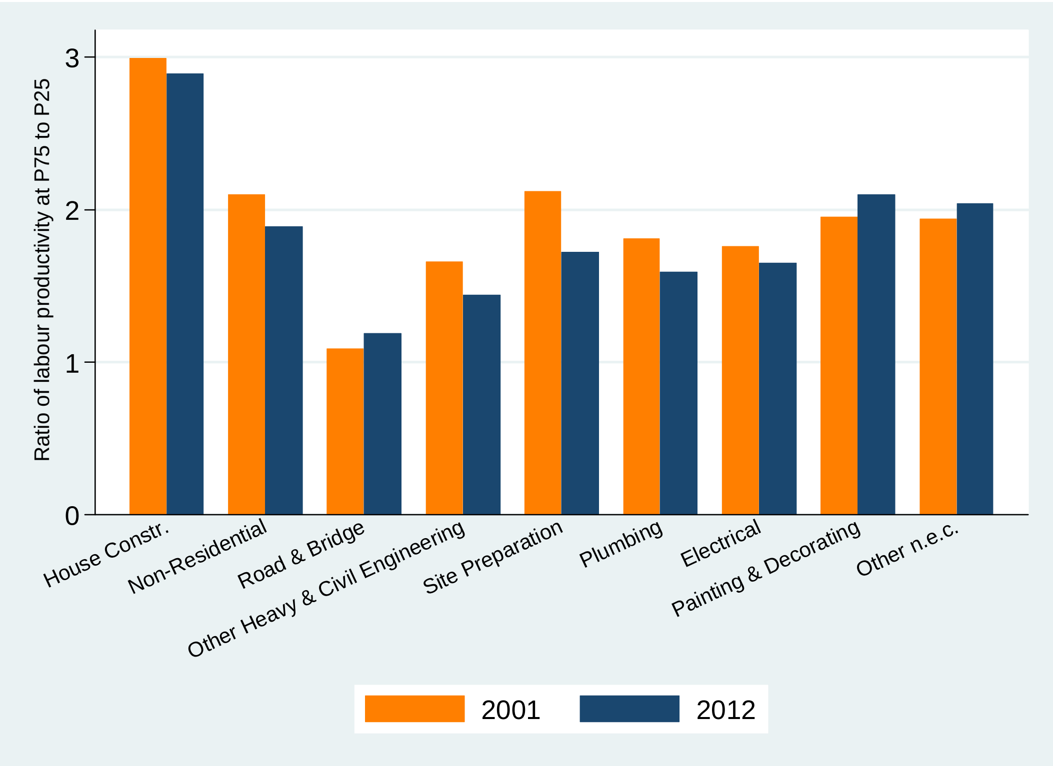
Source: Longitudinal Business Database

Notes: For firms with production data only. Industry description can be found in Table 4 or Appendix Table 3. Shaded rows are discussed in text. [a]Weighted by gross output.

Table 6 shows the distribution of employment and labour productivity for the sub-industries of Construction. This table shows in a more detailed way the earlier finding that construction firms tend to be small. The majority of sub-industries have mean employment of less than five, and this is true for the two dominant sub-industries, 'House construction' (E3011) and 'Electrical services' (E3232). There are a few exceptions in terms of size: in 2012, mean employment was 39 for 'Road and bridge construction' (E3101); 18 for 'Other heavy and civil engineering construction' (E3109); and 11 for 'Non-residential building construction' (E3020). But the median and upper quartile for these sub-industries are still relatively small, indicating that the distribution of employment in the construction industry is highly skewed.

In terms of productivity performance, the construction services sub-industries tend to have relatively low labour productivity, with the exception of 'Site preparation services' (E3212) and 'Hire of construction machinery with operator' (E3292). The most noteworthy sub-industry is 'Land development and subdivision' (E3211), with median labour productivity of $465,000 in 2012, well above all other sub-industries.

Figure 2: Dispersion in labour productivity in the construction industry



Notes: Dispersion measure is taken from Table 6. The selected industries presented in this figure account for 84 percent of value added in the construction industry in 2001 (83 percent in 2012). Bars are ordered by ANZSIC 2006 code.

Sub-industries also differ in the extent of dispersion of productivity across firms. Using the 75th/25th percentile productivity ratio introduced above, 'Land development and subdivision' (E3211) stands out as having the widest dispersion in labour productivity: in 2012 the 75th percentile firm was 7.8 times as productive as the 25th percentile firm, compared with the corresponding ratio of 1.6–3.2 in other sub-industries. Figure 2 illustrates the range of productivity dispersion for the most important sub-industries within construction. For these larger sub-industries, the one with the greatest dispersion is 'Housing construction' (E3011, ratio of about 3), and the least dispersed is 'Road and bridge construction' (E3101), for which the 75th percentile firm has labour productivity less than 20% greater than the 25th percentile firm. The figure also reveals no systematic pattern in productivity dispersion over the period, with some sub-industries showing small increases and some showing small decreases.

8 MFP estimation results

Having examined labour productivity, this section estimates MFP through a Cobb-Douglas production function as set out in equation (5), using the data described in Section 6. Our baseline specification (Section 8.1) has gross output as the dependent variable and is estimated by an Ordinary Least Squares (OLS) regression. Alternative specifications are examined in Section 8.2. To allow for the possibility that production technology varies across industries, the production function is estimated separately for each of the three 2-digit construction industries and three comparator industries (which are important industries in the New Zealand economy):

- E30 Building construction (NZSIOC EE11)
- E31 Heavy and civil engineering construction (NZSIOC EE12)
- E32 Construction services (NZSIOC EE13)
- A014 Sheep, beef cattle and grain farming (NZSIOC AA12)
- A016 Dairy cattle farming (NZSIOC AA13)
- C24 Machinery and other equipment manufacturing (NZSIOC CC82)

8.1 Baseline

Table 7 contains the estimation results for our baseline specification of the Cobb-Douglas production function. Since the output and input variables are expressed in logs, the coefficients on an input variable represents output elasticity with respect to that input. A constraint imposed by the Cobb-Douglas production function is that output elasticities are constant across the quantities of output and inputs. For example, the coefficient of 0.053 for log capital in column 1 indicates that in the 'Building construction' industry, doubling capital input while holding other factors constant would increase gross output by 5.3 percent. Also for this industry, doubling labour and intermediate inputs respectively while holding other factors constant would increase gross output by 21 and 70 percent respectively. Returns to scale, which is the sum of all output elasticities, are estimated to be 0.97, suggesting that doubling all inputs would increase gross output by 97 percent, i.e. returns to scale are slightly decreasing for this industry. On average, gross output for firms whose production data are derived from the AES is 18.6 percent

(=exp(0.171)–1) higher than those whose production data are derived from IR10.[8] This variable might pick up the size effect not captured by the input variables, as firms that are included in the AES tend to be larger than other firms.

Table 7: Baseline production function estimates

Explanatory variable	Building constr. (1)	Heavy & civil constr. (2)	Constr. services (3)	Sheep & beef farming (4)	Dairy farming (5)	Machine manuf. (6)
lnK	0.053***	0.079***	0.064***	0.136***	0.104***	0.090***
	(0.004)	(0.014)	(0.003)	(0.004)	(0.005)	(0.011)
lnL	0.210***	0.230***	0.225***	0.018***	0.194***	0.252***
	(0.004)	(0.018)	(0.003)	(0.005)	(0.004)	(0.012)
lnM	0.703***	0.678***	0.704***	0.928***	0.712***	0.630***
	(0.003)	(0.019)	(0.003)	(0.005)	(0.007)	(0.010)
Production data from AES	0.181***	0.145***	0.132***			0.159***
	(0.010)	(0.025)	(0.008)			(0.016)
Observations	115,407	10,941	231,255	222,732	120,156	28,932
Adjusted R-squared	0.877	0.930	0.866	0.807	0.810	0.905
Returns to scale	0.966	0.987	0.993	1.082	1.011	0.972
	(0.0028)	(0.0059)	(0.0016)	(0.0041)	(0.0040)	(0.0044)
Test for constant RTS	***	**	***	***	***	***
Relative MFP (unweighted)						
P75:P25 ratio	1.48	1.38	1.44	1.79	1.49	1.47
P90:P10 ratio	2.62	2.16	2.40	4.29	2.74	2.68
Relative MFP (weighted)[a]						
P75:P25 ratio	1.28	1.13	1.28	1.46	1.33	1.20
P90:P10 ratio	1.65	1.34	1.73	2.12	1.79	1.55

Source: Authors' estimation from LBD data 2001–2012

Notes: Estimates are from industry-specific Cobb-Douglas OLS regressions as specified in equation 5. Dependent variable is log gross output. Standard errors (in parentheses) are adjusted to allow for 'clustering' due to multiple observations (in different years) of the same firm. *** p<0.01, ** p<0.05, * p<0.1. An intercept and year dummies are included in each regression but not reported here. Numbers of observations have been randomly rounded to base 3 to protect confidentiality. [a]MFP percentiles are weighted by gross output.

We next consider the distribution of MFP, which is estimated as a residual from industry-specific production function regressions. Even though MFP cannot be compared across industries (as it is zero mean within industry, by construction), within-industry comparison is possible. For the 'Building construction' industry, the firm at the 75th percentile of MFP distribution is 1.5 times as productive as the 25th percentile firm, while the 90th percentile firm is 2.6 times as productive as the 10th percentile firm. This dispersion in MFP is much narrower than in labour productivity noted in Section 7. Since firms differ in size, a given share of firms may not necessarily produce the same share of output. When MFP percentiles are weighted by gross output, the 75th percentile firm is 1.3 times as productive as the 25th percentile firm while the 90th percentile firm 1.7 times as productive as the 10th percentile firm. That productivity is less dispersed when MFP percentiles are weighted indicates that firms with low productivity are disproportionately those whose output is also low.

[8] Production data for all A01 firms are derived from IR10 returns.

Similar patterns for output elasticities and relative MFP are observed for 'Heavy and civil engineering construction' (column 2) and 'Construction services' (column 3). Among the six industries examined in Table 7, the construction and manufacturing industries are relatively more labour intensive (as evidenced by the high labour elasticities), while the agricultural industries are relatively more capital intensive. Returns to scale are slightly increasing for the 'Sheep, beef cattle and grain farming' and 'Dairy cattle farming' while slightly decreasing for 'Machinery and other equipment manufacturing', but on the whole they can be said to be more or less constant.[9] MFP dispersion is widest in 'Sheep, beef cattle and grain farming', where the 90th percentile firm is 2.1 times as productive as the 10th percentile firm.

8.2 Robustness checks

In the first robustness check and also to help characterise high-MFP firms in Section 9, we 'augment' the baseline specification by controlling for firm characteristics, including age, employing status, business group membership, contracting status, entry/exit status, and primary location. Comparing the baseline results in Table 7 with the 'augmented' results in Table 8, it appears that while the added controls are statistically significant, they do not affect output elasticities, suggesting that the effects that the extra controls have on gross output are additional to those already captured by the standard input factors. Nor do the added controls materially affect the model's overall explanatory power and MFP dispersion. For example, for the 'Building construction' industry, the adjusted R-squared is the same at 0.877 between the baseline specification (Table 7, column 1) and the augmented specification (Table 8, column 1). This suggests that despite their statistical significance, the added controls do not have a substantial overall impact. Nevertheless, these extra controls enable us to examine how differences in firm characteristics relate to variation in output.

For the 'Building construction' industry, firms that belong to a business group[10] have 15 percent (=exp(0.141)–1) higher gross output than firms that do not. By contrast, entrants have 1.5 percent more while exiters have 8.6 percent (=exp(–0.09)–1) less gross output than continuing firms. Other characteristics that are correlated with lower gross output include age, having no employees other than working proprietors, contracting out, and locating outside Auckland.

[9] Firms that belong to business group are subsidiaries of a parent company. For example, Fletcher Construction and Fletcher Residential are subsidiaries of Fletcher Building.

[10] Our robustness checks show that dropping the AES dummy increases the estimated returns to scales slightly for the construction industries but lowering them slightly for the manufacturing industry considered. However, when this alternative specification is run on firms whose production data are derived from IR10 returns, the estimated returns to scales for these industries are almost identical to those reported in Table 7. Hence, it is unlikely that the non-agricultural industries have relatively low returns to scale because the AES dummy captures the effect of size in the production function regression.

Table 8: Estimation results for the augmented production function

	Building constr.	Heavy & civil constr.	Constr. services	Sheep & beef farming	Dairy farming	Machine manuf.
	(1)	(2)	(3)	(4)	(5)	(6)
lnK	0.055***	0.099***	0.065***	0.122***	0.132***	0.089***
	(0.004)	(0.014)	(0.003)	(0.004)	(0.005)	(0.011)
lnL	0.198***	0.228***	0.211***	-0.029***	0.136***	0.254***
	(0.004)	(0.016)	(0.003)	(0.005)	(0.004)	(0.012)
lnM	0.696***	0.660***	0.694***	0.880***	0.665***	0.623***
	(0.003)	(0.018)	(0.003)	(0.005)	(0.007)	(0.010)
Production data from AES	0.173***	0.126***	0.138***			0.179***
	(0.010)	(0.025)	(0.009)			(0.017)
Working proprietor only	-0.075***	-0.058**	-0.068***	-0.348***	-0.252***	-0.042**
	(0.006)	(0.024)	(0.004)	(0.007)	(0.006)	(0.017)
Log age	-0.037***	-0.064***	-0.026***	0.074***	-0.076***	-0.035***
	(0.003)	(0.009)	(0.002)	(0.004)	(0.004)	(0.006)
Entrant	0.015**	0.050**	-0.017***	0.079***	0.019**	0.004
	(0.006)	(0.024)	(0.005)	(0.010)	(0.008)	(0.016)
Exiter	-0.090***	-0.170***	-0.124***	0.203***	0.028**	-0.132***
	(0.008)	(0.034)	(0.006)	(0.012)	(0.012)	(0.021)
Belongs to a biz. group	0.141***	0.043	0.070***	-0.068*	-0.004	-0.026
	(0.030)	(0.039)	(0.016)	(0.040)	(0.027)	(0.030)
Contracts out	-0.022***	0.010	0.011***	0.030***	0.015***	0.014*
	(0.004)	(0.011)	(0.003)	(0.005)	(0.004)	(0.009)
Waikato	-0.056***	-0.049*	-0.026***	0.127***	0.209***	-0.046*
	(0.010)	(0.029)	(0.007)	(0.018)	(0.024)	(0.024)
Wellington	-0.017*	0.022	-0.006	0.161***	0.170***	-0.062**
	(0.010)	(0.035)	(0.007)	(0.023)	(0.030)	(0.027)
Rest of North Island	-0.053***	-0.076***	-0.036***	0.171***	0.190***	-0.051***
	(0.008)	(0.026)	(0.006)	(0.017)	(0.024)	(0.019)
Canterbury	-0.041***	-0.069*	0.000	0.088***	0.134***	-0.091***
	(0.010)	(0.036)	(0.006)	(0.018)	(0.028)	(0.022)
Rest of South Island	-0.043***	-0.044	-0.029***	0.206***	0.152***	-0.123***
	(0.009)	(0.028)	(0.007)	(0.017)	(0.025)	(0.025)
Observations	113,973	10,773	229,464	219,180	119,304	28,440
Adjusted R-squared	0.877	0.931	0.867	0.816	0.820	0.902
Returns to scale	0.949	0.987	0.970	0.973	0.933	0.966
	(0.0033)	(0.0073)	(0.0020)	(0.0052)	(0.005)	(0.0065)
Test for constant RTS	***	*	***	***	***	***
Relative MFP (weighted)[a]						
P75:P25 ratio	1.28	1.9	1.28	1.45	1.36	1.23
P90:P10 ratio	1.63	1.34	1.74	2.11	1.88	1.58

Source: Authors' estimation from LBD data 2001–2012
Note: As in Table 7, except that the regressions also control for firm characteristics. The reference location is Auckland.

It is interesting that entrants are more productive than existing firms. As another robustness check, we extend the augmented production function in Table 8 by disaggregating entry (exit) status by time since (until) entry (exit). Table 9 shows that new entrants have a productivity advantage, and this advantage diminishes with time; these effects are illustrated graphically in Figure 3. Specifically, compared to firms that entered at least four years ago, firms that entered in the current year have 10 percent (=exp(0.095)–1) more gross output; after three years, this advantage has declined to about 5 percent, but is still significantly different statistically from ongoing firms (specification 1). Somewhat symmetrically, the closer firms are to exit, the less productive they become; two years before exit they have about 2.8 percent less output than similar ongoing firms, and their average performance deteriorates so that they are about 8.3 percent (=exp(−0.087)−1) below in their last year. Specification 2 further shows that how much more gross output a firm has (equivalently, how much more productive a firm is) depends on how close it is to entry and how far it is from exit. This is consistent with the finding in Table 8 that age is negatively correlated with MFP.

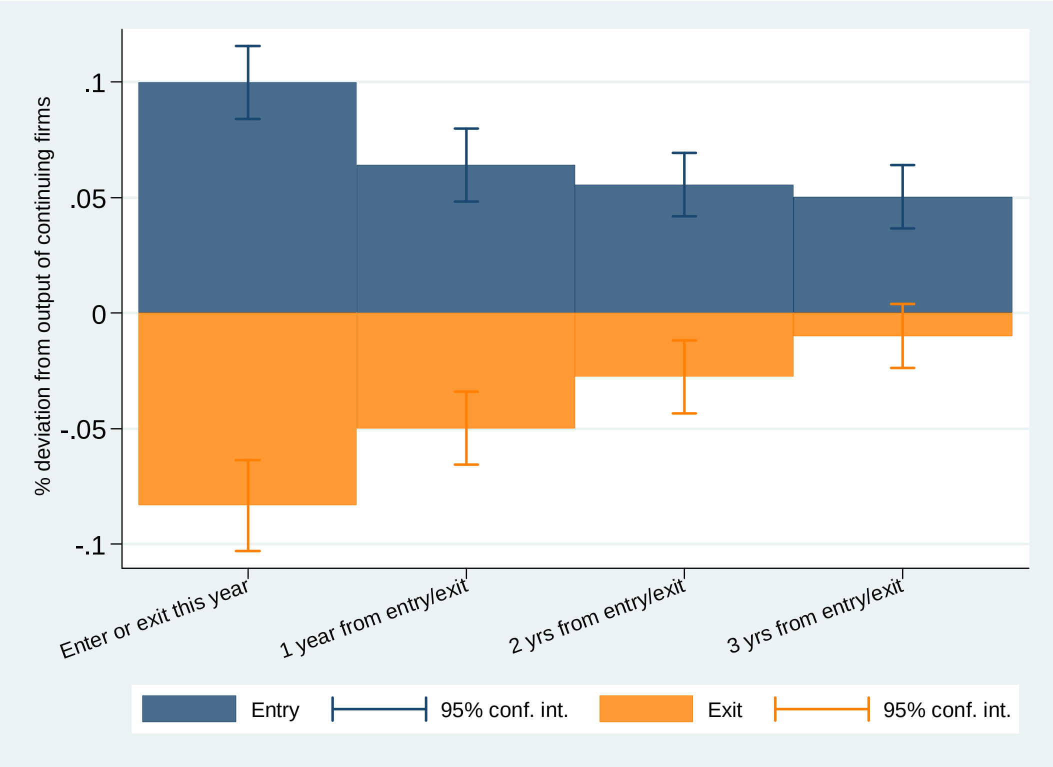
Table 9: Further augmented production function estimates for the 'Building construction' industry

Specification 1		Specification 2	
Explanatory variable	Estimate	Explanatory variable	Estimate
Entered this year[a]	0.095***	Entered 3+ years ago, exit in 1-2 years[c]	-0.049***
	(0.008)		(0.008)
Entered 1 years ago	0.062***	Entered 3+ years ago, exit this year	-0.132***
	(0.008)		(0.013)
Entered 2 years ago	0.054***	Entered 1-2 years ago, exit in 3+ years	0.033***
	(0.007)		(0.007)
Entered 3 years ago	0.049***	Entered 1-2 years ago, exit in 1-2 years	0.014
	(0.007)		(0.011)
Exit this year[b]	-0.087***	Entered 1-2 years ago, exit this year	-0.039**
	(0.010)		(0.017)
Exit in 1 years	-0.051***	Entered this year, exit in 3+ years	0.051***
	(0.008)		(0.009)
Exit in 2 years	-0.028***	Entered this year, exit in 1-2 years	0.036**
	(0.008)		(0.014)
Exit in 3 years	-0.010	Entered this year, exit this year	0.115***
	(0.007)		(0.021)
Observations	78,513	Observations	78,513
Adjusted R-squared	0.875	Adjusted R-squared	0.875
Returns to scale	0.946	Returns to scale	0.943
	(0.0037)		(0.0037)
Test for constant RTS	***	Test for constant RTS	***
Relative MFP (weighted)		Relative MFP (weighted)	
P75:P25 ratio	1.27	P75:P25 ratio	1.26
P90:P10 ratio	1.66	P90:P10 ratio	1.66

Source: Authors' estimation from LBD data
Notes: As in Table 7, except that the sample is 2003–2010 (so that entry/exit status within 3 years can be defined) and that the regressions control for firm characteristics as in Table 8 apart from 'log age', 'entrant' and 'exiter'. [a]Reference category is 'entered at least 4 years ago', [b]Reference category is 'exit at least 4 years later or never exit', [c]Reference category is 'entered at least 3 years ago and exit at least 3 years later or never exit'.

Productivity corresponds loosely to 'doing things well', and we typically think that knowing how to do things well builds with experience, so one might expect older firms to be *more* productive. Thus, the findings that new entrants are the most productive and that age is negatively correlated to productivity are surprising. One might worry that the estimated productivity for entrants could be distorted by one-time data problems associated with their start-up, but the fact that the 'entry effect' declines smoothly over the first few years suggests that this is not the explanation. It seems that, on average, new firms either have new, productive ideas, or their proprietors work extra hard initially. Since we cannot capture the effects of innovation or effort in our explicit input measures, their effect on measured output would, instead, be captured as an increase in average productivity for newer firms.

Figure 3: Effects of entry/exit status on gross output



Notes: Values are computed as exp(β)-1, where β is the respective coefficient estimate in Table 9. Reference category for entry is 'entered at least 4 years ago' and for exit is 'exit at least 4 years later or never exit'.

For further robustness checks, we re-estimate the production function for the 'Building construction' industry under various specifications. All alternative specifications depart from the baseline specification (reprinted in column 1 Table 10). The second specification (column 2) is similar to the baseline specification except that translog terms (interaction terms of one input with another) are added as explanatory variables. The inclusion of the translog terms means that the coefficients on the log terms can no longer be interpreted as output elasticities and that these elasticities vary with quantities of output and inputs. To facilitate comparisons, for this specification we also compute output elasticities evaluated at representative values of the input factors (see Table 11). The third specification (column 3) is estimated by a fixed-effects regression instead of an OLS. In the fourth specification (column 4), the dependent variable is value-added output instead of gross output. The next two specifications (columns 5 and 6) estimate the baseline regression separately for working-proprietor-only firms and employing firms.

Columns 1–3 of Table 10 show that under the same measure of output (gross output), adding translog terms or estimating the regression by a fixed-effects model hardly changes output elasticities and MFP dispersion. The translog specification (column 2) is more flexible in that it allows for output elasticities to vary with quantities of input factors. However, when evaluated respectively at the mean, lower quartile, median and upper quartile values of the input factors (Table 11) these elasticities are not much different from those under the baseline specification.

Indeed, the correlations between the MFP measures obtained from the three gross-output specifications range from 0.97 to 0.99. However, these measures correlate much more weakly with that obtained from the value-added specification (column 4), with correlations ranging between 0.67 and 0.70.[11] The widest MFP dispersion is also seen with this specification, with the 90th percentile being 4.8 times as productive as the 10th percentile firm, compared with the corresponding ratio of 1.7 when the output variable is in gross terms (column 1). This suggests that intermediate inputs interact with capital and labour in shaping MFP, hence MFP is less dispersed when intermediate inputs are controlled for, as in the gross-output specifications.

Table 10: Production function estimates for various specifications for the 'Building construction' industry

	GO CD OLS[a]	GO TL OLS[a]	GO CD FE	VA CD OLS[a]	WP only[a,b]	Employing only[a,b]
	(1)	(2)	(3)	(4)	(5)	(6)
lnK	0.053***	0.130***	0.081***	0.317***	0.052***	0.059***
	(0.004)	(0.037)	(0.004)	(0.005)	(0.005)	(0.004)
lnL	0.210***	1.086***	0.177***	0.682***	0.096***	0.213***
	(0.004)	(0.057)	(0.004)	(0.006)	(0.014)	(0.005)
lnM	0.703***	-0.104***	0.680***		0.702***	0.684***
	(0.003)	(0.033)	(0.004)		(0.005)	(0.005)
Production data fr. AES	0.181***	0.105***	0.084***	0.532***	0.299***	0.166***
	(0.010)	(0.008)	(0.007)	(0.019)	(0.021)	(0.011)
lnK*lnK		-0.001				
		(0.002)				
lnL*lnL		0.043***				
		(0.005)				
lnM*lnM		0.038***				
		(0.002)				
lnK*lnL		0.005				
		(0.005)				
lnK*lnM		-0.007**				
		(0.003)				
lnL*lnM		-0.078***				
		(0.004)				
Observations	115,407	115,407	115,407	110,829	64,479	50,931
Number of firms			26,202			
Adjusted R-squared	0.877	0.884	0.939	0.560	0.697	0.936
Returns to scale	0.966	0.992	0.939	1	0.849	0.956
	(0.0028)	(0.0045)	(0.0046)	(0.0048)	(0.014)	(0.0031)
Test for constant RTS	***	*	***		***	***
Relative MFP (weighted)[c]						
P75:P25 ratio	1.28	1.15	1.39	2.10	1.52	1.32
P90:P10 ratio	1.65	1.34	1.79	4.78	2.39	1.65

Source: Authors' estimation from LBD data 2001–2012

Notes: *** p<0.01, ** p<0.05, * p<0.1. An intercept and year dummies are included in each regression but not reported here. Numbers of observations have been randomly rounded to base 3 to protect confidentiality. [a]Standard errors (in parentheses) are adjusted to allow for 'clustering' due to multiple observations (in different years) of the same firm. [b]GO CD OLS. [c]MFP percentiles are weighted by gross output.

[11] MFP measures from alternative specifications of value-added output are highly correlated with each other (correlations of 0.96–0.99).

Table 11: Output elasticities evaluated at different points for the translog production function

Point of evaluation	Capital elasticity	Labour elasticity	Inter-mediates elasticity	Returns to scale	Test for RTS
Means	0.047***	0.250***	0.694***	0.992	*
	(0.0033)	(0.0056)	(0.0031)	(0.0045)	
25th percentile	0.054***	0.301***	0.644***	0.998***	
	(0.0050)	(0.0079)	(0.0049)	(0.0068)	
50th percentile	0.046***	0.226***	0.715***	0.988***	**
	(0.0035)	(0.0054)	(0.0028)	(0.0052)	
75th percentile	0.041***	0.202***	0.742***	0.986***	***
	(0.0033)	(0.0043)	(0.0030)	(0.0028)	

Source: Authors' estimation from LBD data 2001–2012

Notes: The underlying production function is column 2 in Table 10. At the point of evaluation, the AES dummy takes the value of 0, year is 2001, while each input factor takes the respective value (percentile or mean) in its distribution. For example, at point '25th percentile' capital is the 25th percentile capital value, labour is the 25th percentile labour value and intermediates is the 25th percentile intermediates value.

Returns to scale are the lowest for working-proprietor-only firms; doubling all inputs would increase gross output by only 85 percent for these firms (column 5), even though returns to scale are more or less constant in other specifications. The low returns to scale for working-proprietor-only firms are mainly due to the low output elasticity with respect to labour. Doubling labour input while holding other factors constant would increase gross output by 9.6 percent for working-proprietor-only firms (column 5) but by 21 percent for employing firms (column 6). The low labour elasticity for working-proprietor-only firms might reflect measurement error in labour input. In particular, labour input from working proprietors is a headcount measure that does not take into account the fact that some proprietors contribute very little time while others are fully devoted to the business.[12] Furthermore, capital and intermediate inputs for these firms are likely to contain greater measurement error as it is not always straightforward distinguish business use from home use of these inputs.

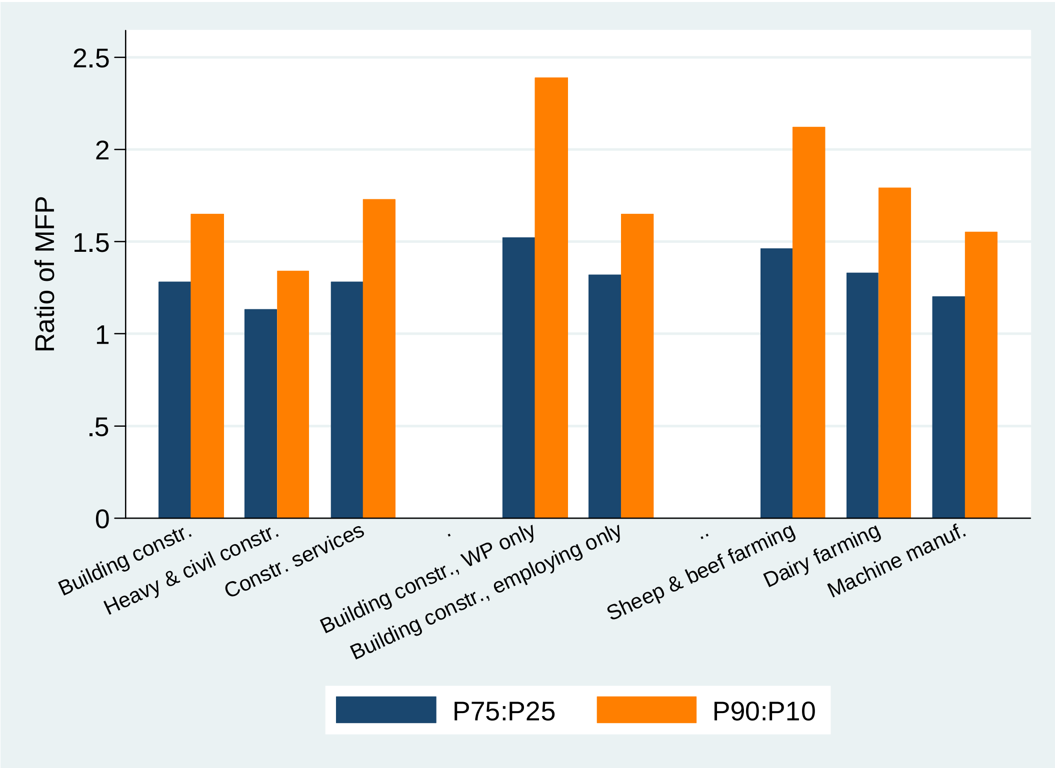
MFP dispersion is much wider among working-proprietor-only firms; the 90th percentile firm is 2.4 times as productive as the 10th percentile firm (column 5, Table 10), while the corresponding ratio is 1.7 for employing firms (column 6). These ratios are almost identical to those calculated based on the baseline specification (2.4 and 1.9 respectively). One contributor to wider MFP dispersion among working-proprietor-only firms is likely to be greater measurement error in inputs noted above, but it also seems likely that these firms are truly quite heterogeneous in nature, with some barely distinguishable from amateurs and some very highly skilled and specialised. Figure 4 shows that working-proprietor-only firms clearly have wider MFP dispersion than both other construction firms and firms in other sectors, but taken as a

[12] Measurement error in labour input is likely a smaller issue for employing firms, as employees' labour input has been full-time equivalised.

whole the construction sub-industries look similar to the comparator agricultural and manufacturing industries.

While output elasticities with respect to labour are very different when we estimate the production function separately by employing status (columns 5 and 6, Table 10), if the focus is on MFP distribution then it seems reasonable to pool working-proprietor-only firms with employing firms. Overall, this section shows that our baseline specification is reasonably robust to a variety of sensitivity analyses.

Figure 4: Dispersion in MFP



Note: Dispersion measure is taken from Table 7 and Table 10.

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9 Characteristics of high-productivity firms

In this section, we explore further what characteristics are associated with high-productivity firms. First, we look at high labour productivity, by regressing labour productivity on firm characteristics. For MFP, we return to the augmented production function results reported in Table 8, as the effect of the 'augmenting' variables added to the basic production function in that table can be interpreted as the effect of those variables on MFP.

Table 12 shows that several firm characteristics are strongly linked to labour productivity. In all industries considered, labour productivity is significantly lower in firms that have no employees other than the working proprietors. Firm's age is negatively correlated with labour productivity in the construction industries and 'Machinery and other equipment manufacturing'.

For 'Heavy and civil engineering construction' and 'Machinery and other equipment manufacturing', there is no relationship between business group membership and labour productivity. However, in the other industries, firms that belong to business group have 17–41 percent higher productivity than firms that do not. Firms that contract out would have lower labour input than other firms, so it is unsurprising that that those firms have higher (19–36 percent) labour productivity in all industries.

Table 12: Regression estimates of the correlates between labour productivity and firm characteristics

	Building constr.	Heavy & civil constr.	Constr. services	Sheep & beef farming	Dairy farming	Machine manuf.
	(1)	(2)	(3)	(4)	(5)	(6)
Production data from AES	0.432***	0.243***	0.287***			0.274***
	(0.022)	(0.040)	(0.018)			(0.024)
Working proprietor only	-0.102***	-0.037	-0.023***	-1.134***	-0.301***	-0.110***
	(0.009)	(0.040)	(0.007)	(0.012)	(0.012)	(0.025)
Log age	-0.023***	-0.045***	-0.023***	-0.005	0.028***	-0.061***
	(0.004)	(0.015)	(0.003)	(0.008)	(0.006)	(0.009)
Entrant	0.028***	0.051	-0.044***	0.273***	0.054***	0.016
	(0.011)	(0.043)	(0.008)	(0.023)	(0.017)	(0.026)
Exiter	-0.055***	-0.224***	-0.175***	0.024	-0.176***	-0.097***
	(0.013)	(0.050)	(0.010)	(0.021)	(0.019)	(0.032)
Belongs to a biz. group	0.345***	-0.072	0.154***	0.166*	0.297***	-0.005
	(0.063)	(0.048)	(0.036)	(0.086)	(0.061)	(0.035)
Contracts out	0.251***	0.209***	0.226***	0.309***	0.229***	0.176***
	(0.008)	(0.027)	(0.006)	(0.011)	(0.011)	(0.017)
Waikato	-0.172***	-0.008	-0.068***	0.346***	0.463***	-0.073*
	(0.017)	(0.055)	(0.013)	(0.036)	(0.037)	(0.038)
Wellington	-0.106***	-0.037	-0.040***	0.450***	0.391***	-0.097**
	(0.017)	(0.057)	(0.012)	(0.045)	(0.053)	(0.045)
Rest of North Island	-0.193***	-0.066	-0.091***	0.394***	0.393***	-0.118***
	(0.014)	(0.044)	(0.010)	(0.032)	(0.037)	(0.028)
Canterbury	-0.098***	0.006	-0.034***	0.421***	0.417***	-0.135***
	(0.017)	(0.052)	(0.012)	(0.034)	(0.044)	(0.032)
Rest of South Island	-0.159***	0.044	-0.045***	0.502***	0.417***	-0.183***
	(0.016)	(0.051)	(0.012)	(0.033)	(0.039)	(0.038)
Observations	109,458	10,341	219,789	161,502	106,179	27,396
Adjusted R-squared	0.0441	0.0362	0.0274	0.181	0.0955	0.0333

Source: Authors' estimation from LBD data 2001–2012

Notes: Estimates are from industry-specific OLS regressions. Dependent variable is log of value added per worker. Standard errors (in parentheses) are adjusted to allow for 'clustering' due to multiple observations (in different years) of the same firm. *** p<0.01, ** p<0.05, * p<0.1. An intercept and year dummies are included in each regression but not reported here. Numbers of observations have been randomly rounded to base 3 to protect confidentiality. The reference location is Auckland.

There is concern that the frequent churn of firms into and out of existence is a drag on the construction industry's productivity, as newly created firms need time operate smoothly and effectively. Contrary to this concern, Table 12 shows that entrants tend to be more productive than continuing firms (except in 'Construction services') while exiters tend to be less productive (except in 'Sheep, beef cattle and grain farming'). Locating outside Auckland is negatively correlated with labour productivity for the construction and manufacturing industries but the relationship is positive for the two agricultural industries considered.

Table 8 shows that age, entry status, Auckland location and employing status also have similar associations with MFP as with labour productivity. However, business group membership and contracting status are less strongly linked to MFP than to labour productivity. Interestingly, exiters have lower MFP in the construction and manufacturing industries, while the opposite is true in the two agricultural industries considered.[13] In summary, construction firms with high labour productivity and MFP are younger, more likely to be a new start-up, to employ, to belong to a business group, and to locate in Auckland, while less likely to exit from economic activity.

10 Decomposition of productivity growth

Having estimated MFP in Section 8, Section 10.1 calculates growth in MFP and other production measures. Section 10.2 then decomposes growth in MFP into contributions from different groups of firms to shed light into what drives MFP growth over time.

10.1 Growth in production measures

As reported in Appendix Table 4, there is considerable variation across industries, years and measures in annual changes in input, output and productivity measures during 2001–2012. Over the 11-year period, aggregate capital input grew by 37 percent, labour input by 13 percent and intermediate inputs by 5.7 percent in the measured sector (i.e. ‘all industries’). Output measures also expanded (12 percent for gross output and 19 percent for value added). Productivity increased much more slowly than input and output measures, at 5.5 percent (0.5 percent per year) for labour productivity[14] and 1.2 percent (0.1 percent per year) for MFP.

Despite a general upward trend, slow-down was not uncommon in the last decade. The sharpest contraction was in 2008–2009, at the peak of the Global Financial Crisis, when gross output declined by 5.8 percent, value added by 3.6 percent and labour productivity by 3.8 percent. MFP changed very little from year to year, except during 2004–2005 when it increased by 2.1 percent and in 2008–2009 when it decreased by 2.7 percent.

The construction industry experienced higher growth than the overall measured sector in all input, output and productivity measures over the period 2001–2012. Within the construction

[13] We also repeat this analysis for firms that appeared in the Business Operation Survey (BOS), a large-scale business sample survey that has been conducted annually by Statistics New Zealand since 2005, targeting businesses that have at least six employees and have been active for at least one year. Our BOS regression sample has just under 500 observations of firms in the ‘Building construction’ industry over 2005–2012. Even though with the BOS data we can control for many more factors (R&D activity, innovative activity, foreign ownership, outward investment status, exporter status, competitive environment, etc.), again, the added controls hardly alter the baseline results.

[14] Average labour productivity in this section is calculated as total industry value added divided by total industry labour input, while in Section 7 it is calculated at the firm level.

industry, 'Heavy and civil engineering construction' experienced the strongest growth in output (97 percent in gross output and 90 percent in value added), yet labour productivity grew by merely 1.5 percent and MFP by 2.3 percent. Both 'Building construction' and 'Construction services' experienced moderate growth in gross output (33–37 percent). Since value added grew much more strongly (72–88 percent) than labour (41–45 percent), labour productivity growth was high for these two industries (22–30 percent). However, while MFP in 'Construction services' grew by 12 percent, the corresponding growth rate is 1.9 percent for 'Building construction'.

These growth rates are quite different from those seen in overall industry data. Statistics New Zealand (2014) shows that over 2001–2012, labour productivity and MFP for the construction industry grew by 1.2 and 1.1 percent per year respectively (Table 13), while the measured sector experienced slightly higher growth in labour productivity (1.3 percent per year) yet weaker growth in MFP (0.4 percent per year). Over the same period, this study finds that labour productivity in the construction industry grew by 1.7 percent per year and MFP 0.5 percent per year, while the overall measured sector saw much weaker growth in both labour productivity (0.5 percent per year) and MFP (0.1 percent per year). The discrepancies are even greater for the period 2018–2012. Appendix Figure 1 shows that while our productivity growth rates have similar trends to those from macro data, the pairs never match.

Table 13: Productivity growth rates: comparison with official statistics

	Labour productivity		MFP	
	This study	Official statistics	This study	Official statistics
2001–2012				
Construction	1.7	1.2	0.5	1.1
Measured sector	0.5	1.3	0.1	0.4
Former measured sector		1.4		0.3
2008–2012				
Construction	2.8	-0.1	0.6	-0.1
Measured sector	0.0	1.3	-0.3	0.0
Former measured sector		1.4		-0.1

Notes: Entries are average annual growth rates, in percentages. Official statistics are from Statistics New Zealand (2014). The former measured sector includes fewer industries than the measured sector, as data for those industries were not available before 1996. In 2012 the measured sector covered 77.3% of New Zealand's GDP while the former sector covered 58.1%.[15]

The discrepancies between our findings and macro data could be due to several reasons. First, the current study only includes firms with production data, which represents only around 60 percent of the industry's total annual gross output (Fabling and Maré, 2015, Table 8a). Second, Statistics New Zealand uses the index number approach and also makes aggregate adjustments to improve coverage and accuracy of official data, whereas this study uses the

[15] See http://www.stats.govt.nz/browse_for_stats/economic_indicators/productivity/ProductivityStatistics_HOTP78-14/Data%20Quality.aspx#industry

econometric approach to estimate MFP. Furthermore, this study ignores productivity change due to between-industry reallocation. The contradiction between macro and micro productivity statistics has been documented in the international literature, as noted in Section 3. This study does not attempt to reconcile differences in macro and micro evidence. Our focus is on looking underneath the overall industry numbers to understand how productivity varies across firms, and how changes at the firm level, differing growth rates of firms, and entry and exit are influencing the overall industry productivity.

10.2 Decomposition of growth in MFP

Section 10.1 has shown that MFP grew very slowly over the 2001–2012 period, for both the construction industry and the overall measured sector. Aggregate productivity change is often the net balance of considerable productivity movements at the firm level. To understand what drives productivity changes, it would be useful to separate the change in average productivity into additive components. In this section we use a decomposition method developed by Griliches and Regev (1995) to decompose within-industry MFP change into contributions from firm entry and exit, and from changes in the size and performance of continuing firms. In a recent study, Maré et al. (2015) use this method to analyse productivity growth and firm dynamics in New Zealand.[16]

Following Maré et al. (2015), we classify firms into groups based on their entry/exit status. With respect to past data, a continuer is a firm that had production and employment data in the previous year, an entrant had no such data, while a sample joiner had employment data but no production data in the previous year. (Note that all firms in our working production sample have production and employment data in the current year.) With respect to future data, a continuer is a firm that will have production and employment data in the next year, an exiter will have no such data, while a sample leaver will have employment data but no production data in the next year. Thus, joiners and leavers are effectively continuers with incomplete past or future data. A firm from a certain category with respect to past data can be in any category with respect to future data. For example, a firm that enters and exits in the same year is an entrant with respect to past data and an exiter within respect to future data.

As Appendix Table 5 shows, the majority of construction firms are continuers, accounting for 73–80 percent of firm counts and even a larger share of gross output (77–91 percent). Each of

[16] Our decomposition analysis differs from that by Maré et al. (2015) in that we include both working-proprietor-only and employing firms and that we focus on (within-industry productivity change in) the construction industry. Maré et al. draw on all employing firms with production data to examine within-industry and between-industry productivity changes and the link between firm productivity growth and skills in the overall measured sector. Despite using different samples, our results are very similar to those obtained by Maré et al. For example, Maré et al.'s (Table 4, top panel) find that on average MFP for employing firms grew by 0.14 percent annually during 2001–2012, compared with the annual average rate of 0.11 percent found in this study (Appendix Table 4) for all firms with labour input.

the two entry groups (entrants and joiners) accounts for 10–15 percent of firms at the end of the year. Exiters (leavers) account for 9–12 percent (12–16 percent) of the firms present at the end of the previous year. The four entry and exit groups all account for much smaller shares of gross output than their respective share in firm counts, suggesting that these firms are relatively less economically significant. This is confirmed by Appendix Table 6 which shows that entrants and exiters are less likely to employ than joiners, leavers and continuers. Entrants and exiters also have much lower capital, labour and intermediate inputs, gross output and value added than joiners and leavers, who in turn compare less favourably to continuers. Overall, there is more turnover (i.e. higher fractions of entrants and exiters) in the construction industry than in the measured sector, consistent with the common belief.

The decomposition results are reported in Table 14. For the overall measured sector, entrants make a positive contribution to MFP growth in all years, suggesting that entrants are on average more productive that existing firms, consistent with the finding in Table 8. A negative contribution is attributed to exiters, suggesting that exiters are on average more productive than staying firms too.[17] However, entrants are more productive than exiting firms, thus the net contribution of firm turnover is positive. Both sample joiners and leavers (continuers with incomplete production data) tend to be less productive than the average firm, so the addition of joiners makes a negative contribution to total productivity growth, while the loss of leavers makes a positive contribution. Even though productivity growth within continuers is negative, it is offset by the contribution from firm reallocation (i.e. reallocating resources from low-productivity firms to high-productivity firms). The largest annual change in productivity within continuers was a decline by 2.4 percent during 2008–2009, while the largest positive contribution (0.5 percent) from reallocation followed in the next year. As summarised in Table 15, of the MFP growth of 1.2 percent over the 2001–2012 period (0.1 percent per year), under 0.1 percent is due to net entry, 1.3 percent to joiners and leavers, and under –0.1 percent to continuers. These patterns are similar to those observed in Maré et al. (2015).

The patterns for the construction industry are also similar, except that MFP in this industry grew more strongly and that the contribution from firm reallocation dominates the contraction within continuers, so the net contribution from continuers is positive. Of the 5.6 percent MFP growth experienced by the construction industry over 2001–2012 (0.5 percent per year), net entry makes the largest contribution, accounting for 2.2 percent, whereas 1.6 percent is due to joiners and leavers, and 1.7 percent to continuers (see Table 15).

[17] The finding that exiters are more productive than existing firms in Table 14 is not necessarily inconsistent with the finding in Table 8. This is because the comparison in Table 14 is unconditional, while in Table 8 it is conditioned on holding other factors constant.

Table 14: Decomposition of within-industry growth in MFP

	Total change	Change for continuers	Re-allocation	Entrants	Joiners	Exiters	Leavers
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Building construction							
2001–2002	-0.89	-0.86	-0.81	0.31	-0.05	-0.01	0.54
2002–2003	2.37	1.24	0.45	0.62	-0.02	0.00	0.06
2003–2004	-1.45	-1.66	0.60	0.18	-0.14	-0.18	-0.24
2004–2005	-0.19	-1.20	0.00	0.32	0.52	-0.15	0.33
2005–2006	-1.21	-1.30	-0.09	0.16	-0.30	-0.04	0.35
2006–2007	-0.55	-0.71	0.20	0.35	-0.66	-0.02	0.30
2007–2008	-1.08	-1.19	-0.06	0.05	-0.01	-0.10	0.23
2008–2009	-0.74	-0.66	0.21	0.05	-0.45	-0.22	0.34
2009–2010	4.29	3.39	0.28	0.12	-0.33	0.16	0.64
2010–2011	3.03	1.99	0.48	-0.01	-0.32	0.01	0.88
2011–2012	-1.51	-2.16	0.08	0.13	-0.14	-0.03	0.62
Cumulative 2001–12	1.89	-3.23	1.34	2.30	-1.88	-0.57	4.10
Heavy and civil engineering construction							
2001–2002	-0.56	-2.27	0.04	0.13	0.09	0.05	1.44
2002–2003	1.11	0.11	0.41	0.13	0.41	0.22	-0.17
2003–2004	-2.44	-2.85	-0.10	0.14	-0.10	-0.03	0.52
2004–2005	3.74	1.06	0.59	1.27	1.31	-0.28	-0.25
2005–2006	0.59	1.49	-0.21	0.23	-0.14	-0.78	0.01
2006–2007	4.91	3.70	0.50	0.01	1.50	-0.03	-0.80
2007–2008	-1.73	-3.68	-0.01	1.96	0.03	-0.13	0.17
2008–2009	-1.42	-2.14	1.03	0.15	-0.16	0.01	-0.29
2009–2010	-3.41	-2.01	-0.39	0.02	0.13	0.06	-1.24
2010–2011	1.47	1.33	0.19	0.06	-0.19	0.01	0.07
2011–2012	0.36	1.18	0.07	0.04	0.02	0.00	-0.94
Cumulative 2001–12	2.33	-4.26	2.13	4.16	2.94	-0.91	-1.51
Construction services							
2001–2002	2.23	2.04	0.11	0.40	-0.58	-0.06	0.32
2002–2003	1.44	0.38	0.69	0.47	0.06	-0.03	-0.13
2003–2004	-0.48	-1.06	0.42	0.54	-0.23	-0.17	0.04
2004–2005	0.70	-0.16	0.61	0.15	0.05	-0.19	0.23
2005–2006	-1.12	-1.30	-0.08	0.21	0.00	-0.21	0.25
2006–2007	5.15	3.57	0.16	0.35	0.65	-0.12	0.48
2007–2008	-0.65	-0.80	0.21	0.16	0.05	0.01	-0.28
2008–2009	-1.04	-1.56	0.22	0.18	0.11	-0.18	0.19
2009–2010	1.73	0.58	0.45	0.17	-0.02	0.05	0.49
2010–2011	2.36	1.92	0.39	0.14	-0.21	-0.21	0.33
2011–2012	0.96	-0.15	0.63	0.09	-0.05	0.17	0.25
Cumulative 2001–12	11.68	3.39	3.89	2.88	-0.17	-0.94	2.19

	Total change	Change for continuers	Re-allocation	Entrants	Joiners	Exiters	Leavers
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
All construction							
2001–2002	0.36	-0.01	-0.27	0.29	-0.36	-0.01	0.72
2002–2003	1.71	0.61	0.57	0.44	0.09	0.04	-0.05
2003–2004	-1.24	-1.71	0.37	0.33	-0.17	-0.15	0.09
2004–2005	1.13	-0.23	0.36	0.50	0.54	-0.19	0.14
2005–2006	-0.69	-0.57	-0.10	0.19	-0.17	-0.30	0.26
2006–2007	2.91	2.00	0.27	0.23	0.35	-0.04	0.08
2007–2008	-1.07	-1.70	0.10	0.58	0.00	-0.05	0.00
2008–2009	-1.03	-1.38	0.47	0.11	-0.19	-0.13	0.11
2009–2010	1.32	0.93	0.18	0.11	-0.08	0.10	0.08
2010–2011	2.22	1.78	0.30	0.08	-0.26	-0.09	0.41
2011–2012	-0.09	-0.48	0.26	0.12	0.00	0.03	-0.01
Cumulative 2001–12	5.57	-0.84	2.56	3.02	-0.25	-0.79	1.82
All industries							
2001–2002	0.76	-0.05	0.04	0.05	-0.27	0.04	0.95
2002–2003	0.35	0.84	0.04	0.15	-0.12	-1.14	0.59
2003–2004	-0.79	-0.68	-0.01	0.19	-0.13	-0.26	0.10
2004–2005	2.09	0.82	0.31	0.68	0.09	-0.09	0.27
2005–2006	-0.11	-0.16	0.30	0.05	-0.06	-0.12	-0.13
2006–2007	-0.58	-0.81	-0.16	0.28	-0.07	-0.04	0.21
2007–2008	0.65	0.51	-0.18	0.25	0.00	-0.10	0.17
2008–2009	-2.66	-2.44	0.19	0.06	-0.38	-0.15	0.06
2009–2010	1.09	0.43	0.45	0.05	-0.14	-0.03	0.31
2010–2011	0.68	0.74	-0.16	0.10	-0.14	-0.10	0.24
2011–2012	-0.16	-0.29	0.24	0.20	-0.39	-0.06	0.13
Cumulative 2001–12	1.24	-1.12	1.07	2.07	-1.58	-2.03	2.93

Source: Authors' estimation from LBD data 2001–2012
Notes: Column 1 of this table does not perfectly match the last column of Appendix Table 4 due to rounding errors. Columns 2–7 sum exactly to column 1 when expressed in logs. The entries in this table have been converted to percentages, so the summation no longer holds, especially for higher values.

Table 15: Contributions to MFP growth over 2001–2012 by transition status

	Construction		All industries	
	Transition status defined based on		Transition status defined based on	
	1-year window	11-year window	1-year window	11-year window
Total growth over period	5.57	5.57	1.24	1.24
Continuers	1.72	1.99	-0.05	-0.89
Change for continuers	-0.84	1.83	-1.12	-0.27
Re-allocation	2.56	0.16	1.07	-0.62
Net entry	2.23	3.13	0.04	2.16
Entrants	3.02	1.33	2.07	1.45
Exiters	-0.79	1.79	-2.03	0.71
Joiners and leavers	1.57	0.34	1.35	-0.02
Joiners	-0.25	-0.04	-1.58	-0.38
Leavers	1.82	0.38	2.93	0.36

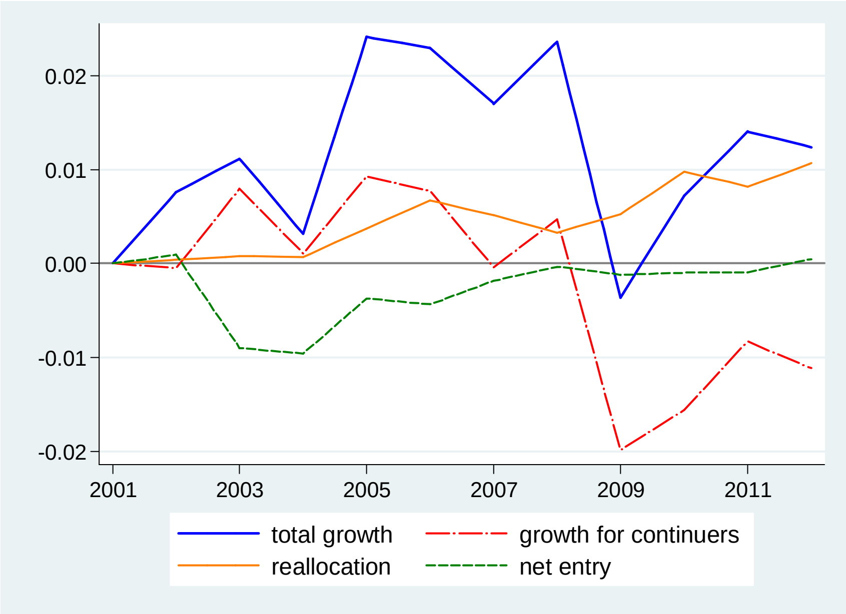
Source: Authors' estimation from LBD data 2001–2012
Note: Entries are percentages.

Within the construction industry, 'Construction services' is the only one whose continuing firms experienced positive cumulative growth (3.4 percent) over the period. Coupled with strong growth due to firm reallocation (3.9 percent), MFP for this sub-industry grew by 12 percent over 2001–2012. For 'Building construction' and 'Heavy and civil engineering construction', net entry makes a positive contribution, but the MFP contraction experienced by continuers is so large, the total within-industry MFP growth is weak in these industries (1.9 percent and 2.3 percent respectively). Overall, the largest positive contributors to MFP growth in the construction industry were growth within continuers and firm reallocation in 'Construction services' and turnover in 'Heavy and civil engineering construction', while the major drags were productivity slow-down by continuers in 'Building construction' and 'Heavy and civil engineering construction'.

Entrants make such as large contribution to total within-industry MFP growth because they are more productive than existing firms, as shown in Table 8 and Table 9. In another robustness check, we decompose MFP growth where transition status is defined over an 11-year window, such that a firm is defined as an entrant if it entered any time in the 2001–2012 period, and likewise for the other statuses. With this definition, entrants make up about two thirds of the sample while continuers' share reduces to just over a quarter. The results summarised in Table 15 show that for the construction industry, of the 5.6 percent MFP growth experienced over 2001–2012, net entry accounts for 3.1 percent, whereas 0.3 percent is due to joiners and leavers, and 2 percent to continuers. In other words, the relative contribution of firm turnover to MFP growth is even greater when the transition window is widened.

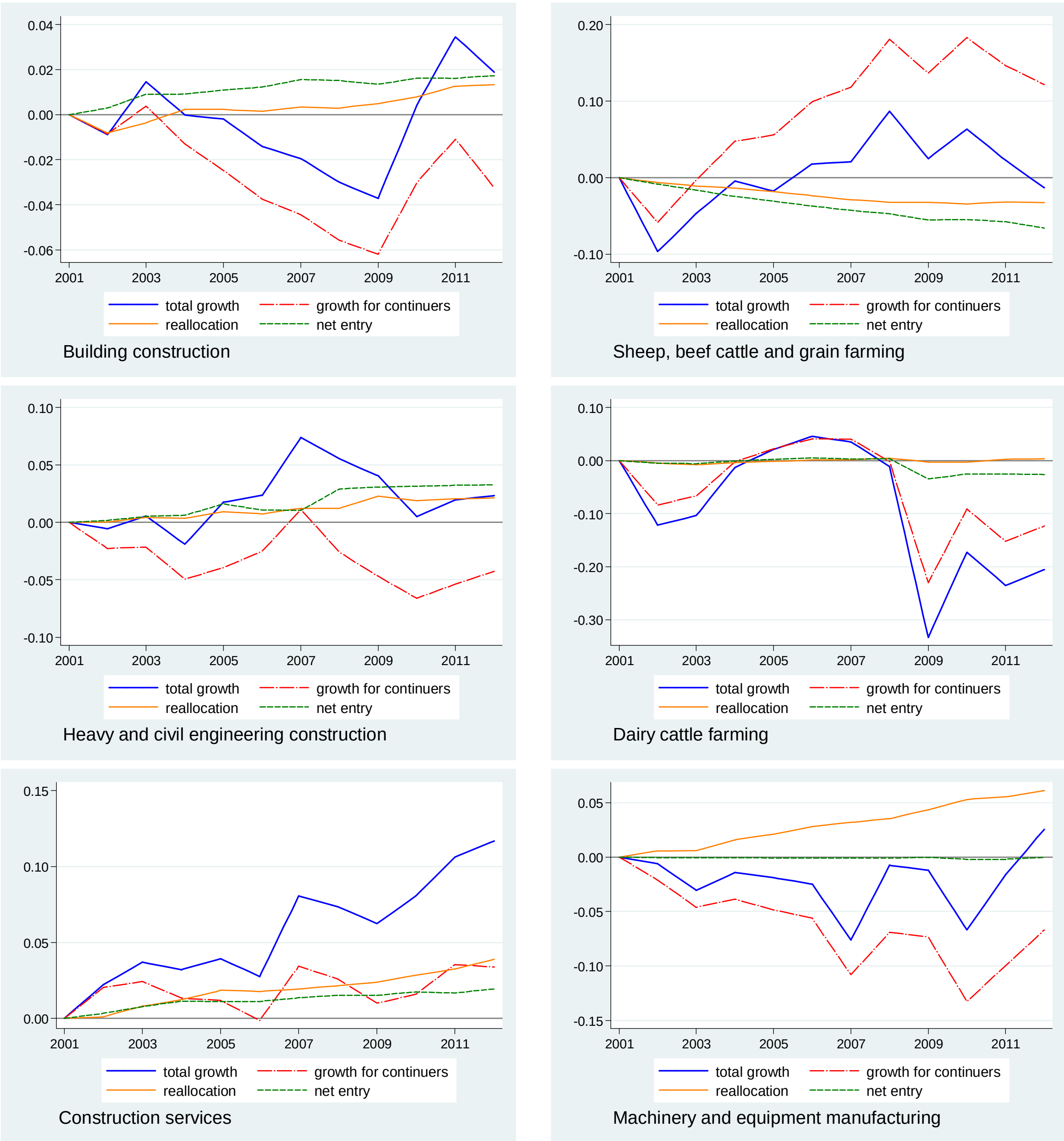
Figure 5 and Figure 6 show that productivity movements vary greatly both within the construction industry and in comparison with selected agricultural and manufacturing industries. However, in all cases total within-industry productivity growth tracks closely the growth path of continuers, which is to be expected, given that this group accounts for three quarters of the sample. In all industries, there was a significant drop in MFP in 2008–2009, but overall MFP changes vary markedly across industries.

Figure 5: Cumulative growth in MFP for all industries



Source: Authors' estimation from LBD data 2001–2012
Note: 'Net entry' is the combined effect of entrants and exiters.

Figure 6: Cumulative growth in MFP for selected industries



Source: Authors' estimation from LBD data 2001–2012
Note: See Figure 5.

11 Conclusions

Concern about low productivity in the construction industry has been widespread in New Zealand and also in other countries. This study uses firm-level data from the LBD to dissect the underlying productivity patterns in the New Zealand construction industry.

Productivity growth rates vary markedly by sub-industry and other firm characteristics. High-productivity firms tend to be younger, more likely to be a new entrants to the industry (except in 'Construction services'), and to belong to a business group (except in 'Heavy and civil engineering construction). Measured productivity is also higher across the industry among firms located in the Auckland region.

We find that, as in other industries, there is a considerable gap within the industry between the productivity of the best and worst performing firms. We find no evidence, however, that the 'problem' of a significant tail of low-performing firms is worse in construction than in other industries in New Zealand. Indeed, although comparisons of this sort across very different industries are somewhat hard to interpret, the lower quartile of construction firms have labour productivity that is slightly *higher* than the lower quartiles in the primary and manufacturing sectors. In contrast, the productivity of the upper quartile of construction firms is much lower than that of the upper quartile in other sectors. This means that the lower overall average labour productivity in construction is associated with a relative absence of star performers, rather than with an over-abundance of productivity underperformers.

More than two-thirds of construction firms have no workers other than the working proprietors. These working-proprietor-only firms are slightly less productive than employing firms, and they have higher productivity dispersion—they are over-represented among both the most productive firms and those with the lowest productivity.

We decompose the growth in productivity at the firm level over time into a portion due to changing productivity at continuing firms, a portion due to reallocation of output from low-productivity to high-productivity firms, and a portion due to the entry and exit of firms. The patterns of productivity change vary by sub-industry within construction. The healthiest overall growth was in the 'Construction services' sub-industry, with the largest sources of this growth being ongoing improvement from continuing firms and reallocation from low-productivity to high-productivity firms. In 'Heavy and civil engineering construction', entry of above-average productivity firms and exit of below-average productivity firms were major contributors to improvement. For construction as a whole, the major drags on overall productivity were productivity slow-down by continuing firms in 'Building construction' and in 'Heavy and civil engineering construction'.

Contrary to common beliefs that frequent firm turnover is a drag on productivity in this industry, this study shows that entry and exit is actually an important driver of MFP growth over

2001–2012, as new firms are on average more productive than continuing firms, who are in turn more productive than exiting firms. As in Maré et al. (2015), we also find reallocation from low-productivity to high-productivity firms to be an important contributor to MFP growth.

The study raises a number of important new questions that we hope to address in future research. We find that entrants have above average productivity, and that continuing firms show a systematic decline in productivity over time. Some—perhaps many—of the entrants are created by employees leaving existing firms. Understanding the dynamic process by which employees interact with firms, move between firms, and start new firms would seem to be key to the productivity challenge. Statistics New Zealand's Linked Employer-Employee Database offers the possibility to trace these pathways and understand their interaction with productivity.

Another intriguing set of issues relates to the fact that the average continuing firm sees declining productivity, but at the same time overall industry productivity is boosted as higher productivity firms grow faster than lower productivity firms. This dynamic involves competitive interactions among firms, along both regional and product-market dimensions. Another aspect of this dynamic is the effect of the costs of complying with environmental and worker safety requirements and building standards. Do the different rates of productivity growth for entrants and continuing firms possibly reflect different levels of compliance with these mandates?

Finally, we come back to the reality that our analysis covers only those firms for which we have adequate data. Comparison of the output of these firms with the industry aggregates constructed by Statistics New Zealand suggests that about 40 percent of industry gross output comes from firms we are not including. By definition, it is difficult to know what is going on at the firms for which we do not have data. But it would be worthwhile to bring together Statistics New Zealand's modelling of the industry aggregates with these analyses of individual firms, to see if more can be understood about the relationship between micro performance and aggregate statistics.

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Appendix

Appendix Table 1: Summaries of international research on productivity in the construction industry

Source	**Country, data source, time frame**	**Method/Design**	**Findings**
Thomas et al. (1986), "Learning curve models of construction productivity"	United States and European countries Three data sources: 1965 European housing construction data; 1980 US study of specific bridge; and US data collected on a six-story apartment building. In total there are data from 65 construction activities.	The study investigates learning models of construction productivity: the idea that production rates will increase with experience and practice, so that cumulative production can predict cumulative man-hours per unit. Data are used to test whether the common straight-line model is adequate (in log-log form, so the learning rate remains constant throughout time spent).	Using R-squared to judge the different models, the study suggests that a cubic model of learning is the best, where the returns to experience level drop off as hours increase. The way in which people learn is non-linear, and a simple linear learning model may not capture the ways that experience affects labour productivity. This study is very task-specific; there could be other factors that affect labour productivity as hours on a project increase (for example more machinery could be brought in).
Thomas et al. (1990), "Modeling construction labor productivity"	n/a (theoretical paper)	The study argues for a new paradigm in modelling crew-level construction labour productivity. In the past, investigations into construction productivity have used the delay, activity and task models, but these authors argue for factor models and expectancy models as attractive alternatives. These can be estimated with regression techniques.	The study argues that delay, activity and task models of labour productivity are unsuitable for most construction projects, most fundamentally because they emphasise the time taken to perform tasks but struggle to model other factors. This is especially limiting in a labour-intensive area like construction. The factor model has the following core features: it focuses on the crew as the basic work unit rather than individuals; improvements resulting from repetition can be modelled; and the model should include the major factors affecting productivity for a given project. R-squared is used to judge and guide the models. The expectancy model seeks to explain why a team exerts effort, and can similarly be estimated using regression.

Source	Country, data source, time frame	Method/Design	Findings
Herbsman and Ellis (1990), "Research of factors influencing construction productivity"	United States Case study of a residential building firm	The study develops a statistical model to estimate the productivity of specific items (e.g. man hours per square metre for tiles). The model parameters are then estimated using a residential building company.	The preferred regression model includes four explanatory variables, only two of which (the number of identical elements and supervisory quality) are found to have statistically significant effects on item productivity.
Halligan et al. (1994), "Action-response model and loss of productivity in construction"	United States No data used	The study develops a (non-mathematical) model of how construction firms can respond to adverse shocks such as poor weather and material shortages. It aims to explore why labour productivity does not necessarily drop after these negative shocks (as suggested by other literature).	The study suggests that good management skills can help maintain labour productivity, in response to negative shocks. Three case studies are used to emphasise this point.
Proverbs et al. (1999), "Productivity rates and construction methods for high rise concrete construction: a comparative evaluation of United Kingdom, German and French contractors"	United Kingdom, Germany and France Surveys of contractors (31 from the United Kingdom, 13 from France and 10 from Germany)	The study examines differences in reported productivity across countries for one specific activity so that comparisons can be made; the productivity of formwork to beams (measured as man-hours per square metre). Surveys were sent to top contractors, with response rates of 21% in the United Kingdom, 17% in France and 18% in Germany.	The mean productivity rate in the United Kingdom is lowest, at 2.08 hours per square metre (compared with 1.24 for France and 1.32 for Germany). United Kingdom contractors use traditional timber formwork methods, and the study suggests that productivity would increase significantly if these contractors switched to proprietary (as in Germany) or prefabricated (as in France) forms. Note that the surveys are not representative, and may lead to especially productive French and German contractors selecting in (as they are engaging in a foreign study).
Smith (1999), "Earthmoving productivity estimation using linear regression techniques"	United Kingdom Data from four highway construction projects	141 separate earthmoving activities, averaging 62 minutes each, were observed and data collected. Activity-productivity for a single loader (measured as hauler cycle rate * load volume) is regressed on various activity-level explanatory variables.	Significant explanatory factors include: number of trucks; buckets per load and volume; and truck travel time and haul length. Note that some of these explanatory variables are components that make up the outcome variable (productivity), which is why the model has high R-squared (0.91). The study acknowledges that it has only considered the productivity of one specific loader, and that it may overestimate productivity for particularly over- or under-resourced projects.

Source	Country, data source, time frame	Method/Design	Findings
Allmon et al. (2000), "U.S. construction labor productivity trends, 1980 – 1998"	United States Mean's Building construction cost data (used by contractors for cost estimation) 1960–1997	The study examines productivity trends across different sub-industries within Construction. However, its main measure of productivity is simply marketable output, with no relation to inputs such as labour or capital.	The study finds that productivity has either stayed constant or increased for all construction tasks studied. That is, output has either remained constant or increased, and all tasks had decreasing real labour costs.
El-Rayes et al. (2001), "Impact of rainfall on the productivity of highway construction"	Canada Hourly records of rain and other weather measures in Toronto and Montreal 1965–1999 (for Toronto)	Highway practitioners were interviewed for estimates of how rainfall hurts productivity (measured as working days lost). These assumed effects depend on the amount of rainfall, the timing of the rain, drying conditions, and the stage of the project (e.g. earthmoving vs. making drainage layers). A three-stage procedure was then used to develop a program ('WEATHER') that can use these assumptions to estimate increases in activity duration due to the rainfall.	Using data for 40 different earth-moving activities throughout 1995 and 1996, the study finds that WEATHER estimates agree with an industry rule of thumb which says a construction activity that requires 5 days needs an additional day in the presence of rain (i.e., activity duration is extended by 20%). But note that these estimates come from industry rule-of-thumbs (practitioner's beliefs on the effect of rain), so agreement with a more general rule-of-thumb is not necessarily validation. Nonetheless, it is clear that rainfall does negatively affect highway projects through delays and lost working hours.
Sharpe (2001), "Productivity trends in the construction sector in Canada: A case of lagging technical progress"	Canada Aggregate productivity measures from Statistics Canada 1961–2000	The study explores trends in explanatory variables to explain the poor productivity growth in the construction industry relative to the business sector.	Because of the labour-intensive nature of construction, it seems to struggle with productivity increases (despite an increased capital-labour ratio and a more educated workforce). Measurement issues with aggregate statistics may also be a contributing factor.

Source	Country, data source, time frame	Method/Design	Findings
Goodrum et al. (2002), "The divergence in aggregate and activity estimates of United States construction productivity"	United States Data from commercial estimation manuals 1976 and 1998	The study examines productivity for 200 construction activities, to further investigate the apparent contradictions between aggregate productivity measures (which show a poor trend) and other activity based measurements (which tend to show improvement). Activity labour productivity is measured as output per work hour, and MFP is output/(labour cost + equipment costs).	The study considers percentage changes to make productivity across projects more comparable, the mean improvement for labour productivity across the projects was 30.9% (1.2% per year) while the mean improvement in MFP for a given activity was 36.2% (1.4% per year). There is evidence that capital has replaced labour at the activity level over this period: capital-labour ratios increased and together with technology measurements can explain 36% of the variation in labour productivity. The study cites aggregate measurement difficulties as an explanation for why aggregate and activity-level findings differ. It also raises the interesting point that projects may have become more complex over the period, so that even as specific activities become more efficient, firm output on the whole may not if activities do not come together cleanly.
Rojas and Aramvareekul (2003), "Is construction labor productivity really declining?"	United States Aggregative productivity measures from United States agencies 1979–1998	Concerned about the accuracy of aggregate construction productivity measures, since microeconomic studies (e.g. Allmon et al. 2000) suggest labour productivity increased, not decreased, this study examines data collection, manipulation and analysis used by other studies.	Labour productivity measures are inaccurate because of the raw data used and interpretations needed. Productivity should be measured at the sub-industry level rather than at the industry level, because of the variety of activities within Construction (residential, commercial, industrial and heavy construction).
Rojas and Aramvareekul (2003), "Labor productivity drivers and opportunities in the construction industry"	United States Web-based survey of 64 people (owners, consultants, contractors) 2001	Survey of views on factors driving construction labour productivity	Management skills and manpower (worker experience, motivation etc.) are reported as the most important productivity drivers. Respondents think labour productivity is under their control, with external conditions not considered so important.

Source	Country, data source, time frame	Method/Design	Findings
Goodrum and Haas (2004), "Long-term impact of equipment technology on labor productivity in the U.S. construction industry at the activity level"	United States Estimation handbooks (e.g. Means Building construction cost data) 1976–1998	The study examines how changes in equipment technology affect labour productivity at the activity level. The study develops a technology index for 43 types of hand tools and 31 types of machinery, with technological improvements identified from catalogues and handbooks. For each activity, simple regressions of labour productivity are performed on capital/labour ratio and technology index for that activity.	Most of the 200 activities examined saw improvements in labour productivity, in line with other studies at the activity/micro level but going against aggregate studies. Technological advances and a higher capital/labour ratio increase labour productivity, as expected. The study does not account for improvements from completely new methods (e.g. trenchless technology, computers etc.)
Kadir et al. (2005), "Factors affecting construction labour productivity for Malaysian residential projects"	Malaysia Survey of 70 contractors, 11 developers and 19 consultants	Survey of views on most important project-related factors affecting construction labour productivity	Most important factors are: material shortages on site; changes/lateness in consultant duties; and incompetency of site management in organising activities. Most frequently reported factors: material shortages on site; payment problems; lack of workers to hire; and coordination problems between main and sub-contractors.
Park et al. (2005), "Benchmarking of construction productivity"	n/a (theoretical paper)	Based on advice from 73 industry experts, the study constructs a common set of construction productivity metrics, so that other research into construction productivity can be comparable. This set, called the Construction Productivity Metrics System, measures 56 unique elements that together fill up seven different categories.	The result is a labour productivity measure for different activities, where the measure is hours worked per unit produced.

Source	Country, data source, time frame	Method/Design	Findings
Ok and Sinha (2006), "Construction equipment productivity estimation using artificial neural network model"	North America Data from various contractor projects	The study examines two different methods of estimating dozer productivity: regression estimation and artificial neural network methods. It suggests the latter may do a better job because of the non-linearity inherent in the environment of each construction project. The study criticises the use of manufacturers' performance handbooks to estimate equipment productivity, as these handbooks may be more of a marketing device than a signal of productivity.	Productivity is measured from estimates of contractors, who adjust the standard rates in a given productivity chart to estimate for an activity under the given project conditions. Rather than considering coefficient estimates of the two different methods, the study focuses on explanatory power and argues the non-linear neural network method can better explain dozer productivity. It concludes that manufacturers could use this method to improve their productivity estimating charts.
Harrison (2007), "Can measurement error explain the weakness of productivity growth in the Canadian construction industry?"	Canada Various survey and administrative data from Canada 1981–2006	An overview and synthesis of the work of others, motivated by the concern that mis-measurement is contributing to the apparent low productivity of Canada's construction industry	There is evidence of a downward bias in productivity estimates due to the use of input cost-based deflators to create real output (done because of the difficulty in controlling for quality in construction projects). This bias may account for up to half of the gap in productivity growth compared with the business sector.
Abdel-Wahab et al. (2008), "Trends of skills and productivity in the United Kingdom construction industry"	United Kingdom Aggregate data from Labour Force Survey and United Kingdom National Accounts 1995–2006	The study investigates whether training and increasing worker skill is a suitable way to increase productivity for the construction industry. Specifically, it examines construction labour productivity trends (measured as value added per worker), along with trends in skills indicators (qualification completion and training).	There was an increase in the fraction of the workforce with National Vocational Qualifications Level 2, from 0.5% to 5% over the period 1995–2006. There was also an increase of 20% in training rates (fraction of those doing any kind of training). The study concludes that increased qualifications and training do not necessarily lead to improved productivity, as construction productivity did not steadily improve over the period and was generally disappointing. Hence, the study questions the policy focus on skills and training as a means to improve productivity. Note that this study only presents simple correlations without controlling for other trends, and its qualification/education measures are rather broad.

Source	**Country, data source, time frame**	**Method/Design**	**Findings**
Kazaz et al. (2008), "Effect of basic motivational factors on construction workforce productivity in Turkey"	Turkey Survey of 82 firms	Survey of views on most important factors affecting construction labour productivity	Organisational factors are reported as the most important factor group in affecting construction labour productivity, more so than economic, physical and socio-psychological factors. (Though the study notes that management staff will naturally emphasise management practices in improving outcomes.)
Abdel-Wahab and Vogl (2011), "Trends of productivity growth in the construction industry across Europe, United States and Japan"	Germany, France, United Kingdom, United States, and Japan EU KLEMS database 1971–2005	The study uses growth-accounting to examine trends in construction labour productivity and TFP across major OECD countries.	There has been a general slow-down in labour productivity growth in all industries, including construction, across major OECD countries with the exception of the United Kingdom. Furthermore, construction's poor TFP growth largely explains the gap in labour productivity growth between construction and the economy in general, again with the exception of the United Kingdom. Despite the difficulties of cross-country comparisons, the study suggests the industry in developed countries has struggled with productivity growth compared to the economy in general. The study suggests further cross-country research should examine the micro-level, though with caveats of the difficulties in deflating revenue and costs.

Source	Country, data source, time frame	Method/Design	Findings
Borg and Song (2013), "Quality change and implications for productivity development: Housing construction in Sweden 1990–2010"	Sweden Survey data	The study examines if construction productivity growth has been understated because of quality changes. Regulation-driven quality changes were taken from Swedish Association of Public Housing Companies (2011), along with estimated costs. Customer-driven quality improvement was measured as the change in number of 'quality' characteristics of a home, where these quality traits were based on Nathorst-Boos (1999) and input from interviews. Then, for the housing characteristics that showed changes over time, a small number of industry experts were asked for estimates of cost to build a structure today with the old quality. Total quality change is given by combing the estimated regulatory costs and customer-driven costs.	The study finds an overall housing quality increase of 3750 SEK per square metre (18%) over a 20 year period. 1750 SEK is due to regulatory changes and 2000 SEK due to customer-driven quality changes. This translates to a yearly average of around 0.8%, suggesting that productivity growth has been understated by around 0.8 percentage points. Note that the Swedish statistical agencies try to do quality adjustment in constructing price indices, but they only consider the number of balconies, the number of hygiene areas, and the number of garages/parking lots. Although this study's method of estimating quality changes is crude, it is one of the few that seek to account for quality.
Wang et al. (2013), "A total factor productivity measure for the construction industry and analysis of its spatial difference: A case study in China"	China Aggregate regional-level construction industry figures from the Chinese Bureau of Statistics 2006–2010	The study measures TFP of the construction industry for the 31 provinces of China. TFP is calculated using the DEA-Malmquist index, where the inputs are total construction assets; number of construction workers; and the total power of machinery and equipment owned. The two outputs are industry value added and gross output. The study also considers spatial differences in TFP using spatial clustering analysis.	Using the Malmquist index to decompose TFP changes, the study finds that construction productivity has improved steadily, mainly due to improvements in science and technology.

Source	Country, data source, time frame	Method/Design	Findings
Chia et al. (2014), "Economic development and construction productivity in Malaysia"	Malaysia Aggregate productivity statistics 1970–2011	The study examines the relationship between nationwide construction productivity and economic development over the period 1970 to 2011, when three construction cycles occurred. It presents correlations between construction productivity and various controls.	A simple bivariate regression suggests that construction productivity is positively correlated with the business cycle (GDP per capita) in 1985–1998 and 1998–2009 (though not pre-1985). The study argues that construction activity and construction employment were driving construction productivity during the period 1985–1998, and GDP and population were driving it during 1998–2009. The study concludes that a better management of the boom-bust construction cycle would lead to more productivity because of the presented correlations.
Richardson (2014), "Productivity in the construction industry"	Australia Australian Bureau of Statistics Productivity Estimates 1994–2013	Simple industry-level comparisons of productivity growth over time	The construction industry in Australia is relatively productive in both level terms and growth rates, with output defined as value added. Construction MFP growth is over three times the growth of other industries (combined).
Yi and Chan (2014), "Critical review of labor productivity research in construction journals"	United States n/a (literature review)	A literature review of research into construction labour productivity	There appears to be a clash between macro studies, which generally show declining construction labour productivity in the United States, and micro studies, which show the opposite. Regardless, at the industry level several factors have been highlighted that can affect productivity: management; labour (skills, motivation etc.); and government (regulations etc.). The study also raises the conceptual concern of considering construction productivity, since there is substantial variation in activities within the industry.

Appendix Table 2: Summaries of studies related to productivity in the New Zealand construction industry

Source	Data source, time frame	Method/Design	Findings
Page (2010), "Construction industry productivity", BRANZ	Statistics New Zealand published data and surveys conducted by the authors 1987–2009	The study examines construction productivity trends, differences in sub-industries, and some comments on measurement issues.	Reviewing the literature, the study notes that skills training is important; management of multi-projects should be at the firm level; there should be fewer one-off designs; we should benchmark at the firm level to encourage improvements and investigate what innovative/efficient firms are doing differently; increasing firm size would increase efficiency; government should work with the industry to mitigate construction volatility (boom-bust cycles); and regulation should be simpler. Civil engineering has the highest value added ($69000 per worker) followed by all buildings ($58000). Labour productivity at the industry level has been declining by about 0.1% per year since 1988 (though this analysis does not break this up into the distinctive years with different trends, as Conway and Meehan 2013 do). MFP has decreased by about 1% per year. The study notes that unmeasurable quality increases may understate productivity, and suggests quality effects are best considered at the project level.
Tran, V. (2010), "Exploring construction productivity statistics in New Zealand"	Various data sources (Statistics New Zealand, BRANZ etc.) 1997–2007	The study examines the movement of factors that may affect construction labour productivity.	Even though aggregate construction productivity declined over the period, house and land prices have increased while labour and material costs have remained stable. Tran argues these last factors ought to have increased productivity, and so the productivity decline is especially disappointing.
Page and Curtis (2011), "Firm productivity variations", BRANZ	Business Operations Survey 2009	The study examines labour productivity across different sub-industries of construction. Labour productivity is defined as value added per person.	The sub-industries with highest value added per person include non-residential buildings, roading/bridging, land development etc., at over $80,000 per person. Those in the middle group include house construction, concreting, plumbing, electrical, structural steel etc. at $60,000–$80,000 value added per person. The lowest group includes bricklaying, plastering, tiling/flooring, painting and landscaping at $50,000–$55,000 value added per person.

Source	Data source, time frame	Method/Design	Findings
Durdyev and Mbachu (2011), "On-site labour productivity of New Zealand construction industry: Key constraints and improvement measures"	(Primary) survey	The study examines the key constraints to on-site labour productivity in the construction industry. Out of 250 invitations to consultants and contractors, 37 people completed the survey. These 37 were generally highly experienced and highly ranked, though are clearly not representative.	In descending levels of reported importance, internal constraints to construction labour productivity include reworks; lack of skill and experience of the workers; incompetency of construction method; buildability issues; and poor supervision/coordination. External factors were generally thought less important, but (in descending importance) include statutory compliance; unforeseen events; and wider external dynamics.
PWC (2011), "Valuing the role of construction in the New Zealand economy"	PwC Regional Industry Database (intellectual property developed by PwC detailing employment, GDP business size, labour productivity and industry concentration at different geographic levels)	Broad overview of the construction industry, and how the government can and should be involved (both directly as a buyer of construction services and indirectly through policies)	Construction is the fifth largest industry in New Zealand, and is characterised by small firms, volatility and low labour productivity. The industry is important in developing the country's capital stock, which itself is essential for growth. To help the industry, the government could improve planning of capital works programmes; build counter-cyclically to reduce volatility; consider whole-life costs rather than initial contract costs; lower barriers to business; and remove bias toward speculative residential investment (which would reduce volatility in residential construction) etc.
Tran and Tookey (2011), "Labour productivity in the New Zealand construction industry: A thorough investigation"			This is a shortened version of Tran (2010), with the same findings.
Abbot and Carson (2012), "A review of productivity analysis of the New Zealand construction industry"	n/a (literature review)	A summary and synthesis of the different studies on New Zealand construction productivity	Construction productivity growth was probably higher in the 1960s than in subsequent decades, though the stagnation since the 1970s may have been overstated from using value-added measures of output. The growth is also cyclical, so past studies covering a narrow period may be dominated by recessions/booms. A longer time frame is needed for accurate findings. Future studies should try to use quality-adjusted outputs and avoid techniques that require reliable data on prices.

Source	Data source, time frame	Method/Design	Findings
Tookey (2012), "Group builders project for Productivity Partnership Evidence Working Group"	Interviews of builders/business owners	The author interviews house-builders regarding their productivity behaviour, and, given what they think is important, lays out several ways that housing productivity could be improved.	House-builders seem uninterested in reducing total build time, but are interested in reducing the costs of materials and labour. Given this, study suggests that the following will improve housing productivity: prefabrication to reduce skilled labour requirements; house size reduction; designs that reduce costs, such as terraced, multi-storey complexes etc.; deskilling of the process; and better active management of logistics to reduce transport costs.
Conway and Meehan (2013), "Productivity by the numbers: The New Zealand experience"	Statistics New Zealand's published figures 1978–2012	An investigation into productivity trends both nationwide and at the industry level	At the national level, labour productivity grew at an average annual rate of 1.9% between 1978 and 2012, while MFP grew at 0.8%. But this growth was uneven; generally strong in the 1990s but weaker in the 2000s. New Zealand's deteriorating GDP per capita gap with other OECD countries has been driven by a growing gap in labour productivity. Construction productivity levels (measured as GDP per hour paid) were among the lowest in 2010. But construction reversed its poor productivity growth in the 1990s to have relatively strong growth in the 2000s (up to 2008).
NZIER (2013), "Construction productivity: An evidence base for research and policy issues"	A number of customised data sets from Statistics New Zealand 1978–2011	The study uses various sub-industry and regional comparisons of aggregate productivity figures to evaluate the drivers of productivity differences within Construction, and compares the findings with Australia.	There are differences across sub-industries (construction services and heavy and civil compare poorly). Low competition may hurt productivity. There is no consistent evidence that firm size affects productivity (though small and large firms face different problems: scale inefficiencies vs. lazy balance-sheets). Construction workers tend to earn more than workers with comparable skills, which may lower incentives to develop new skills. Also there is low labour mobility which may hurt new ideas and technology from spreading.

Source	Data source, time frame	Method/Design	Findings
Curtis and Page (2014), "Small construction firms in New Zealand", BRANZ	(Primary) survey	The study uses a sample of 15 builders and their sub-contractors who responded to a survey request to examine the characteristics of small firms (which make up around 91% of all construction firms).	Employers in small building firms spend 40% of their day on tool time, while employees spend about 66%. Employers spend less time on tool time as the number of workers increases, while those without workers report less idle time and breaks. Small firms say the two most important factors for productivity/performance are having good trade skills and managing projects well. Note the small, non-representative sample.
Curtis and Norman (2014), "Productivity trends and implications for our industry", BRANZ	Statistics New Zealand published data 1978–2012	The study uses a number of measures to investigate how construction productivity is affected by the business cycle.	The construction industry's GDP is more volatile than other industries, and is driven by booms and busts. There is a surge in construction labour productivity at the beginning of an upturn but businesses eventually hire more workers and so labour productivity drops back down. Similarly, firms tend to hoard labour at the beginning of a downturn but eventually shed workers. If firms responded more quickly to the volatility, this could improve labour productivity. However, this would not be good for the workers who lose jobs, and that hoarding workers may keep skills/knowledge with a firm.
Haji Karimian (2014), "Improving productivity in road pavement maintenance and rehabilitation in New Zealand"	(Primary) survey 2014	The study uses interviews and an online survey to see what contractors and consultants think are the most important factors affecting road construction productivity.	The most important factors under one's control are inaccurate estimates; poor management; location and environmental constraints; and last-minute changes in plan. Uncontrollable factors include regulations, poor weather and the level of competition in the industry. To improve productivity the study recommends better training for workers; having enough money to use new technology and using new cost-effective materials; providing accurate estimations; better management; and improving the accuracy and quality of designs.

Source	Data source, time frame	Method/Design	Findings
NZIER (2014), "Bespoke residential housing demand and construction innovation"	(Primary) survey questions and Statistics New Zealand housing figures Widest range is 1991–2013	Survey questions to home buyers and builders, and desktop research on various problems relating to housing productivity	The study notes that in some areas (particularly for bespoke houses with novel designs), housing innovation is high. Because building productivity is difficult to measure, the study instead considers building costs and find the costs to build residential homes are similar in New Zealand to those in Australia, while apartment costs are 15% cheaper in Auckland than in Sydney. The interviews indicate that builders do not think small size is a barrier to innovation; there are high levels of sub-contracting and the industry is highly networked; management is especially important to productivity in such a networked, complex environment; and regulation is seen by builders as a real obstacle to innovation.
Page and Norman (2014), "Measuring construction industry productivity and performance", BRANZ	Statistics New Zealand published data 1978–2013	The study gives an overview of construction productivity trends, and develops firm-level performance measures so that future work can investigate why some firms perform well (which itself would lead to more productivity).	The lack of productivity growth in the last 20 years may be due to failures to pass along price increases; changes in the sizes of sub-industries (especially residential construction); uncertainty due to demand volatility; and difficulties in measuring quality, capital and labour. To measure firm performance the study recommends that researchers measure financial viability, worker retention, innovation and client satisfaction.

Appendix Table 3: ANZSIC 2006 and NZSIOC codes for the construction industry

ANSIC Code	**Industry description**	**NZSIOC code**
E30	BUILDING CONSTRUCTION	EE11
E301	Residential building construction	
E3011	House construction	
E3019	Other residential building construction	
E302	Non-residential building construction	
E3020	Non-residential building construction	
E31	HEAVY AND CIVIL ENGINEERING CONSTRUCTION	EE12
E310	Heavy and civil engineering construction	
E3101	Road and bridge construction	
E3109	Other heavy and civil engineering construction	
E32	CONSTRUCTION SERVICES	EE13
E321	Land development and site preparation services	
E3211	Land development and subdivision	
E3212	Site preparation services	
E322	Building structure services	
E3221	Concreting services	
E3222	Bricklaying services	
E3223	Roofing services	
E3224	Structural steel erection services	
E323	Building installation services	
E3231	Plumbing services	
E3232	Electrical services	
E3233	Air conditioning and heating services	
E3234	Fire and security alarm installation services	
E3239	Other building installation services	
E324	Building completion services	
E3241	Plastering and ceiling services	
E3242	Carpentry services	
E3243	Tiling and carpeting services	
E3244	Painting and decorating services	
E3245	Glazing services	
E329	Other construction services	
E3291	Landscape construction services	
E3292	Hire of construction machinery with operator	
E3299	Other construction services n.e.c.	
E3291	Landscape construction services	
E3292	Hire of construction machinery with operator	
E3299	Other construction services n.e.c.	
Comparator industries used in this study		
A014	Sheep, beef cattle and grain farming	AA12
A016	Dairy cattle farming	AA13
C24	Machinery and other equipment manufacturing	CC82

Appendix Table 4: Annual growth rates (%) in production measures

	Capital	Labour	Inter-mediates	Gross output	Value added	Labour product-ivity	MFP
Building construction							
2001–2002	0.1	4.0	-2.1	-0.7	3.7	-0.3	-0.9
2002–2003	13.7	9.1	16.4	16.5	16.6	6.9	2.4
2003–2004	35.7	12.8	13.0	12.3	10.3	-2.3	-1.5
2004–2005	15.2	11.1	17.5	14.4	3.7	-6.7	-0.2
2005–2006	10.6	9.4	5.6	6.6	11.1	1.6	-1.2
2006–2007	1.2	4.8	1.8	1.5	0.8	-3.8	-0.5
2007–2008	7.7	2.8	-4.8	-3.3	1.4	-1.3	-1.1
2008–2009	14.6	-0.4	-4.9	-3.2	3.3	3.7	-0.7
2009–2010	29.7	-12.6	-15.9	-11.2	3.1	18.0	4.3
2010–2011	-3.2	-3.2	1.8	2.5	3.9	7.3	3.0
2011–2012	-19.5	-0.1	-3.8	-3.1	-1.1	-1.0	-1.5
Average	8.6	3.2	1.8	2.6	5.0	1.8	0.17
Cumulative 2001–12	148.5	40.9	21.2	32.6	71.8	21.9	1.9
Heavy and civil engineering construction							
2001–2002	17.8	28.6	36.1	32.1	22.8	-4.5	-0.6
2002–2003	9.6	6.8	5.2	6.9	10.0	2.9	1.1
2003–2004	2.7	1.6	8.1	3.7	-3.9	-5.4	-2.4
2004–2005	21.4	16.9	29.4	28.6	25.0	6.9	3.7
2005–2006	10.8	15.7	4.8	8.9	17.9	1.9	0.6
2006–2007	7.5	-1.2	-3.0	2.4	12.8	14.2	4.9
2007–2008	0.4	4.8	-3.7	-3.1	-2.2	-6.7	-1.7
2008–2009	0.9	4.1	-4.9	-3.3	-0.7	-4.6	-1.4
2009–2010	-12.0	-8.3	-19.1	-18.2	-16.6	-9.1	-3.4
2010–2011	1.6	0.6	26.4	18.7	6.6	5.9	1.5
2011–2012	-8.1	-9.2	3.0	-0.5	-7.1	2.3	0.4
Average	4.4	5.0	6.3	6.0	5.1	0.1	0.21
Cumulative 2001–12	59.8	70.6	96.8	90.0	73.1	1.5	2.3
Construction services							
2001–2002	0.4	6.6	10.0	11.8	14.7	7.6	2.2
2002–2003	9.3	10.0	9.0	10.9	14.2	3.7	1.4
2003–2004	8.1	6.6	8.5	7.6	6.5	-0.1	-0.5
2004–2005	12.0	9.5	8.6	8.5	7.9	-1.4	0.7
2005–2006	11.5	7.6	2.8	3.9	5.9	-1.6	-1.1
2006–2007	7.2	5.5	-7.0	1.5	16.4	10.3	5.1
2007–2008	4.1	3.6	-1.3	-0.1	1.6	-2.0	-0.6
2008–2009	-0.9	0.4	-5.6	-3.5	-0.5	-0.9	-1.0
2009–2010	-1.2	-8.2	-10.9	-8.7	-5.9	2.5	1.7
2010–2011	-4.1	-1.2	-0.9	1.5	4.5	5.8	2.4
2011–2012	0.3	-1.4	-0.5	0.7	2.1	3.6	1.0
Average	4.1	3.4	0.9	2.9	5.9	2.4	1.01
Cumulative 2001–12	55.8	44.6	10.6	37.2	88.1	30.1	11.7

	Capital	Labour	Inter-mediates	Gross output	Value added	Labour product-ivity	MFP
All construction							
2001–2002	4.8	10.4	8.7	10.2	13.0	2.3	0.4
2002–2003	10.3	9.1	11.3	12.1	13.9	4.4	1.7
2003–2004	12.3	6.9	10.4	8.6	5.2	-1.6	-1.2
2004–2005	15.3	11.5	16.5	14.8	10.2	-1.2	1.1
2005–2006	11.1	9.9	4.5	6.1	10.3	0.4	-0.7
2006–2007	5.8	3.7	-2.2	1.7	10.8	6.8	2.9
2007–2008	3.9	3.7	-3.4	-2.1	0.5	-3.0	-1.1
2008–2009	3.4	1.1	-5.1	-3.3	0.5	-0.6	-1.0
2009–2010	4.5	-9.3	-14.9	-11.9	-6.1	3.6	1.3
2010–2011	-2.5	-1.2	5.8	5.5	4.8	6.1	2.2
2011–2012	-8.3	-3.1	-1.1	-1.1	-1.0	2.2	-0.1
Average	5.3	3.7	2.4	3.4	5.5	1.7	0.49
Cumulative 2001–12	76.4	48.9	29.5	44.7	79.6	20.6	5.6
All industries							
2001–2002	0.8	1.1	1.9	2.2	2.1	1.0	0.8
2002–2003	7.6	4.1	4.4	4.8	5.2	1.0	0.3
2003–2004	5.1	4.7	2.6	3.0	3.2	-1.4	-0.8
2004–2005	3.1	2.8	13.9	11.1	7.2	4.3	2.1
2005–2006	4.2	3.4	-7.6	-3.3	3.2	-0.2	-0.1
2006–2007	3.2	0.2	-2.2	-1.7	-0.9	-1.1	-0.6
2007–2008	4.3	2.8	4.4	4.5	4.6	1.7	0.6
2008–2009	2.0	0.2	-7.2	-5.8	-3.6	-3.8	-2.7
2009–2010	-1.0	-4.8	-3.1	-3.4	-4.0	0.8	1.1
2010–2011	2.1	-1.5	1.6	1.8	1.9	3.5	0.7
2011–2012	0.4	-0.4	-1.4	-1.0	-0.7	-0.3	-0.2
Average	2.9	1.1	0.5	1.0	1.6	0.5	0.11
Cumulative 2001–12	36.5	13.0	5.7	11.6	19.2	5.5	1.2

Source: Authors' estimation from LBD data 2001–2012
Note: Entries are percentages.

Appendix Table 5: Firm turnover

	End-of-period sample	Continuers	Entrants	Joiners	Exiters	Leavers
All construction			% of firms count[a]		% of firm count[b]	
2000–2001	27,042					
2001–2002	26,634	75.55	11.35	13.10	10.18	15.42
2002–2003	27,684	73.60	13.44	12.96	8.80	14.71
2003–2004	28,368	73.30	14.75	11.95	8.98	15.90
2004–2005	29,655	72.35	15.28	12.37	9.60	14.77
2005–2006	31,038	72.78	14.99	12.23	9.44	14.40
2006–2007	31,725	74.92	13.82	11.26	9.75	13.67
2007–2008	32,955	74.55	13.95	11.51	9.70	12.87
2008–2009	31,965	78.62	11.03	10.35	10.80	12.94
2009–2010	30,498	79.58	10.15	10.27	11.64	12.42
2010–2011	30,435	78.11	11.21	10.69	9.94	12.10
2011–2012	29,601	78.48	11.58	9.93	10.49	13.18
Total	357,600					
			% of gross output[a]		% of gross output[b]	
2001–2002		77.22	4.46	18.33	3.39	12.37
2002–2003		83.06	5.40	11.54	2.77	12.59
2003–2004		85.17	5.31	9.52	2.75	12.52
2004–2005		82.27	6.61	11.13	3.64	10.79
2005–2006		86.53	4.45	9.02	3.70	9.41
2006–2007		86.44	4.19	9.37	2.56	11.12
2007–2008		86.31	5.06	8.63	3.10	12.73
2008–2009		87.42	2.83	9.75	2.78	10.00
2009–2010		91.10	2.70	6.21	2.80	10.60
2010–2011		88.50	2.91	8.59	2.66	8.89
2011–2012		90.12	2.90	6.99	2.37	10.60
All industries			% of firms count[a]		% of firm count[b]	
2000–2001	191,295					
2001–2002	187,896	75.46	11.08	13.45	8.98	16.90
2002–2003	190,956	74.14	12.06	13.79	8.52	16.12
2003–2004	190,284	74.90	12.42	12.68	8.66	16.71
2004–2005	191,793	74.69	12.52	12.79	9.25	15.47
2005–2006	192,795	74.92	12.80	12.28	9.00	15.69
2006–2007	193,815	75.87	12.11	12.02	9.17	14.56
2007–2008	197,799	75.38	12.12	12.49	9.05	14.02
2008–2009	194,109	77.58	10.68	11.74	9.73	14.14
2009–2010	188,256	79.03	9.84	11.13	9.84	13.51
2010–2011	186,735	78.25	10.47	11.28	8.76	13.63
2011–2012	180,780	78.71	10.56	10.74	9.24	14.56
Total	2,286,513					
			% of gross output[a]		% of gross output[b]	
2001–2002		86.31	4.38	9.31	3.22	10.16
2002–2003		84.87	2.79	12.33	6.04	8.30
2003–2004		89.79	3.05	7.16	2.34	8.75
2004–2005		86.12	7.28	6.60	1.51	8.20
2005–2006		91.00	2.91	6.09	1.81	11.34
2006–2007		90.70	3.39	5.91	1.85	8.26
2007–2008		90.72	2.90	6.38	1.91	7.33
2008–2009		91.17	2.11	6.72	1.62	7.11
2009–2010		93.32	1.76	4.92	1.69	6.65
2010–2011		92.97	1.87	5.17	1.55	7.21
2011–2012		92.56	2.07	5.37	1.34	7.06

Source: Authors' calculation from LBD data 2001–2012

Notes: Numbers of observations have been randomly rounded to base 3 to protect confidentiality. [a]Shares are based on current-period sample. [b]Shares are based on previous-period sample.

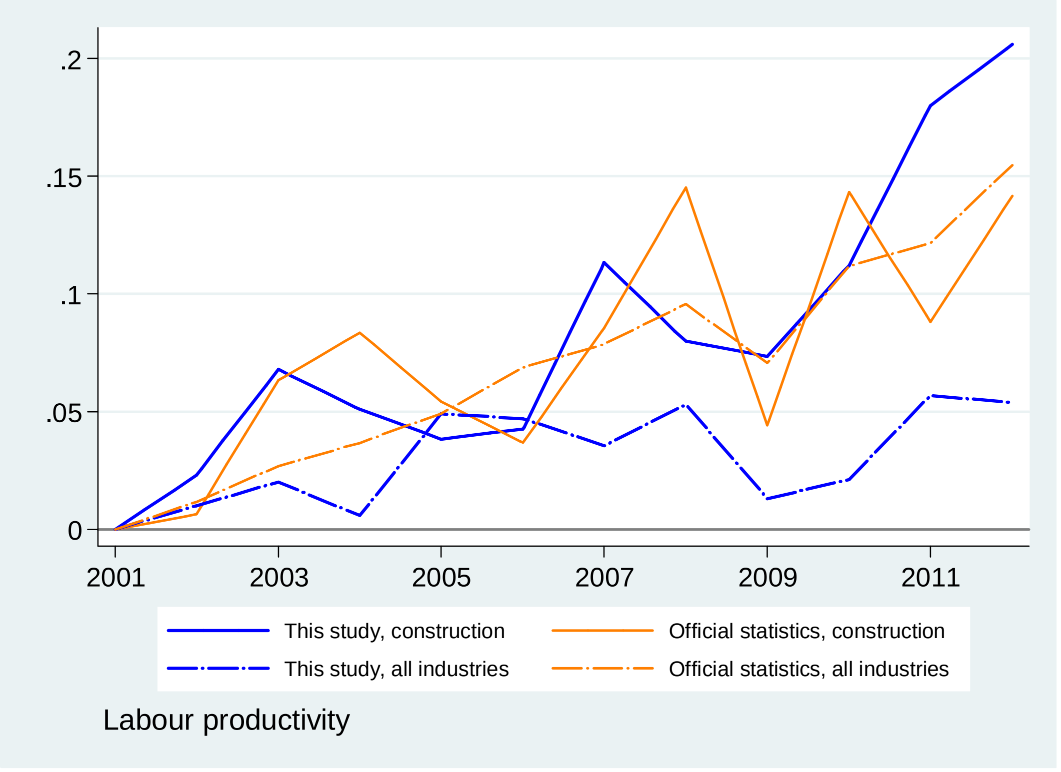
Appendix Table 6: Descriptive statistics for construction firms by transition status, 2011–2012

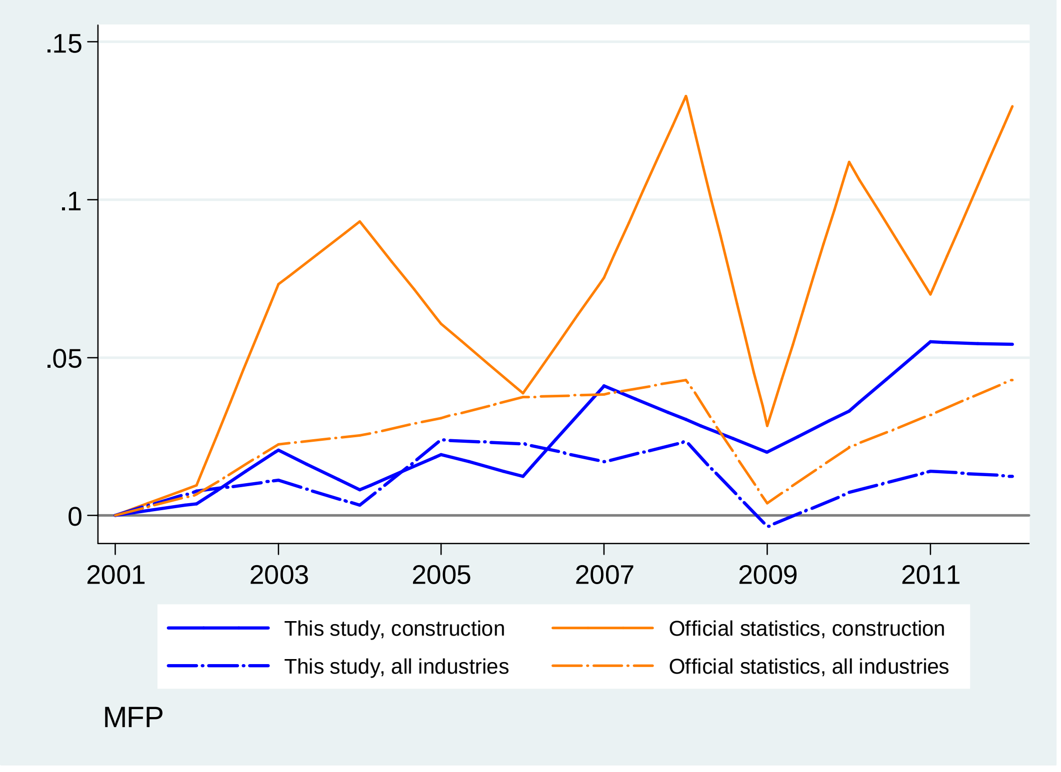
	Continuers	Entrants	Joiners	Exiters	Leavers
% with working proprietors only[a]	51.3[b]	66.8[b]	53.7[b]	71.1[c]	51.6[c]
Mean					
Capital input[d]	51,600	12,500	31,200	11,400	32,600
Labour input	3.36	0.76	2.28	0.68	2.92
Intermediate input[d]	527,700	108,900	314,900	105,300	347,200
Gross output[d]	827,300	180,200	507,000	159,700	570,100
Value added[d]	300,300	72,200	192,600	56,300	223,600
Employees	2.83	0.32	1.78	0.22	2.42

Source: Authors' calculation from LBD data

Notes: [a]Numbers of underlying observations have been randomly rounded to base 3 to protect confidentiality. [b]Shares are based on current-period sample. [c]Shares are based on previous-period sample. [d]In 2007 prices, rounded to the nearest hundred.

Appendix Figure 1: Cumulative growth in productivity: our estimates in comparison with official statistics





Source: Authors' estimation from LBD data 2001–2012

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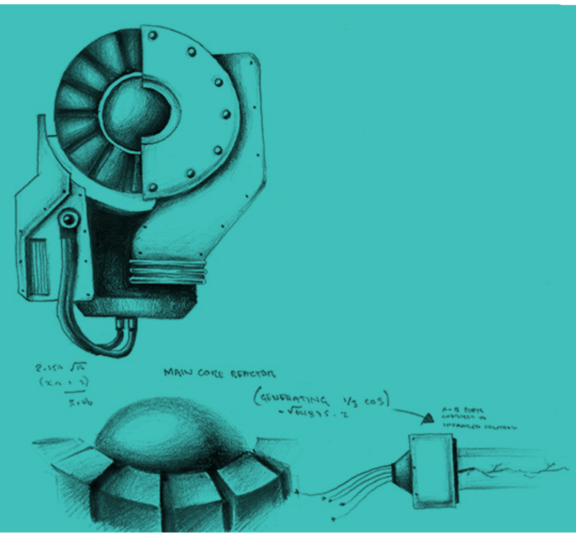
PRODUCTIVITY DISTRIBUTION AND DRIVERS OF PRODUCTIVITY GROWTH IN THE CONSTRUCTION INDUSTRY



This Executive Summary outlines the main findings of a Working Paper published by Motu Economic and Public Policy Research.

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INTRODUCTION

Productivity
has risen. Thank entry and
reallocation.

The construction industry contributes a large and growing share of the New Zealand economy, with total employment rising to almost 10% and value added (GDP contribution) rising to about 9% by 2012. While aggregate statistics have raised some concerns about poor construction productivity, the New Zealand construction industry is not an underperformer when looked at through the lens of individual firms.

Using firm-level data, this study finds that over the period 2001–2012, labour productivity of the average firm in the construction industry grew by 1.7 percent annually and MFP by 0.5 percent annually, compared with 0.5 and 0.1 percent annually respectively for the overall measured sector.

Within the construction industry, productivity growth rates vary markedly by sub-industry and other firm characteristics. Labour productivity is more widely dispersed than is MFP. High-productivity firms tend to be younger, more likely to be a new start-up, to belong to a business group, and to locate in Auckland than low-productivity firms. Working-proprietor-only firms are slightly less productive on average than employing firms, while displaying more productivity dispersion (both more high productivity firms and more low productivity firms).

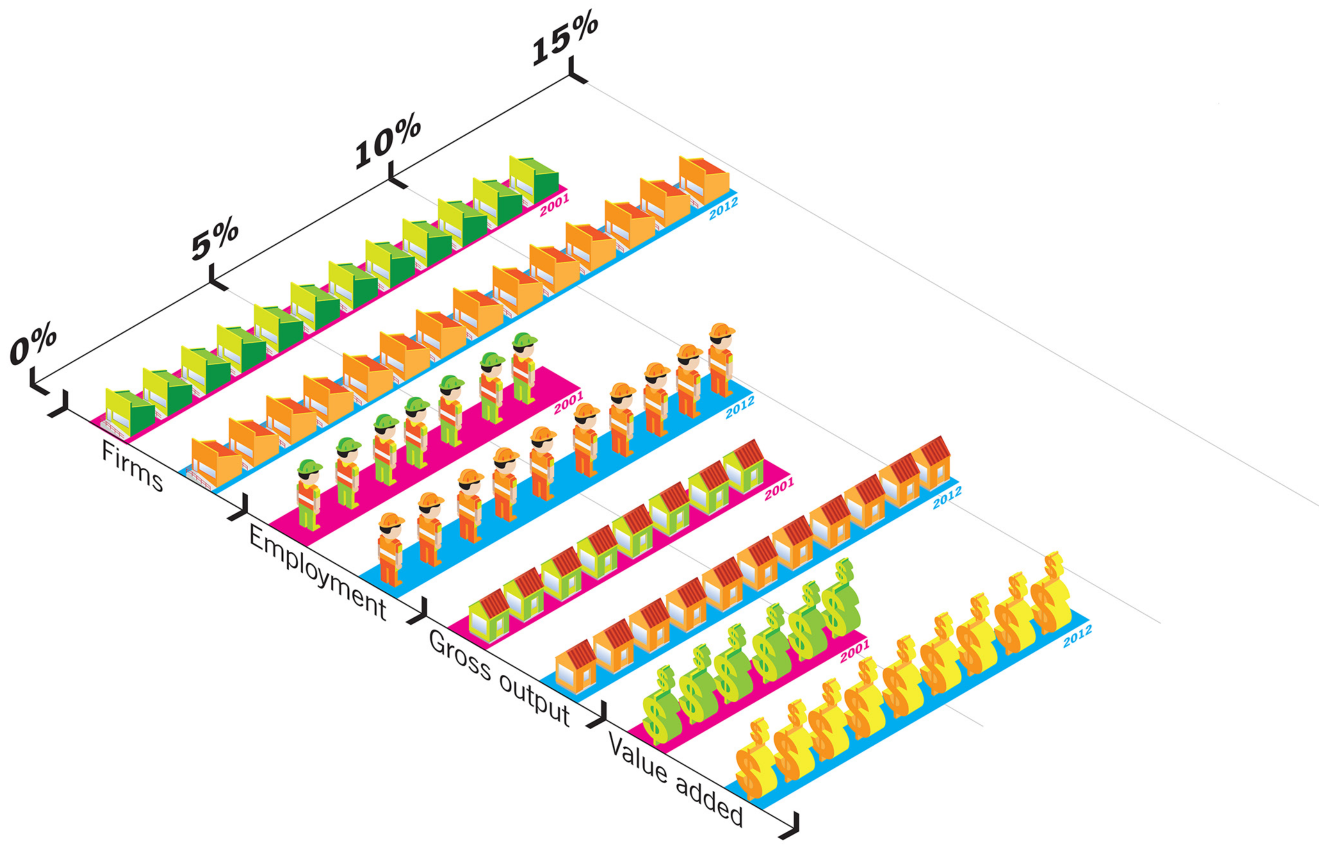
METHODOLOGY

Quantifying what makes the difference between firms and measuring productivity isn't easy. This study measured productivity by looking at the differences between specific sub-industries within construction right down to the individual firm level and accounting for other types of input beyond labour and capital. This is only possible with the sort of data found in the Longitudinal Business Database (LBD).

> *Weak productivity growth in construction has been a concern for some time. What we found, however, was that many individual construction firms—particularly new entrants—exhibit healthy productivity levels.*
>
> **ADAM B JAFFE**
> **DIRECTOR, MOTU ECONOMIC AND PUBLIC POLICY RESEARCH**

The LBD is a linked longitudinal database that contains tax- and survey-based financial data, merchandise and services trade data, a variety of sample surveys on business practices and outcomes, and government programme participation lists (Fabling, 2009), providing comprehensive information on firms' demographic characteristics, business activity and performance.

Figure 1: Construction Industry as Percentage of Measured Business Sector



The research looked at approximately 2.3 million yearly observations of 487,000 firms, including 358,000 observations of 78,000 construction firms in the LBD across the twelve years that were examined.

Comparison of the output of these firms with the industry aggregates constructed by Statistics New Zealand suggests that about 40% of industry gross output comes from firms we are not including. By definition, it is difficult to know what is going on at the firms for which we do not have data. But it would be worthwhile to bring together Statistics New Zealand's modelling of the industry aggregates with these analyses of individual firms, to see if more can be understood about the relationship between micro performance and aggregate statistics.

The study uses an econometric multi-factor productivity approach, which measures productivity via estimating the parameters of a production function. This means that instead of using revenue to compare across industries the researchers analyse rates of growth that are not accounted for by observed labour, capital, intermediate inputs, or revenue factors within the industry in question. Using the production function approach allows comparisons between different firms while providing micro-level patterns that elucidate change.

Acknowledgements

This study is funded from the Building Research Levy through BRANZ and the Productivity Hub under the Productivity Partnership programme. The results in this study are not official statistics, they have been created for research purposes from the Integrated Data Infrastructure (IDI) managed by Statistics New Zealand. The opinions, findings, recommendations and conclusions expressed in this study are those of the authors not Statistics New Zealand, the New Zealand Productivity Commission, BRANZ, or Motu Economic & Public Policy Research.

This approach differs from all previous productivity research into the construction industry in New Zealand and is an international first in studies of this kind.

INITIAL RESULTS

Across the measured sector there was an increase of 2.1 percent in the number of economically active firms, from 476,000 in 2001 to 485,000 in 2012. During this time, the number of construction firms increased by 15 percent (from 54,000 to 62,000). This proportional increase is greater than for other services (7.4 percent), and is only lower than in the utilities industry (18 percent).

In terms of size, construction firms tend to be relatively small, with around three workers on average compared with the overall measured sector average of over five. The only smaller industry is primary, while manufacturing and utilities have much larger firms on average. Within construction, the upper quartile of employment is lower than the mean, indicating that a few large firms account for most of the employment in this industry.

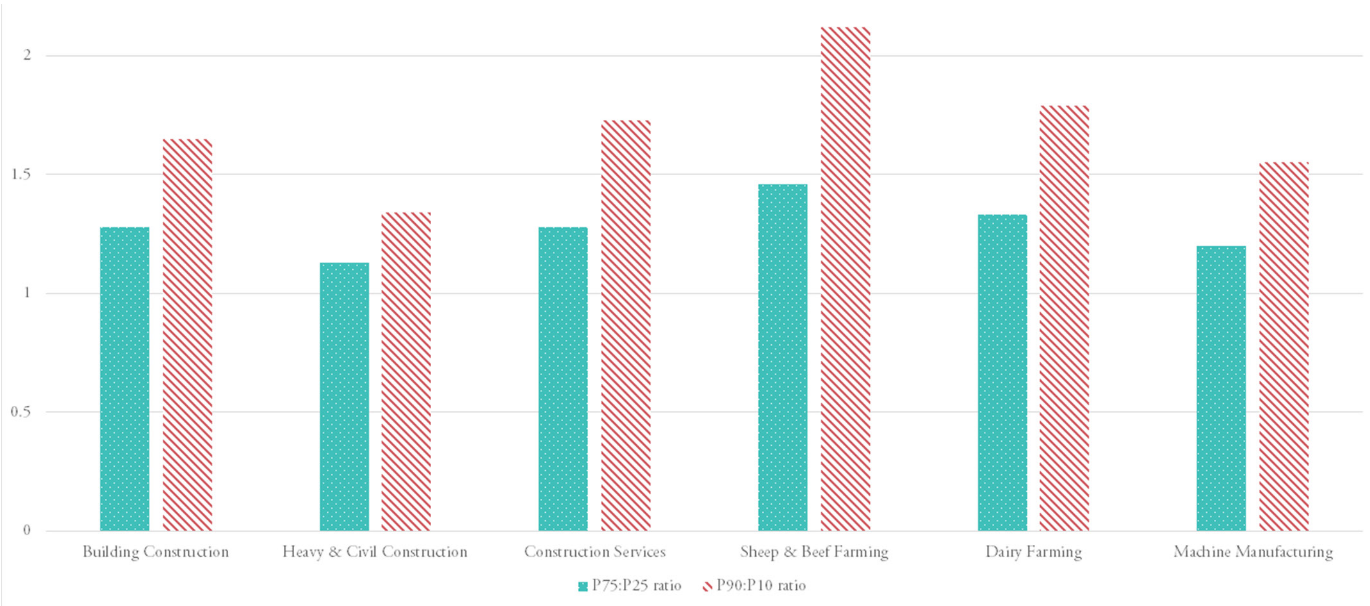
Construction has a high (71 percent in 2012) percentage of working-proprietor-only firms (i.e., those with no employees other than the proprietors).

COMPARISON WITH OTHER INDUSTRIES

Labour productivity in construction firms tends to be lower than in other industries, likely due to lower average skill and lower capital intensity in construction compared to other industries. There is also significant dispersion in labour productivity, meaning that firms with the same number of workers vary widely in their “value added” (revenue minus cost of inputs other than labour and capital). For example, in 2012 the firm at the 75th percentile of labour productivity distribution for construction had 2.2 times the value-added output per worker as the 25th percentile firm.

Interestingly, this ratio is actually smaller in the construction sector than in other industries, e.g. the corresponding ratio is 5.4 for manufacturing and 3.7 for primary. There is therefore no evidence to support a conjecture that relatively poor average productivity performance in construction is due to a greater proportion of firms that significantly lag behind the best performers. Indeed, while construction has similar lower quartile labour productivity to that of most other industries, its median and upper quartile are much lower. This means that the lower overall average labour productivity in construction is associated with a relative absence of star performers, rather than with an over-abundance of productivity underperformers.

Figure 2: **Multi-Factor Productivity across Different Firm Types**



In making these comparisons, it is assumed that the many different input and outputs in different industries can be put on a comparable basis by measuring everything in dollar values. This is only approximately true, so that all cross-industry productivity comparisons should be taken with a grain of salt.

To allow for the possibility that production technology varies across industries, the production function is estimated separately for building construction, heavy and civil engineering construction, construction services, sheep and beef farming, dairy cattle farming, and machinery and other equipment manufacturing.

Among the six industries examined, the construction and manufacturing industries are relatively more labour intensive, while the agricultural industries are relatively more capital intensive. Returns to scale are more or less constant. MFP dispersion is widest in 'Sheep and beef farming ', where the 90th percentile firm is 2.1 times as productive as the 10th percentile firm.

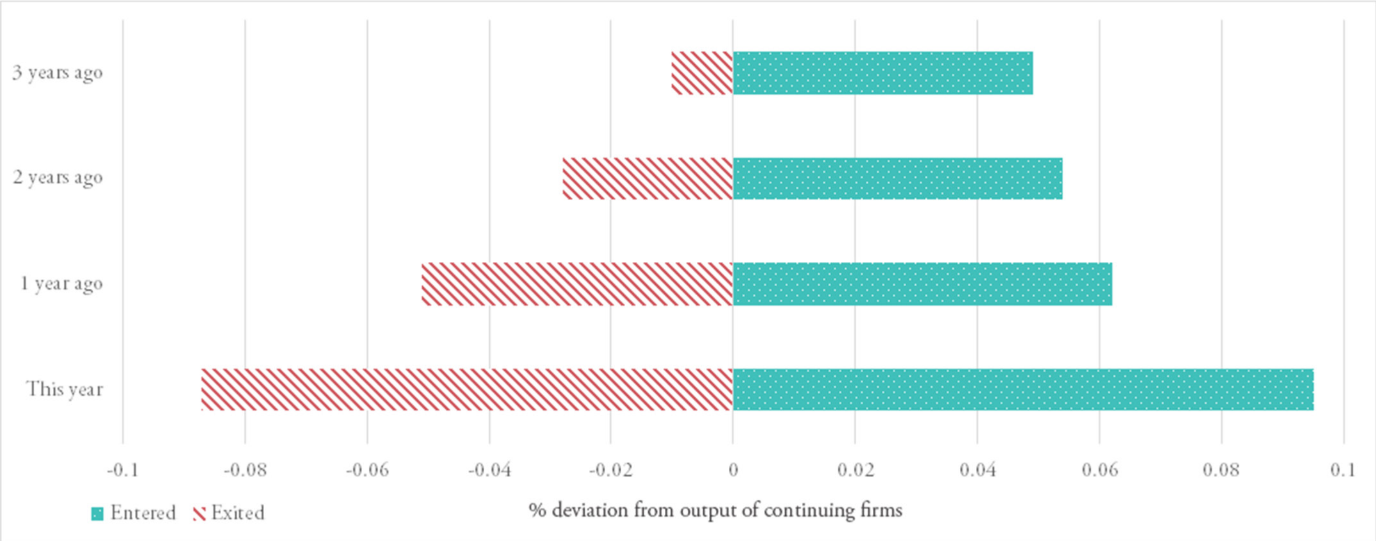
CHARACTERISTICS OF PRODUCTIVE FIRMS

Several firm characteristics are strongly linked to labour productivity, which is

- Higher in entrants than continuing firms.
- Negatively correlated with firm's age in the construction industries and 'machinery and other equipment manufacturing'.
- 19–36 percent higher for firms that contract out (due to lower labour input).
- Significantly lower in firms that have no employees other than the working proprietors.
- 0–41 percent higher for firms that belong to business groups than firms that do not.
- Higher for firms located in Auckland.

Age, entry status, Auckland location and employing status also have similar associations with MFP. However, business group membership and contracting status are less strongly linked to MFP than to labour productivity. Interestingly, exiters have lower MFP in the construction and manufacturing industries. It is, however, important to remember that these correlations do not establish causality. For example we cannot say that if a firm starts contracting out it will become more productive as a result.

Figure 3: Dispersion of Output of Firms Entering and Exiting the Sector Compared to Continuing Firms



The findings that new entrants are the most productive and that age is negatively correlated to productivity are surprising. It seems that, on average, new firms either have new, productive ideas, or their proprietors work extra hard initially. Since we cannot capture the effects of innovation or effort in our explicit input measures, their effect on measured output would, instead, be captured as an increase in average productivity for newer firms.

TURNOVER

The majority of construction firms are continuers, accounting for 73–80 percent of firm counts and even a larger share of gross output (77–91 percent). Entry and exit groups account for much smaller shares of gross output than their respective share in firm counts, suggesting that these firms are relatively less economically significant. Overall, there is more turnover (i.e. higher fractions of entrants and exiters) in the construction industry than in the measured sector, consistent with the common belief.

Coupled with strong growth due to firm reallocation (3.9 percent), MFP for this industry grew by 12 percent over 2001–2012. Overall, the largest positive contributors to MFP growth in the construction industry were growth within continuers and firm reallocation in 'construction services' and turnover in 'heavy and civil engineering construction', while the major drags were productivity slow-down by continuers in 'building construction' and 'heavy and civil engineering construction'.

DIFFERENCE IN FINDINGS

It is widely reported that the construction industry has poor productivity performance. For example, Statistics New Zealand figures from 2014 showed that over the period 1978–2012, labour productivity for this industry grew by 0.6 percent annually, compared with 1.5 percent for all goods-producing industries and 2.1 percent for the business sector.

Similar patterns were seen with respect to multi-factor productivity (MFP).

The discrepancies between our findings and macro data could be due to:

- The current study only including firms with production data, which represents only around 60 percent of the industry's total annual gross output (Fabling and Maré, 2015) and not making aggregate adjustments to improve coverage and accuracy of official data.
- This study using a firm-level econometric approach rather than an aggregate index number approach.
- This study ignoring productivity change due to between-industry reallocation.

The inconsistency between macro and micro productivity statistics has been documented in the international literature. This study does not attempt to reconcile these differences. Rather, it shows that, looking at firm-level data for those firms with usable production data, the New Zealand construction industry is not a productivity underperformer.

SUMMARY

Contrary to received wisdom, frequent firm turnover does not appear to be a drag on productivity, but rather is associated with productivity improvement. New firms are, on average, more productive than incombent firms while those that exit have lower productivity than those who remain. The largest positive contributors to MFP growth in the overall construction industry were growth within continuers and reallocation from low-productivity to high-productivity firms in 'construction services' and turnover in 'heavy and civil engineering construction', while the major drags were productivity slow-down by continuers in 'building construction' and 'heavy and civil engineering construction'.

As in other industries, there is a considerable gap within the industry between the productivity of the best and worst performing firms. This gap is largest for the large number of firms that have no workers other than a worker-proprietor. We find no evidence, however, that the 'problem' of a significant tail of low-performing firms is worse in construction than in other sectors. Indeed, although comparisons of this sort across very different industries are somewhat hard to interpret, the construction sector appears to have less dispersion than other large sectors.

The study raises a number of important new questions that we hope to address in future research. Understanding the dynamic process by which employees interact with firms, move between firms, and start new firms is key to the productivity challenge. Other questions include the effect of the cost of compliance and the impact of "phoenix" firms. Continued research on these topics will broaden the evidence base and help inform policymaking and discussion.